Research paper

ERP investigation of attentional disengagement from suicide-relevant information in patients with major depressive disorder

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ABSTRACT

Background: Previous studies suggest the presence of attentional bias towards suicide-relevant information in suicidal individuals. However, the findings are limited by their reliance on behavioral measures. This study investigates the role of difficulty in disengaging attention from suicide-relevant stimuli using the P300 component of event-related potentials (ERPs).

Methods: Forty-four adults with Major Depressive Disorder (MDD) were administered the spatial cueing task using suicide-relevant and negatively-valenced words as cue stimuli. Disengagement difficulty was measured using reaction time and P300 during invalid trials.

Results: P300 amplitudes at Pz were higher in suicide-relevant compared to negatively-valenced word condition on invalid trials for participants with low rates of suicidal behavior. However, no such difference was found among participants with high rates of suicidal behavior. P300 amplitudes for suicide-relevant word condition were negatively correlated with “lifetime suicide ideation and attempt” at Pz. No significant results were found for the reaction time data, indicating that the ERP may be more sensitive in capturing the attentional disengagement effect.

Limitations: The groups were divided according to Suicidal Behaviors Questionnaire-Revised (SBQ-R) total score. Neutral stimulus was not included as cue stimuli. Most participants were under medication during the experiment.

Conclusions: Our results indicate that patients with MDD and low rates of suicidal behavior show difficulty in disengaging attention from suicide-relevant stimuli. We suggest that suicide-specific disengagement difficulties may be related to recentness of suicide attempt and that acquired capability for suicide may contribute to reduced disengagement difficulties.

1. Introduction

Every year, over 800,000 people die by suicide and about 20 times more people attempt suicide worldwide (World Health Organization, 2014). Global suicide rates have increased 60% in the last 45 years and are expected to increase continuously (WHO, 2014). In particular, South Korea has the highest suicide rate among the members of the Organization for Economic Cooperation and Development (OECD, 2013), an international organization composed of 35 member countries to collaborate for improvements in global economy and its well-being (OECD, 2016). Suicide is a serious and prevalent health concern, and it demands more empirical attention to enhance the understanding of its causes and risk factors.

One of the main predictors of suicide is depression, the most common mental disorder suffered by those who commit suicide (Bertolote et al., 2003; Lejoyeux et al., 1993). However, not every individual with depression commits suicide, and vice versa. Therefore, this study focuses on investigating the vulnerability to suicidal behaviors among the group of individuals with major depression.

Cognitive theories of suicide have suggested that the attentional bias (i.e., selectively shifting attention towards or away from a specific type of stimulus (Macleod et al., 1986; Seehuis, 2015)) towards suicide-relevant information can be interpreted as a cognitive vulnerability for suicide. Wenzel and Beck (2008) proposed that this bias can lead to suicidal crisis when one encounters suicide-relevant cues during the state of hopelessness. In such a situation, one can experience
difficulty disengaging attention from suicidal cues and fixate attention on suicide as the only means of escape. This cognitive model is supported by empirical research using the Stroop task. For instance, Becker et al. (1999) and Williams and Broadbent (1986) found that suicide attempters take longer reaction time (RT) to name the color of suicide-relevant words compared to neutral, positive, or negative words. In other words, suicide attempters have greater difficulty in inhibiting the response of reading the suicide-relevant word, demonstrating attentional bias, as opposed to other types of words (Cisler et al., 2009). Moreover, Cha et al. (2010) found that suicide-specific attentional bias is most evident among individuals with recent suicide attempts, and predicts future suicide attempt over the next 6 months. Although these findings support the presence of attentional bias in suicidal individuals, a few studies have reported contradicting results. For instance, suicide ideators and attempters did not show longer RT to suicide-relevant words compared to negatively-valenced words (Chung and Jeglic, 2016). Richard-Devantoy et al. (2016) reported similar results as there was no significant difference in RTs to suicide-related, positive, negative, and neutral words between suicide attempters and patient controls.

Furthermore, the results of previous studies are limited by their reliance on a single type of assessment method, the Stroop task. Stroop task fails to identify the type of attention process that contributes to suicide-relevant attentional bias (Cisler et al., 2009; MacLeod et al., 1986). Specifically, attentional bias is often related to strongly engaging attention to and/or showing difficulty in disengaging attention from a certain stimuli (e.g., Koster et al., 2006; Stormark et al., 1995; Amir et al., 2003). Previous studies have found that attentional bias towards negative information in depressed individuals is associated with attentional disengagement difficulties rather than facilitated engagement (Koster et al., 2005a, 2005b; Sanchez et al., 2013; Sears et al., 2010). Considering that suicide-relevant stimuli also contain negative valence, these findings suggest that suicidal individuals among major depressive disorder (MDD) patients may have attentional bias characterized by disengagement difficulties. To our knowledge, no studies have investigated the role of attentional disengagement in suicidal individuals.

Studies that examine disengagement difficulties have used Posner’s (1980) spatial cueing task due to its ability to differentiate between attentional engagement and disengagement processes (Derryberry and Reed, 2002; Kessels et al., 2010; Koster et al., 2005a, 2005b). The spatial cueing task examines the covert orienting of attention through measuring the response to a target, which appears after presentation of a cue (Posner, 1980). Attentional engagement and disengagement are measured using RTs on valid (target presented in the same visual field as a cue) and invalid trials (target presented in the opposite visual field as a cue), respectively. Therefore, this study utilized the spatial cueing task to investigate the role of attentional disengagement in individuals with suicidal behavior. Since depression is related to attentional bias towards negatively-valenced information (Peckham et al., 2010; Sanchez et al., 2013), suicide-relevant and negatively-valenced words (i.e., words with negative valence that is unrelated to suicide) are used as cues; it was expected that the difference in task performance between the two stimuli, which contain similar levels of negative valence, would exhibit suicide-related attentional bias in patients with MDD at risk of suicide.

To measure attentional disengagement, we used the method of Event-Related Potentials (ERPs) in addition to behavioral measures. We decided to add ERPs due to a limitation with behavioral measures, where overt response (e.g., RT) reflects the output of multiple stages of information processing (Luck, 2014). In fact, past studies have shown that the RT measure of attentional bias has poor reliability (Brown et al., 2014; Kappenman et al., 2014). Meanwhile, ERPs or small voltage fluctuations that are time-locked to certain events (Jagaroo and Santangelo, 2017) can measure specific cognitive processes using different components (Fichtenholz et al., 2007). Also, ERPs provide a millisecond level of temporal resolution (Luck, 2014), allowing the investigation of the attention processes as soon as the event occurs (Jagaroo and Santangelo, 2017).

Specifically, we assessed the P300, an ERP component that is observed about 300 ms after a presentation of a task-relevant stimulus (Andreas, 2013). P300 has been widely used to measure attention processes since its amplitude is proportional to the amount of attentional resources engaged in processing a given stimulus (Johnson, 1988), and is unaffected by response selection and execution processes (Crites et al., 1995). Studies using the spatial cueing task have reported increases in P300 amplitude during target stimulus processing when it was more difficult to disengage attention from the previously cued stimuli (e.g., Kessels et al., 2010; Pollak and Tolley-Schell, 2003). Thus, P300 could be used as an index of disengagement difficulties. P300 would provide a useful data and may be more sensitive to attention effects than RT.

The present study aimed to examine the role of attentional disengagement in suicidal individuals using RT and P300 while performing the spatial cueing task. In this study, suicidal behavior is defined as the overall suicide-related behavior, ranging from suicide ideation, plans, to attempts. Our main hypothesis was that MDD patients with greater level of suicidal behavior would demonstrate greater difficulty in disengaging attention from suicide relevant words, compared to negatively-valenced words. This would be depicted through longer RT and higher P300 amplitude in suicide-relevant words compared to negatively-valenced words during invalid trials for individuals with high level of suicidal behavior. We predicted that there will be no differences in RT or P300 between the two word stimuli for individuals with lower level of suicidal behavior. We also hypothesized that suicide-related attentional bias would be associated with attentional disengagement, rather than engagement. Thus, we did not expect any differences in RT and P300 amplitude between the two word stimuli in both groups during valid trials.

2. Methods

2.1. Participants

Forty four patients diagnosed with MDD were recruited from Ilsan Paik Hospital and community mental health centers in South Korea. Participants were diagnosed according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5; American Psychiatric Association, 2013) by board-certified psychiatrists. Participants were between ages of 20 and 65 and right-handed without any history of psychotic symptoms or bipolar disorder. Participants with severe medical disease, epilepsy, impaired vision, and brain injury were excluded from this study. In addition, participants who attempted suicide in the past 72 h or reported having the intention to commit suicide within a week were excluded due to the risk of future suicide attempt. The high suicidal behavior (n = 24) and low suicidal behavior group (n = 20) differed in terms of the risk for suicide. The depression and anxiety scores significantly differed between the two groups. This is possibly due to the high correlations of depression and anxiety with suicidal behavior (Apter et al., 1993; Minkoff et al., 1973). In addition, 67% and 5% of the participants had suicide attempt history in high and low suicidal behavioral group, respectively. Lastly, 93.2% of the participants were on antidepressant medication, such as citalopram, desvenlafaxine, and venlafaxine.

All procedures were approved by the Institutional Review Board of Inje University Ilsan Paik Hospital. Informed consent was obtained from all participants prior to participation. Demographic information and scores of psychological scales are presented in Table 2.

2.2. Psychological assessment

The severity of depression was assessed by the Korean version of Beck Depression Inventory (BDI-II), a commonly used self-reported
The Cronbach’s alpha for the current sample was \( \alpha = .95 \). Anxiety was measured by the Korean version of Beck Anxiety Inventory (BAI), a self-reported questionnaire composed of 21 items. BAI showed internal consistency \( \alpha = .96 \). Depression was measured by the Korean version of Beck Depression Inventory-II (BDI-II = Beck’s Depression Inventory-II; BAI = Beck’s Anxiety Inventory). All participants were debriefed after the experiment.

### Table 1

<table>
<thead>
<tr>
<th>Suicide-relevant word (n = 20)</th>
<th>Negatively valenced word (n = 20)</th>
<th>p-Value</th>
<th>Effect size (partial eta squared)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>87.75</td>
<td>147.75</td>
<td>.97</td>
</tr>
<tr>
<td>Suicide/Death relevance</td>
<td>4.96</td>
<td>.44</td>
<td>.00***</td>
</tr>
<tr>
<td>Valence</td>
<td>−2.28</td>
<td>.85</td>
<td>.10</td>
</tr>
<tr>
<td>Arousal</td>
<td>1.66</td>
<td>.76</td>
<td>.40</td>
</tr>
</tbody>
</table>

*** p < .001

Table 2

<table>
<thead>
<tr>
<th>Low suicidal behavior (n = 20)</th>
<th>High suicidal behavior (n = 24)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>42.80</td>
<td>13.30</td>
</tr>
<tr>
<td>Education (years)</td>
<td>13.11</td>
<td>2.37</td>
</tr>
<tr>
<td>Digit Span</td>
<td>25.30</td>
<td>7.58</td>
</tr>
<tr>
<td>BDI-II</td>
<td>14.25</td>
<td>11.57</td>
</tr>
<tr>
<td>BAI</td>
<td>34.55</td>
<td>12.53</td>
</tr>
</tbody>
</table>

BDI-II = Beck’s Depression Inventory-II; BAI = Beck’s Anxiety Inventory.

### 2.3. Event-related potential paradigm

During the electroencephalography (EEG) session, participants wore an electrode cap and were seated in front of a monitor. Participants were asked to place a joystick (JTJ-JTPC-108) where they found it comfortable and remained in the same position until the task ended. Then, the participants were administered the spatial cueing task.

The experiment was composed of 4 blocks of 60 trials each (total of 240 trials). The ratio of valid to invalid condition trials was 2:1, established in a way to shorten the duration of the experiment regarding short attention span in depressive individuals (American Psychiatric Association, 2013). Typically, larger ratios are used to prevent the ‘inhibition of return effect’, or the biased attention towards novel locations. This effect is demonstrated by slowed RT on valid than invalid trials (See Wright and Richard, 2000; Posner and Cohen, 1984). In order to ensure that the participants attend to the cue, we informed the participants that they will be asked to recall the words after the experiment. Greater RTs for invalid trials compared to valid trials would indicate that the participants have successfully attended to the cued location.

Word stimuli for each block were randomly selected with respect to the distribution ratio. There were 20 words for each word type and each word was presented with equal number of times from both left and right location. Targets were black squares (1 cm × 1 cm). For each trial, after a fixation period of 500 ms where a fixation point (+) was presented, word stimuli (22-point Courier New font) were randomly displayed for 700 ms on either left or right side of the screen. Then, 300 ms of the blank screen was presented, followed by a target on either side of the screen. Participants were asked to identify the position of the target (left or right) using a joystick as quickly as possible. The target remained on the screen until a response was recorded. After a 1000 ms interval, the next trial continued (Fig. 1).

For the participants to become familiar with the task, a practice trial was conducted before the experimental session began. A break was given as long as the participant required after 2 blocks of the experiment. All participants were debriefed after the experiment.

### 2.4. Word stimuli

The two sets of stimuli contained similar levels of valence and arousal but differed in suicidality. Specifically, we extracted lists of words that were suicide-related and negatively-valenced on the basis of suicidal words adopted from previous studies (Cha et al., 2010; Lee et al., 2013), the contemporary Korean word frequency list at the National Academy of the Korean language, and the Korean Affective Word list developed by Kim et al. (2010). Twenty one students in counseling and clinical psychology master degree program at Sogang University were asked to list words that they perceived as suicide-relevant. Thirty
words that appeared the most were selected accordingly. For negatively-valenced words, the researchers selected 30 words that have matching syllables and frequency with 30 selected suicide-relevant words. Then, the 21 students rated the 60 words based on suicidality on a 7-point Likert scale, and valence and arousal on a 9-point Likert scale (Table 1). Accordingly, 20 pairs of suicide-relevant and negatively-valenced words, which differed in suicidality but not in valence and arousal, were selected (supplement 2). As a manipulation check, the participants were instructed to rate suicide relevance, valence, and arousal for each word using the same rating scale after the experiment.

2.5. Measures and analysis

2.5.1. Behavioral measures

Difficulty in attentional disengagement was measured by the RT of the performance on invalid trials. During invalid trials, the participant had to disengage attention from the cue stimuli to shift attention to the target and respond. Therefore, longer RT reflects higher difficulty in disengaging attention from the cue. Errors consisted of inaccurate responses (e.g., pressing the right button when the target appeared on the left side) and omissions. Errors were analyzed to rule out a possible speed/accuracy tradeoff.

2.5.2. ERP measures

EEG signals were recorded using a NeuroScan SynAmps 2 amplifier (Compumedics, El Paso, TX, USA) from 62 Ag/AgCl surface electrodes mounted on a Quik-Cap (Compumedics, El Paso, TX, USA) according to the extended International 10–20 system. As a reference, a linked electrode pair was located at the left (M1) and right mastoid (M2), and the ground electrode was placed on the forehead. The vertical electrooculogram (EOG) was recorded using bipolar electrodes: one located above and one below the right eye. A horizontal EOG was recorded at the outer canthus of each eye. The impedance of the electrodes was maintained at less than 5 kΩ. EEG data were recorded with a 0.1–100-Hz bandpass filter at a sampling rate of 1,000 Hz, with 60 Hz noise removed using a notch filter.

The recorded EEG data were preprocessed using Scan 4.3 software (Compumedics, El Paso, TX, USA). The gross artifacts, such as movement artifacts, were rejected by visual inspection by a trained person with no prior information regarding the data origin. Artifacts related to eye movement or blinks were removed using the mathematical procedure implemented in the preprocessing software (Semlitsch et al., 1986). The data were filtered using a 0.1–30 Hz bandpass filter (zero phase-shift 24 dB/oct) and epoched from 100 ms pre-stimulus to 2000 ms post-stimulus. The epochs were subtracted from the average value of the pre-stimulus interval (−100 to 0 ms) for baseline correction. If any remaining epochs contained significant physiological artifacts (amplitude exceeding ±75 μV) in any of the 62 electrode sites, they were excluded from further analysis. Only artifact-free epochs were averaged across trials and participants for ERP analysis. After the artifact rejection, the number of epochs was not significantly different between two groups. The number and percentages of remaining epochs for the high and low suicidal behavior group were as follows: 1) suicide-relevant words/valid trials (72.21 ± 5.58 [90.26%] vs. 73.57 ± 5.54 [91.96%], p = .42); 2) suicide-relevant words/invalid trials (36.33 ± 3.25 [90.83%] vs. 35.14 ± 4.00 [87.86%], p = .28); 3) negatively-valenced words/valid trials (70.71 ± 5.77 [88.39%] vs. 73.24 ± 5.27 [91.56%], p = .13); 4) negatively-valenced words/invalid trials (36.13 ± 3.23 [90.33%] vs. 36.00 ± 2.75 [90.00%], p = .89).

2.6. Statistical analysis

Behavioral data (RT and error) were analyzed with a 2 (validity type: valid vs. invalid) × 2 (word type: suicide-relevant vs. negatively-valenced) × 2 (group: high vs. low suicidal behavior) repeated measures ANOVA with validity and word type as within-subject variables, and group as a between-subject variable. Age was included as a covariate to control for its effect on RT (Der and Deary, 2005) and P300 amplitude (Juckel et al., 2012).

ERP analysis was evaluated on the midline electrodes Fz, Cz, and Pz as P300 peak amplitudes and the related attentional processes generally appear largest at these sites (Johnson, 1993). The P300 peak amplitude increases in magnitude from frontal to parietal sites (Polich, 2007), which was also found in this study, where Pz generally showed the largest peak amplitudes. P300 amplitude was defined as the maximum positive peak amplitude between 250 and 500 ms after the target onset (Polich, 2007). 2 × 2 × 2 repeated measures ANOVA was conducted for each electrode. Then, 2 (word type) × 2 (group) ANOVA was conducted at each level of validity type in the case of significant higher-order effects. If significant interaction was found, simple main effect analysis with Bonferroni adjustments was performed. The above analysis was repeated with BDI and BAI scores as covariates in order to control for the potential effect of depression and anxiety levels on the results.

In addition, correlation analyses were performed between the P300 amplitudes of each condition and the SBQ-R items to examine the relationship between specific suicidal behaviors and attentional disengagement. The bootstrap resampling (n = 5000) was used in order to correct multiple correlations (Dudoit et al., 2004).

Lastly, paired samples t-tests were conducted to compare the participants' ratings on suicide relevance, valence, and arousal between the two word stimuli.

The significance level was set at p < 0.05 (two-tailed). Statistical analyses were performed using SPSS 21 (SPSS, Inc., Chicago, IL, USA).

3. Results

3.1. Behavioral measures

Outliers were examined following Koster et al. (2004)'s suggestions. As a result, RTs for inaccurate responses (0.8%), RTs shorter than 150ms or longer than 1000ms (2.8%), and RTs more than 3 standard deviation away from the individual's mean RT were removed from the data (1.5%).

Repeated measures ANOVA for the error analysis revealed a significant main effect of validity, F(1, 42) = 4.52, p = .04. There were greater number of inaccurate responses for invalid condition (M = .17, SD = .51) than valid condition (M = .55, SD = 1.18). No other significant main effects or interactions were found.

In addition, repeated measures ANOVA indicated that there was a significant main effect of validity, F(1, 42) = 5.05, p = .03. Specifically, the mean RT of invalid trials was higher than that of valid trials. No further significant main effect or interactions were found (Table 3).

<table>
<thead>
<tr>
<th>Word Type</th>
<th>Valid Mean</th>
<th>Valid SD</th>
<th>Valid p-Value</th>
<th>Invalid Mean</th>
<th>Invalid SD</th>
<th>Invalid p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suicide-relevant</td>
<td>461.16</td>
<td>79.39</td>
<td>.28</td>
<td>474.66</td>
<td>93.18</td>
<td>.96</td>
</tr>
<tr>
<td>Negatively-valenced</td>
<td>465.55</td>
<td>79.40</td>
<td>.73</td>
<td>474.90</td>
<td>97.73</td>
<td></td>
</tr>
<tr>
<td>High Suicidal Behavior</td>
<td>452.06</td>
<td>111.04</td>
<td>.61</td>
<td>473.74</td>
<td>133.24</td>
<td>.23</td>
</tr>
<tr>
<td>Negatively-valenced</td>
<td>450.61</td>
<td>113.38</td>
<td>.74</td>
<td>480.47</td>
<td>132.73</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Behavioral measures. Mean reaction time (ms) and standard deviations by validity, suicidal behavior groups, and word type.
3.2. ERPs

Repeated measures ANOVA revealed a significant main effect of validity for electrodes Pz, $F(1, 41) = 5.35, p = .03$. Specifically, the mean P300 amplitude of invalid trials was higher than that of valid trials (Fig. 2). There was a significant three-way interaction among validity type, word type, and group at electrode Pz, $F(1, 42) = 7.45, p = .01$. No main effects or interactions were found at other electrode sites. Thus, all further analyses were restricted to electrode Pz.

Mixed ANOVA for the invalid condition at electrode Pz revealed a significant interaction between word type and group, $F(1, 42) = 7.50, p = .01$. Within group comparison for the low suicidal behavior group revealed a higher P300 amplitude for the suicide-relevant word trials than for the negatively-valenced words trials, $F(1, 19) = 8.48, p = .01$, Bonferroni-corrected. No significant results were found for the high suicidal behavior group (Fig. 3). For the valid condition, no main effect or interaction was statistically significant (Supplement 3).

Furthermore, similar pattern of results was obtained when the above analysis was repeated with BDI and BAI scores as covariates. Analyses revealed that the low suicidal behavior group had higher P300 amplitude for the suicide-relevant word compared to negatively-valenced word trials, $F(1, 16) = 8.52, p = .01$.

Lastly, we found a significant negative correlation between SBQ-R item 1 (lifetime suicide ideation and attempt) and P300 amplitudes, $r = -.30, p = .05$, CI [-.56, -.02], and a marginally significant negative correlation between SBQ-R item 2 (frequency of suicide ideation over 12 months) and P300 amplitudes, $r = -.28, p = .07$, CI [-.51, -.02] at electrode Pz in invalid/suicide-relevant words condition. There were no significant correlations of SBQ-R item 3, $r = -.13, p = .40$, and item 4, $r = -.04, p = .82$, with the P300 amplitudes in the corresponding condition, as well as other conditions.1

3.3. Word ratings

Paired samples t-test revealed a significant difference in ratings on suicide/death relevance between the suicide-relevant ($M = 4.08, SD = 1.64$) and the negatively-valenced words stimuli ($M = 2.76, SD = 1.06$), $t = 6.38, p = .00$. There were no significant differences between word types for valence and arousal ratings.

These results manifest that the participants perceived similar levels of valence and arousal but different level of suicidality for the two word types. This demonstrates that the difference in P300 amplitudes between the word stimuli reflect the difference in suicidality rather than valence or arousal.

4. Discussion

This study investigated whether suicidal behavior is related to difficulty in disengaging attention from suicide-related information by analyzing RTs and P300 amplitude of the spatial cueing task. Our ERP results suggest that MDD patients with high rates of suicidal behavior have less difficulty in disengaging attention from suicide-relevant words as opposed to negatively-valenced words. Specifically, the low suicidal behavior group showed higher P300 amplitude in response to suicide-relevant words compared to negatively-valenced words on invalid trials at Pz. For the high suicidal behavior group, there was no significant difference in P300 amplitude between the two word types on invalid trials. These results remained significant after the BDI and BAI scores were entered as covariates, suggesting that the results can be attributed to the level of suicidality rather than depression or anxiety severity. Furthermore, SBQ-R item 1 and item 2 had significant and marginally significant correlations with P300 at Pz, respectively. These results suggest that “lifetime suicide ideation and attempt” and “frequency of suicide ideation over the past year” may be dimensions of suicidality that are especially associated with reduced difficulty in disengaging attention from suicide-relevant information. The results did not replicate at Pz and Cz sites. These findings are different from our hypothesis that the high suicidal behavior group would have greater disengagement difficulties.

As expected, there was no group difference in valid trials whereas a significant interaction was found in invalid trials. This suggests that the difference in suicide-relevant attentional bias is manifested in attentional disengagement difficulties rather than enhanced attentional engagement. In addition, both RT and P300 amplitude at Pz for invalid trials were longer and higher, respectively, than those of valid trials. This ensures that the participants have successfully attended to the word stimuli with greater cognitive resource, warranting the use of P300 amplitude as an index of attentional disengagement as suggested by previous studies (Kessels et al., 2010).

In general, the results do not support the existence of attentional bias towards suicide-relevant stimuli in individuals with suicidal behavior. This could be due to lack of consensus on the definition of “suicidal behavior.” For instance, Cha et al. (2010) recruited participants from the emergency department, and Becker et al. (1999) recruited individuals who had attempted suicide within the past year. This study included suicide attempters whose last suicide attempt varied from a few months to 17 years ago, as well as suicide ideators without suicide attempt history. Attentional bias towards suicide-relevant stimuli from previous studies could be related to acute state and recency of suicide attempt (Richard-Devantoy et al., 2016). Indeed, attentional bias was reported to be the strongest among those who had attempted suicide within the previous week (Cha et al., 2010; Williams and Broadbent, 1986).

The high suicidal behavior group in this study may not have shown suicide-specific disengagement difficulties due to other suicide-related constructs such as fearlessness of death and liberal attitude towards suicide. For instance, Joiner’s Interpersonal Theory of Suicide (IPT) emphasizes the role of reduced fear of death along with elevated pain tolerance in lethal suicidal behavior (referred to as acquired capability for suicide) (Van Orden et al., 2008). There is a general tendency to show selective attention towards fear-related stimuli (Waters et al., 2004). Therefore if one is fearless of death, one may not show difficulty in disengaging attention from suicide-related information. Regarding that the reduced fear of death is associated with suicide attempt history and near death experiences (Smith et al., 2010; Van Orden et al., 2008; Williams and Broadbent, 1986), high suicidal behavior participants in our study may have exhibited reduced fear of death; most of the participants in the high suicidal behavior group had suicide-attempt history as well as greater lifetime suicide ideation and behavior than the

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1 We have additionally performed a mixed-measures ANCOVA with SBQ-R as a continuous covariate. There was a marginally significant 3-way interaction between word type, trial type, and SBQ-R total score, $F(1, 42) = 3.565, p = .06$. For invalid trials, there was a significant main effect of word type, $F(1, 42) = 5.06, p = .03$, and a significant interaction between word type and SBQ-R total score, $F(1, 42) = 3.479, p = .07$.
low suicidal behavior group. Similarly, several studies have discovered that individuals with suicide ideation, attempt history, and future suicide intent have more liberal and permissive attitude towards suicide (Beautrais et al., 2004; Limbacher and Domino, 1986). Since the high suicidal behavior group had higher scores on the SBQ-R items that assess the above variables than the low suicidal behavior group, they could have had a more liberal attitude towards suicide, leading to less difficulty in disengaging attention from suicide-relevant stimuli. However, we did not make any assessments associated with the fear of death or attitude towards suicide, and therefore the interpretation of the results still remains speculative. These factors are interesting topics to explore in the future.

Lastly, findings in behavioral measures did not support the ERP findings. The RT was similar between suicide-related and negatively-
valenced words trials for both groups. This suggests that the ERP may be a more sensitive method than the RT in capturing the attentional disengagement effect in individuals with suicidal behavior. To our knowledge, this is the first study to use ERP in examining attentional disengagement of suicidal individuals through Posner’s spatial cueing task. ERP studies in individuals with anxiety have reported ERP as a more sensitive method for assessing attentional bias towards threat-related stimuli (e.g., Bar-Haim et al., 2005; Kessels et al. 2010). Hence, ERP may be an informative index for a study of attentional disengagement in suicidal individuals. Because the interaction effect was statistically significant only at Pz site, future studies are necessary to confirm these results. This could be due to P300 amplitude typically being reported as maximal and most reliable at this site (Kautoiu et al., 2002; Polich, 2007)

This study has several limitations. First, the groups were divided according to the SBQ-R total score, a measure that encompasses different dimensions of suicidality. However, some researchers argue that specific type of suicidal behavior represents a different phenomenon (Beauchais, 2001; O’Carroll et al., 1996). If so, using the SBQ-R total score could have affected our results, considering that many previous studies have measured suicidality based on a specific type of suicidal behavior, such as suicide attempt and ideation. Second, neutral words were not included as cue stimuli. Although we have deliberately selected suicide-relevant and negatively-valenced words, the inclusion of neutral stimuli would have provided even more reliable and ample results. Third, the results remained significant even after BDI and BAI were included as covariates, but the results may have been affected by depression and anxiety levels as they are closely associated with suicidality. Yet, additional correlational analysis of depression and anxiety levels with RT and P300 revealed no significant results. Fourth, recent suicide attempt history (within 72 h) and the intent to commit suicide within a week were part of the exclusion criteria for participation in this study. This was done for ethical reasons, as exposure to suicide-related words had a possibility of harming such individuals. However, acute state or recentness of suicide attempt could be a critical factor in establishing the relationship between attentional bias and suicidality. Finally, most of the participants were under medication. Antidepressants could reduce P300 amplitude (d’Ardhuy et al., 1999), yet there were no group differences on the type and amount of medication they were on.

In conclusion, the results suggest that patients with MDD and high suicidal behavior exhibit less suicide-related attentional disengagement difficulties than those with low suicidal behavior. Our results suggest that more sophisticated suicide-related constructs, such as the recentness of suicide attempt and acquired capability for suicide, should be considered for future studies on attentional bias in individuals with suicidal behavior.

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Appendix A. Supporting information

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