Electrophysiological Evidence of Attentional Avoidance in Sub-Clinical Individuals With Obsessive-Compulsive Symptoms

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ABSTRACT Obsessive-compulsive (OC) disorder (OCD) is characterized by obsessions and compulsions, giving rise to a high level of social and occupational impairments. Accumulating evidence indicates that the cause and maintenance of OCD are related to attentional bias. In this study, the neural processes underpinning attentional bias were carefully inspected for thirty participants with a high/low propensity of OC symptoms (HOC/LOC). Both behavioral and electroencephalogram (EEG) data were collected while participants were performing a dot-probe task with the threat or neutral pictures as stimuli. It was discovered from the event-related potential (ERP) results that compared to the neutral pictures, the threat pictures elicited higher amplitudes of ERP component $C_1$ for both the HOC and LOC groups during the stimuli onset period. However, only the HOC group exhibited lower amplitudes of ERP component $P_1$ to the threat pictures than to the neutral ones, indicating that individuals with a high level of contamination fear might divert their attention away from the threat automatically. The novel findings from the present study can pave an avenue for unveiling the complex neural mechanism associated with attentional avoidance in individuals with contamination fear.

INDEX TERMS Attentional bias, contamination fear, obsessive-compulsive disorder, event-related potentials, dot-probe paradigm.

I. INTRODUCTION

Obsessive-compulsive disorder (OCD) is featured by intrusive and unwanted obsessions mainly together with rigid and repetitive compulsions [1]. According to a previous demographic census, the lifetime prevalence of OCD is up to 2-3% [2]. To date, OCD is ranked as one of the ten most handicapping medical conditions by the World Health Organization, bringing a huge burden to our families and societies [3], [4]. More importantly, recent studies demonstrated that compared to other mental disorders, OCD exhibited increased social dysfunctions [5] and heightened mortality risks [3]. Therefore, it is essential for us to reveal the complex pathogenesis mechanism of OCD hereby to guide existing treatments or discover new therapeutics.

Intriguingly, accumulating evidence indicates that attentional bias to threats might be the cause and maintenance of OCD symptoms [6]–[12]. Attentional bias is denoted as the unbalanced allocation of attention resources between the potential threat and neutral stimuli [13]–[15], which consists of three main components: the facilitated attention, difficulties in disengagement, and attentional avoidance [16].
Interestingly, a bunch of behavioral studies has been performed to inspect attentional bias in OCD, in which the findings are contradictory to each other. In particular, several investigations illustrated that OCD patients exhibited an attentional bias to threats [8], [9], [12] while additional work failed to identify this phenomenon [17]–[19]. These inconsistent observations in behavior data might be due to the influence of OCD subtypes. For example, previous reports revealed that only OCD patients with contamination themes [6], [17] rather than other subtypes such as OCD checkers demonstrated attentional bias [18], [19]. Meanwhile, it was discovered that different behavior test paradigms might also contribute to the inconsistent behavior results.

To date, a bunch of behavior test paradigms is provided to inspect attentional bias, in which the Stroop and dot-probe tasks are the two representative ones that are routinely used to measure the behavior data of OCD. However, the dot-probe task is superior to the emotional Stroop task in examining attentional bias since the dot-probe one can offer a more direct and accurate measure of attention allocation [14], [15], [20].

Unlike behavioral studies, event-related potential (ERP) with a high temporal resolution, is capable of decoding the exclusive and exquisite information of early and later cognitive processing stage (Luck, 2014). The early-stage ERP components including C1/N1/P1/P2 and later-stage ERP components such as N2/P3 are involved in automatic and strategic processing, respectively. Importantly, ERP data have been ubiquitously utilized to inspect the neural mechanism of attentional bias while participants (clinical and nonclinical populations) are performing a dot-probe task [21]–[30]. The neuroimaging studies demonstrated that ERP recordings have unbeatable advantages in identifying internal reliability as compared to behavioral measures [21], [22].

Specifically, the elicited ERP components during the dot-probe task can be analyzed independently for two periods: the stimuli onset and target onset. During the stimuli onset period, the elicited ERP components, such as C1, P1, P2, are generally examined. The C1 wave is the first ERP component triggered by a visual stimulus originated from the visual cortex, which starts between 40-60 ms and then reaches its peak around 80-100 ms after stimuli onset [31]. Interestingly, a high C1 amplitude from threat (such as anger or fearful) rather than happy faces is detected for healthy controls [27] or subclinical anxious individuals [25]. The elevated C1 amplitude modulated by emotional valence demonstrates that a more intense emotion processing is undergoing in the primary visual cortex, which has an interaction with subcortical limbic structures [25], [27]. In addition, P1 (peak around 100 ms) is sensitive to attention allocation [32], which might be an index of attention vigilance to emotional stimuli [7], [10] regulated by the amygdala [16], [29]. Previous studies showed that individuals with social anxiety disorders (SAD) [31] or with high fear of evaluation [32] manifested enhanced P1 in cases when they were performing emotional tasks [26]–[28]. The high P1 amplitude might represent the initial hypervigilance to threats that are resulted from the interaction with the amygdala [29] or diminished attention control [30]. Further, P2, whose peak appears around 200 ms after stimuli onset, represents the classification or emotion evaluation of stimuli [33], indicating that it is an index of difficulties in disengagement [7], [30]. In particular, the large P2 amplitude elicited by dot-probe task can be ascribed to increased difficulties in disengaging attention from threats that are over-estimated [30].

Likewise, two additional ERP components, C1 and P1 were generally inspected and involved in the target onset period. Specifically, the C1 effect is consistently reported in previous studies during the target onset period [27]–[30] although this is not the case for P1 [23]–[30]. The controversial findings on P1 might be due to the various experiment designs associated with different studies [23]–[25].

By contrast, the ERP recordings based on the dot-probe task have never been performed to reveal the neural underpinnings of attentional bias in OCD or even subclinical individuals. Therefore, it is hypothesized in this study that if attentional avoidance occurs at the early stage of the cognitive processing (stimuli onset), the neutral stimuli should be able to elicit larger C1, P1, or P2 amplitudes as compared to the threat ones. However, if attentional avoidance occurs at the late cognitive-processing stage, lower P1 or C1 amplitudes can be detected during target onset.

To test this hypothesis, EEG neuroimaging combined with a modified dot-probe paradigm was carried out to inspect the attentional bias in individuals with the propensity of OC symptoms. Interestingly, pictures rather than language words or facial expressions were chosen as the stimuli materials for the present dot-probe task since they can elicit stronger emotional arousal and induce more attention in exploring attentional bias. In addition, only individuals with the tendency of contamination fear were recruited for the present study since previous behavioral studies demonstrated that OCD patients or individuals with contamination fear manifest abnormal avoidance habituation or propensity to threats [36]–[38]. Further, participants were screened by the Padua Inventory and were categorized into two groups (low and high) based on their propensity of OCD [6], [34]–[36].

In summary, the aim of this study was to explore the time courses of attentional bias in individuals with the propensity of contamination fear. To the best of our knowledge, this is the first study to explore the attentional bias of the selected individuals. The investigation into the brain activation of attentional bias will provide us new ways to reveal the complex neural mechanism associated with individual differences in contamination fear before the emergence of psychopathology.

II. METHODS

A. PARTICIPANTS

Thirty participants were selected from a sample of 500 college students aged 16–27, who were recruited from the China Southwest University campus in Chongqing. All participants were screened by using the contamination subscale of the...
The paradigm was shown in Fig. 1 in total), which were presented randomly. The schematic of equal blocks and each block contained 120 trials (360 trials per participant and the computer was kept around 80 cm. of attenuation and dim room, and the distance between the participant and the computer was maintained around 80 cm. of visual comfort. The participants were seated in a comfortable chair in a sound-attenuated booth. The Chinese affective picture system [42] was used in the experiment, whereas general threat and neutral pictures were adapted from an OCD-related picture system [41], whereas contamination threat pictures were extracted from an OCD-related picture system [41]. Collectively, 15 participants with very low and another 15 high PI-C scale scores were provided to the LOC (11 female) and HOC (13 female) group, respectively (Table 1). The study was approved by the local Institutional Review Board from both the Southwest University (Chongqing, China) and the University of Macau (Taipa, Macau SAR, China). Informed consent documents were signed prior to the experiments. All participants were right-handed with normal or corrected-to-normal vision and were free of neurological or psychiatric histories.

**Table 1. The demographic data of two groups (M ± SD).**

| Age | LOC  | HOC  | t (28) | Sig(2-tailed) |
|-----|------|------|-------|--------------|
| PI-C | 21.47±2.39 | 20.53±1.89 | 1.19 | .25 |
| BAII | 2.80±3.12 | 24.29±5.00 | -13.99 | .00** |
| BDI | 7.00 ± 8.75 | 14.53 ± 14.28 | -1.74 | .09 |

PI-C, contamination subscale of Padua Inventory; BAII: Beck Anxiety Inventory; BDI: Beck Depression Inventory; LOC/L: Low/High level of Obsession and Compulsion.

B. STIMULI AND PROCEDURES

The stimuli comprise three categories of pictures: the contamination threat pictures, general threat pictures, and neutral pictures. The contamination threat pictures were extracted from an OCD-related picture system [41] whereas the general threat and neutral pictures were adapted from a Chinese affective picture system [42]. During the experiment, participants were sitting in a comfortable chair in a sound-attenuated and dim room, and the distance between the participant and the computer was kept around 80 cm.

The stimuli task for EEG recordings consisted of three equal blocks and each block contained 120 trials (360 trials in total), which were presented randomly. The schematic of the paradigm was shown in Fig. 1. The paradigm had two stages: the stimuli onset stage and the target onset stage. The stimuli onset stage started with a white fixation cross in the center of a PC monitor for a duration of 500 ms, followed by the presentation of a picture pair (contaminant-neutral pair, general-neutral pair, or neutral-neutral pair) displayed on the left and right of the screen for 500 ms. Then the screen of the PC monitor turned black for 200 ms. Subsequently, the paradigm started with the target onset stage, in which a dot displayed in the exact location from one of the picture pairs for 1000 ms. Participants needed to respond as quickly and accurately as possible to determine whether the dot was on the left or right of the monitor by pressing different keyboard buttons. The inter-trial interval was 500 ms and the task was programmed with E-prime 1.0 (Psychology software tools, Pittsburgh, PA).

Congruent conditions denoted that the dots were presented where threat pictures disappeared, whereas incongruent conditions represented that the dots showed up where neutral pictures disappeared. For behavior measurements, attention bias indices were calculated for each participant, which were generated by using the mean RT (reaction time) difference between the congruent and incongruent conditions.

C. EEG DATA ACQUISITION

EEG data were recorded from 64 scalp sites using tin electrodes attached to an elastic cap (Brain Products, GmbH, Gilching, Germany) with FCz as the reference electrode for the international 10-20 system. Horizontal EOGs (Electrooculograms) were recorded from the right orbital rim while vertical EOGs were measured from electrodes placed below the right eye. All inter-electrode impedance was kept below 5 kΩ. Both EEG and EOG signals were amplified by using a bandpass (DC = 100 Hz) and continuously sampled at 500 Hz/channel for off-line analysis. A bandpass filter of 0.1 to 30 Hz was applied during off-line EEG signal processing and eye movement artifacts were corrected with Brain Vision Analyzer (Brain Products). In this study, trials with EOG artifacts (mean EOG voltage exceeding ±100 µV) and data contaminated with artifacts due to amplifier clipping, bursts of EMG (Electromyography) activity, or peak-to-peak deflection exceeding ±100 µV were discarded for further analysis.

D. EEG DATA ANALYSIS

The EEG data were segmented into various trials for both groups, in which the epoch was 600 ms for the stimuli onset stage, involving 100 ms pre-stimuli, and 500 ms post-stimuli period. ERP (trial-average EEG) data were generated by averaging the epochs for each condition from each participant.
According to grand-averaged ERPs (Fig. 2A), three dominant ERP components were identified based on the analysis of mean latency and amplitudes in the occipital cortex (PO3, POz, PO4, O1, Oz, O2): C1-pic (50-80 ms), P1-pic (80-110 ms), and P2-pic (200-280 ms). Two (Group: HOC, LOC) by three (Picture: Contamination, General, Neutral) repeated ANOVAs were performed for each ERP component of occipital electrodes (PO3, POz, PO4, O1, Oz, O2).

Meanwhile, the epoch for the target onset stage was 600ms as well, which consisted of a pre-stimuli period of 100ms and subsequently a post-stimuli period of 500ms. For this stage, we discovered that three additional ERP components (Fig. 2B) were revealed in the occipital cortex (PO3, POz, PO4, O1, Oz, O2): C1-probe (60-110 ms), P1-probe (110-160 ms), and N2-probe (170-230 ms). In addition, an attentional bias index (valid clue minus invalid clue) was calculated (Eldar et al., 2010) and subsequently two (Group: HOC, LOC) by two (Picture: Contamination, General) repeated ANOVAs were conducted for each ERP component of occipital electrodes (PO3, POz, PO4, O1, Oz, O2).

III. RESULTS
A. BEHAVIOR RESULTS
The HOC (0.99 ± 0.13) and LOC (0.99 ± 0.01) groups exhibited no significant difference in mean accuracy (t_{29} = -0.18, p = 0.86). The measurements of attentional bias indices were provided in Table 2 for both the LOC and HOC groups.

### TABLE 2. The mean reaction time (MS) of HOC and LOC groups (M ± SD).

|                | General Threat Case | Contamination Threat Case | Neutral Case |
|----------------|---------------------|---------------------------|--------------|
|                | Incongruent  | Congruent  | Bias Index  | Incongruent  | Congruent  | Bias Index  | Incongruent  | Congruent  | Bias Index  |
| LOC            | 399.80±37   | 405.1±5   | -5.57±5    | 407.03±5   | 405.0±5   | 1.99±5     | 406.02±5   | 63.38±5   |
|                | 57.86±5    | 77.8±10   | 10.52±5    | 61.33±5   | 62.85±5   | 8.54±5     | 65.38±5   |
|                | 399.14±5   | 397.1±2   | 2.01±2     | 400.00±5   | 398.3±1   | 1.71±1     | 403.39±5   |
| HOC            | 52.32±5   | 56.5±13   | 13.76±13   | 55.21±5   | 54.27±5   | 7.57±5     | 54.58±5   |

A 2 × 2 repeated ANOVA was applied to the attentional bias indices with group (LOC, HOC) as a between-subjects factor and threat (general, contamination) as a within-subjects factor. We discovered that the analysis results showed no significant effect (Threat: F_{1,28} = 2.01, p = 0.17, η^2_p = 0.07; Group: F_{1,28} = 1.54, p = 0.22, η^2_p = 0.05; Group × Threat: F_{1,28} = 2.38, p = 0.13, η^2_p = 0.08).

Holistically, the attentional bias was not detected for both the HOC and LOC groups. As such, we examined whether the attenuation of attentional bias resulted in the absence of this phenomenon [43]. Therefore, the attentional bias indices were generated for each block (Table 3), and one-way repeated ANOVAs with the block as a within-subjects factor were also performed for each group. The results demonstrated that the attentional bias index of general threat pictures (F_{2,13} = 0.61, p = 0.55, η^2_p = 0.04) and contamination fear pictures (F_{2,13} = 2.33, p = 0.12, η^2_p = 0.14) stimuli were not attenuated in the LOC group. Likewise, the HOC group also did not manifest attenuated attentional bias index regarding the general threat pictures (F_{2,13} = 0.09, p = 0.84, η^2_p = 0.01) and contamination threat pictures stimuli (F_{2,13} = 0.10, p = 0.91, η^2_p = 0.01).

### TABLE 3. The attentional bias indices for the two groups (M±SD).

|                | General threat pictures | Contamination threat pictures |
|----------------|-------------------------|-------------------------------|
|                | Block1  | Block2  | Block3  | Block1  | Block2  | Block3  |
| LOC            | -1.01±1 | -4.75±2 | -7.33±3 | -8.9±2  | -4.49±2 |
|                | 24.1±4  | 17.7±4  | 31.7±4  | 12.9±7  | 16.1±6  |
|                | 8.5±4   | 3.6±4   | 2.39±4  | 4.07±4  | 0.77±4  |
|                | 17.29±4 | 16.27±4 | 25.33±4 | 20.02±4 | 22.37±4 |
| HOC            | 19.20±4 | 17.1±4  | 29.0±4  | 21.2±4  | 18.9±4  |

B. ERP RESULTS
C1-pic (50-80 ms): The main effect of picture type was significant, F_{2,27} = 3.47, p = 0.045, η^2_p = 0.21. Further analyses showed that the threat-related pictures (contaminant: −1.53 ± 0.20 μV; general: −1.54 ± 0.17 μV) induced a larger C1 amplitude than neutral pictures (−1.34 ± 0.20 μV). No other effects were further identified (Group: F_{1,28} = 0.38, p = 0.54, η^2_p = 0.01; Group by Picture: F_{2,27} = 1.42, p = 0.25, η^2_p = 0.05).
FIGURE 3. The ERP waveforms of different stimuli onset in two groups. (A) The grand-averaged ERPs of six electrodes (PO3/PO4/POz/O1/O2/Oz) in the HOC group. (B) The grand-averaged ERPs of six electrodes (PO3/PO4/POz/O1/O2/Oz) in the LOC group. The black curves denote the onset of the neutral/neutral picture, the blue curves represent the general threat/neutral pictures onset and the red curves denote the contamination threat/neutral pictures onset.

P1-pic (80-110 ms): The main effects were not discovered (Group: $F_{1,28} = 3.10, p = 0.09, \eta^2_p = 0.10$; Picture: $F_{2,27} = 3.8, p = 0.06, \eta^2_p = 0.01$), although the interaction effect was very significant, $F_{2,27} = 4.84, p = 0.01, \eta^2_p = 0.15$. Further analysis (Fig. 3) revealed that the threat-related pictures in the HOC group (contamination: 0.43 ± 0.60 μV; general: 0.44 ± 0.63 μV) exhibited lower ERP amplitudes than the neutral pictures (0.75 ± 0.65 μV) although this is not the case for the LOC group.

P2-pic (200-280 ms): The main effect of picture type was significant, $F_{2,27} = 6.74, p = 0.002, \eta^2_p = 0.19$, where the neutral pictures case (4.46 ± 0.43 μV) showed higher ERP amplitude as compared to the threat-related pictures case (contamination: 4.19 ± 0.43 μV; general: 3.99 ± 0.43 μV). The other analyses, however, showed no significant effects (Group: $F_{1,28} = 0.40, p = 0.53, \eta^2_p = 0.01$; Group × Picture: $F_{2,27} = 0.60, p = 0.55, \eta^2_p = 0.02$).

C1-probe (60-110 ms): No significant effects were detected for all statistical analysis (Picture: $F_{1,28} = 0.38, p = 0.54, \eta^2_p = 0.01$; Group: $F_{1,28} = 0.49, p = 0.49, \eta^2_p = 0.02$; Group × Picture: $F_{1,28} = 0.28, p = 0.60, \eta^2_p = 0.01$).

P1-probe (110-160 ms): The measures exhibited no significant effects (Picture: $F_{1,28} = 0.58, p = 0.45, \eta^2_p = 0.02$; Group: $F_{1,28} = 3.11, p = 0.09, \eta^2_p = 0.10$; Group × Picture: $F_{1,28} = 0.40, p = 0.53, \eta^2_p = 0.01$).

N2-probe (170-230 ms): No significant effects were discovered for all the analysis results (Picture: $F_{1,28} = 0.28, p = 0.60, \eta^2_p = 0.01$; Group: $F_{1,28} = 0.82, p = 0.37, \eta^2_p = 0.03$; Group × Picture: $F_{1,28} = 0.01, p = 0.93, \eta^2_p = 0.00$).

IV. DISCUSSION

The present study aimed at investigating the neural underpins associated with attentional bias in sub-clinical individuals with contamination fear by using combined ERP measures and dot-probe tasks. The behavioral data demonstrated that the RTs between the congruent and incongruent conditions exhibited no significant differences for both the LOC and HOC groups. By contrast, the ERPs results, however, showed exclusive and elaborate details about the cognitive processing during both the stimuli onset and target onset stages. At the stimuli-onset stage, enhanced C1-pic amplitudes were elicited by threats as compared to those from neutral stimuli across all participants. More importantly, the HOC group exhibited significantly lower P1-pic amplitudes to threats than to neutral stimuli although this is not the case for the LOC group. However, at the target-onset stage, the ERP results showed no statistical effects for C1-probe, P1-probe, and N1-probe. Based on the ERP analysis results, it is plausible for us to infer that the HOC individuals with contamination fear automatically diverted their attention away from the threats.

Interestingly, the behavior data exhibited no significant difference between the congruent and incongruent conditions for the two groups, which were consistent with previous reports [19], [21], [22], [26], [43]. One possible reason might be due to the attenuation of bias over time [43]. Another possible cause might be because the RT-based measure of attentional bias during the dot-probe task is insufficient. For example, previous studies demonstrated that the internal reliability of RT-based measures during the dot-probe task was inadequate [21], [22]. It was discovered from the present study that no attenuation of bias over time was identified for our behavioral data, whereas ERP-based chronometry might be more stable and appropriate for dot-probe tasks [21], [22].

A. STIMULI ONSET STAGE

C1-pic was elicited by the threat pictures rather than the neutral ones across all participants. Interestingly, the $C1$ effect has been documented in previous studies [25], [27], demonstrating that participants exhibited a higher $C1$ amplitude to fearful faces than to happy faces [27]. In addition, the $C1$ effect might be regulated by emotional significance [27], in which rapid projections from limbic regions (i.e. amygdala) plausibly play an essential role in elevating visual responses of primary visual cortex to fear-related stimuli. Our results showed good agreement with previous findings, indicating that ascended $C1$ amplitudes to the threat pictures might be due to the cognitive interactions between the limbic system and the primary visual cortex.
Meanwhile, the HOC group manifested a smaller $P1$ amplitude to the threat pictures than to the neutral ones although this is not the case for the LOC group. Interestingly, previous work demonstrated that a large $P1$ amplitude was elicited for the sad or subclinical participants to the threat faces [29], [30]. Since a large $P1$ amplitude denotes the hypervigilance to a stimulus while a small one represents the avoidance of a stimulus [7], [29], [30], the enhanced $P1$ effect might infer that the sad patients showed initial vigilance to fearful faces caused by the interaction with the amygdala [29]. Hence, our results indicated that the HOC group diverted their attention away from the threat pictures including general threat and contamination threat pictures. Importantly, the attentional avoidance of threats has also been illustrated in previous studies for both clinical and subclinical OCD individuals [7], [34]–[37]. For example, by utilizing ERP recordings and an emotional Stroop task, our past study showed that the OCD patients manifested attentional avoidance of threats including general threat words and OCD-related threat words when compared to that from neutral words [7]. Accumulating evidence also indicates that OCD patients are inclined to develop excessive avoidance habits [37].

Besides, our ERPs results also demonstrated that the threat pictures induced smaller $P2$-pic amplitudes as compared to neutral pictures. $P2$ generally represents the functions of the classification or emotion evaluation of different stimuli [33]. Therefore, the distinct $P2$ amplitudes to different pictures indicated that the stimuli categories were successfully differentiated during the stimuli onset.

**B. TARGET ONSET STAGE**

At this stage, both $C1$-probe and $P1$-probe showed no significant differences between the congruent and incongruent conditions across all participants. Our $C1$-probe findings were in line with previous studies, indicating that no $C1$-probe effect was detected for health, subclinical or clinical populations [27]–[30]. No $P1$ effect was identified for the present study, which also agreed well with previous reports [23]–[25]. Although several studies also demonstrated a larger or smaller $P1$ effect towards emotional faces under congruent conditions than under incongruent conditions [26]–[30], these investigations adopted different task designs from ours. In particular, the dot-probe task used for the present work was modified, in which participants were instructed to respond not only to the location of targets but also the properties of targets. For instance, a go/no-go task was integrated into the dot-probe task and only the no-go ERP components were analyzed [27]–[29].

**C. LIMITATIONS**

First, the relatively small sample size might have an obvious effect on the analysis results. In particular, the participants are recruited from college students, which might not represent the whole population. Second, although we set a relatively high bar in $PI-C$ (scores $> 20$) to screen our participants, a full psychiatric evaluation was not performed, which might affect the diagnosis accuracy. Third, the absence of other sub-type groups such as subclinical OCD checkers might affect the statistical analysis results since we cannot ensure that attentional avoidance only exists in OCD washers rather than other subtypes.

**D. CLINICAL IMPLICATIONS**

Attentional bias modification treatment (ABMT) has been proposed [13], [44] based on the dot-probe paradigm, in which the attention resources of individuals can be diverted to or away from the threat [44]. ABMT can be used to recalibrate attention patterns in individuals with the propensity of OC symptoms. More importantly, our present and previous studies [34]–[37] further demonstrated that non-clinical individuals with OC symptoms tend to avoid threats abnormally. Interestingly, a successful training case was also documented, where reduced attentional avoidance in subclinical OCD samples was detected with ABMT [45]. Accordingly, ABMT might serve as a protective means to HOC individuals by adjusting their attention patterns, and further studies should be conducted to validate that.

**V. CONCLUSION**

In summary, this pilot study demonstrated that individuals with high contamination-related OC symptoms manifested attentional avoidance of threats, which can be evidenced by the $P1$-pic effect. Our results also demonstrated that HOC individuals exhibited attentional avoidance that occurs at an early automatic processing stage. Further study should be performed to examine whether the change of attentional avoidance patterns, which is from the automatic to strategic processing, is related to the transition from a HOC individual to an OCD patient.

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