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# Heightened but Inefficient Thought-Action Fusion in Obsessive-Compulsive Disorder: New Insight From a Multiple Trial Version of the Classic Thought-Action Fusion Experiment

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**Objective** Thought-action fusion (TAF), which is a tendency to make the relationship between one's thoughts and external consequences, is a dysfunctional belief linked to obsessive-compulsive disorder (OCD). While the TAF is commonly evaluated using the Thought-Action Fusion Scale (TAFS), it cannot fully reflect the actual experience of experimentally evoked TAF. In the present study, we applied a multiple-trial version of the classic TAF experiment and evaluate two variables, reaction time (RT) and emotional intensity (EI).

**Methods** Ninety-three patients with OCD and 45 healthy controls (HCs) were recruited. The participants were asked to read the name of a close or neutral person embedded in different positive (PS) or negative (NS) TAF statements. During the experiments, RT and EI were gathered.

**Results** The OCD patients presented with longer RT and lower EI in the NS condition than HCs. In each group, the HCs showed a significant relationship between RT in the NS condition and TAFS scores, whereas the patients did not, although they had higher TAFS scores than the HCs. In contrast, the patients showed a trend toward a correlation between RT in the NS condition and guilt.

**Conclusion** These findings may indicate our multiple-trial version of the classical TAF showed reliable results of the two new variables, especially RT, in the task and allow to newly identify paradoxical patterns in which the TAFS scores are high but actual performance is impaired, that is, the inefficient activation of TAF in OCD.
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**Keywords** Metacognition; Assessment; Obsessive–compulsive disorder; Dysfunctional belief; Cognitive appraisal.

## INTRODUCTION

Obsessive-compulsive disorder (OCD) is characterized by recurrent intrusive anxiety-provoking thoughts or images (i.e., obsessions) and compulsive repetitive behaviors to reduce uncomfortable responses related to obsessions (i.e., compulsions). Contemporary cognitive models of OCD have emphasized the role of various types of dysfunctional beliefs or appraisals in the development and maintenance of specific obsessions and compulsions.[1,2] Of these dysfunctional beliefs, thought-action fusion (TAF) is one of the most extensively studied.[3-7] The term TAF describes the belief that (a) thoughts can directly influence the relevant external event or (b) that having thoughts is morally equivalent to carrying out a prohibited act.[8,9] TAF was also categorized as a kind of metacognitive belief, the so-called thought-fusion belief, and it's original conceptualization by Rachman[10] was discerned by actions (TAF) and events.[11,12] Moreover, TAF was incorporated into the importance/control of thoughts among six maladaptive beliefs.[13]

Exaggerated TAF responses can increase the significance of obsessional thoughts that lead to preoccupation with thoughts, guilt, avoidance, or neutralization, which are closely connected to the psychopathology of OCD.[8,14] Moreover, OCD patients reported higher TAF scores than nonclinical individuals and university students, or a positive correlation between TAF severity and obsessive-compulsive (OC) symptoms, specifically obsession.[4,6,9] Therefore, TAF may be a core maladap-

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tive belief associated with OCD.

However, previous studies were mostly dependent on a self-reporting questionnaire, the Thought-Action Fusion Scale (TAFS)[9] and its association with other scales, causing potential limitations in which only the conceptual relevance of the TAF is likely to be reflected.[4] Moreover, it has validity issue because of the nature of self-report, as the abstract thinking pattern of TAF can be more difficult to measure than first-level thinking, as TAF is a type of metacognition.[15] It is thought that these problems can be overcome using experimental methods. Multiple experimental manipulations of TAF have refined our understanding of this construct.[12,16-21]

In a classic experiment on TAF responses,[19] the participants are asked to fill the name of their close friend or relative in the blank space of a negative sentence "I hope …… is in a car accident." This experimental manipulation was successfully shown to increase anxiety and the subsequent urge to neutralize it among university students with "high" TAFS scores. Although this experiment illustrated the TAF response well, a discrepancy was observed between the measurements directly from the experiment and TAFS scores. In fact, evoked anxiety and feelings of responsibility in the experiment revealed only a small to moderate degree of correlation with TAFS scores.[19] Moreover, the two following studies involving university students with "all ranges" of TAFS scores found no correlation between the TAFS scores and increase in anxiety after TAF provocation.[17,21] These findings suggest that the TAFS scores cannot, or at best, can partially reflect the actual experience of TAF. To reduce this discrepancy, some researchers have proposed modified versions of this experiment by adjusting familiarity[22] and intentionality[23] and adding the sentence of incest-provoking moral TAF.[16,18,24] However, the classic and modified versions of the TAF experiment have a common limitation of measurement that fundamentally relies on subjective evaluation only in a single provocation trial. Surprisingly, almost all these experimental studies were conducted on university students and not on OCD patients. Therefore, it is necessary to develop more objective and standardized measures of TAF for both healthy individuals and OCD patients.

Under the assumption that the values obtained through repeated measurements would be more objective, we focused on two variables, emotional intensity (EI) and reaction time (RT), through multiple provocations of different TAF statements. EI is a general measure of mixed subjective feelings that has been typically used and found to increase after TAF induction in previous studies.[16,17,19,21] In contrast, RT is a novel variable in this study that may reflect the TAF response, because people tend to respond more quickly to avoid negative feelings about mishaps associated with their loved ones.[25] In a broader sense, RT has been an important measure that reflects the implicit emotion processing, which TAF response shares.[26]

Using these two variables, we first hypothesized that RT would be shorter and EI would be higher in the classic TAF condition than in other conditions. Second, RT and EI in the TAF condition would show better relationships with the TAFS scores than those in the other conditions. Moreover, if the two variables show a good relationship with the TAFS, these variables would correlate with OC symptom dimensions which were associated with the TAFS in previous studies.[27,28] In this sense, the two variables would also show some relationships with guilt and inflated responsibility which have been emphasized as important dysfunctional beliefs that contribute to the development and maintenance of OC symptoms[29] and might be induced concurrently by the TAF experiment.[19] TAF measures have shown positive correlations with measures of responsibility and guilt.[14,19] Third, we hypothesized that OCD patients would show a longer RT than healthy controls (HCs). Many characteristics of OCD, such as indecisiveness, self-ambivalence, doubt, and perfectionism indicate a potential delay in RT during TAF induction. Meta-analyses have also revealed that OCD individuals exhibit general motor slowing.[30,31] Also, in our previous study, OCD patients showed a longer RT than HCs only in the negative statements (NS) condition.[32] To verify the hypotheses, we designed a multiple-trial version of the classic TAF experiment including statements in terms of familiarity (close person [CP] vs. neutral person [NP]) and valence (NS vs. positive statement [PS]), and conducted the experiment for OCD patients and healthy participants.

## METHODS

### Participants

Ninety-three OCD patients (65 male and 28 female) and 45 healthy volunteers (37 men and 8 women) were included. For the patients, the「Structured Clinical Interview for DSM-5 Disorders, Clinical Version (SCID-5-CV)」was conducted to determine the presence of OCD and other comorbid conditions. Patients were excluded if they had current comorbid major psychiatric illnesses, such as major depressive disorder or schizophrenia/other psychotic disorders, intellectual disability, neurological diseases, or a history of head injury or medical illness with documented cognitive sequelae. For HCs, psychiatric interviews were conducted to exclude existing psychiatric pathologies, psychotic symptoms, mental retardation, neurological diseases, and history of head injury or medical illness. All interviews were conducted by two experienced psychiatrists. All participants provided written informed consent in accordance with procedures approved by the Institu-

tional Review Board of Kyungpook National University Hospital (2021-04-032). Behavioral data from some of these participants have been published previously in neuroimaging studies.[25,32] However, the sample size was small and OCD patients were not included in one study;[25] another study with a small sample size of OCD patients did not include any relationship between behavioral data and other psychological variables in a detailed manner.[32]

## Procedure

The participants completed a demographic questionnaire and baseline psychological measurements. Then, we introduced the TAF experiment and assessed overall anxiety using a Likert scale ranging from 1 to 10. After completing the experiment, anxiety, discomfort, unwanted thought intrusion, and upset behavior were assessed using the same method.

## A modified TAF-evoking experiment

Before the experiment, the participants were asked to name two CP and NP, respectively, who were then included in the TAF paradigm. We used eight PSs and NSs. An example of the former was "I hope that (CP or NP) will win a lottery in the near future." An example of the latter was "I hope that (CP or NP) will be in a terrible car accident in the near future." Our experiment included PS since positive TAF can be related to OCD regarding harm avoidance or mental neutralizing.[6] A full list of statements has been provided elsewhere.[32]

The modified TAF experiment included four conditions: PS/CP, PS/NP, NS/CP, and NS/NP. Each trial for each statement consisted of three phases with a fixed time. First, the participants were asked to think about the CP or NP while watching the name of the person displayed on the screen for 4 seconds. Second, they were instructed to silently read the subsequent PS or NS, including the name for 10 seconds. Third, they were asked to rate how gladly or badly they felt about the PS or NS, respectively, which indicated their EI on a Likert scale from 1 (very little) to 4 (very much), using a button box for another 4 seconds, followed by rest. RT was defined from the beginning of the third phase to the time to push the button. In total, our modified version of the TAF experiment lasted for approximately 15 minutes (28 seconds for each statement × eight statements for each condition × four conditions). All participants were asked about 16 NSs, followed by 16 PSs. NPs and CPs were mixed in a pseudorandomized order within each statement type. The TAF paradigm was adapted from a previous report[19] and modified for functional magnetic resonance imaging (fMRI) experiments.[25]

## Psychological measures

The TAFS[9] consists of 19 items that measure the degree of TAF belief and is divided into three categories: TAF-morality (12 items), TAF-likelihood-self (3 items), and TAF-likelihood-others (4 items). Each item is rated on a 5-point scale ranging from 0 (strongly disagree) to 4 (strongly agree). We used a recently validated Korean version of the TAFS with high internal consistency (Cronbach's α=0.92−0.93).[33]

The Dimensional Obsessive-Compulsive Scale (DOCS)[34] is a 20-item self-report measure that is used to assess four OC symptom dimensions: contamination, responsibility for harm and mistakes, unacceptable thoughts, and symmetry and ordering. Each item is evaluated on a scale ranging from 0 to 4. Each subscale score ranges from 0 to 20. The DOCS subscales correlated well with other measurements of OC symptoms. The Korean version of DOCS has been validated previously, and the reliability of each dimension in the Korean version of DOCS was shown to be excellent (Cronbach's α=0.91−0.95).[35]

The Obsessive Belief Questionnaire (OBQ)-44[36] was developed by the Obsessive Compulsive Cognitions Working Group to measure beliefs that are considered important in the development and maintenance of OCD. An exploratory factor analysis revealed four factors: perfectionism and intolerance of uncertainty, importance and control of thoughts, responsibility, and overestimation of threat. Among the scores of these factors, only the responsibility factor score was used in this study. We selected 16 relevant items from the Korean translation of the OBQ-44 for this study (Cronbach's α=0.88 for the responsibility subscale).[37]

The Guilt Inventory (GI),[38] a 45-item self-report inventory, was used to assess the domains of trait guilt, defined as a continuing sense of guilt beyond immediate circumstances; state guilt, defined as present guilt based on current or recent transgressions; and moral standards, defined as subscription to a code of moral principles without reference to specific behaviors or overly specific beliefs. Only the trait guilt subscale was used in this study. Twenty relevant items were selected from the Korean translation of GI by Lee[39] (Cronbach's α=0.78 for the trait guilt subscale).

Beck's Depression Inventory (BDI)[40] consists of 21 questions. The BDI measures depressive symptoms during the past week; each item is scored from 0 to 3, and the total score ranges from 0 to 63. In this study, a validated scale of the Korean version of the BDI was used (Cronbach's α=0.90).[41]

## Statistical analysis

Our data analysis approach included the following steps. First, we computed the descriptive statistics for all variables and used the Kolmogorov−Smirnov test to determine the normality of the RT and EI for all conditions in each group. Comparisons of RT and EI between conditions were performed within a group using paired t-tests. Second, Spearman's cor-

relation was used to investigate the associations among age, depression scores, and behavioral data to identify potential covariates. Third, group differences in behavioral data between OCD patients and HCs were analyzed using multiple analysis of covariance (MANCOVA) after controlling for depression as a covariate. Moreover, we performed partial correlations to examine the relationships between behavioral data and the TAFS score and other dysfunctional beliefs as well as the DOCS after controlling for depressive symptoms. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 23 (IBM Corp., Armonk, NY, USA). For correlational analyses, false discovery rate (FDR)-adjusted $p<0.1$ level using Benjamini-Hochberg procedure was used. Otherwise, statistical significance was set at $p<0.05$.

# RESULTS

## Demographic and psychological characteristics

Table 1 shows the demographic and clinical data of the OCD and HC groups. The mean and standard deviation of the age of the OCD patients and HCs was 25.4±6.0 and 24.0±3.5 years, respectively. No intergroup differences were observed in terms of age, sex, or educational level.

The age at onset and duration of illness were 18.7±5.3 and 6.7±5.1 years in the OCD patients. The OCD patients showed higher scores on OC and depressive symptoms than did the HCs, all of which fell within the clinical range. The patients showed higher scores on all subscales of the TAFS and GI and an inflated sense of responsibility.

Of the 93 patients, 39 were drug-naïve or unmedicated for at least three months, while 54 were medicated. Among the

**Table 1.** Demographic and clinical characteristics of patients with OCD and HC groups

| Characteristics | OCD (N=93) | HC (N=45) | Statistics | |
|---|---|---|---|---|
| | | | $t/\chi^2$ | p |
| Age (yr) | 25.4±6.0 | 24.0±3.5 | 1.8 | 0.082 |
| Male/female | 65/28 | 37/8 | | 0.122 |
| Level of education (yr) | 14.5±1.6 | 14.9±1.0 | -1.9 | 0.059 |
| Age at onset of OCD (yr) | 18.7±5.3 | - | - | - |
| Duration of illness (yr) | 6.7±5.1 | - | - | - |
| Symptom measures | | | | |
| DOCS | | | | |
| Contamination | 5.7±5.0 | 3.1±2.2 | 4.2 | 0.001 |
| Responsibility for harm | 8.0±5.7 | 2.9±3.1 | 6.8 | <0.001 |
| Unacceptable thoughts | 9.4±5.5 | 3.0±3.2 | 8.4 | <0.001 |
| Symmetry/ordering | 4.9±5.1 | 1.8±2.4 | 4.8 | <0.001 |
| Total | 27.9±12.9 | 10.9±9.4 | 8.8 | <0.001 |
| Beck Depression Inventory | 17.7±11.1 | 5.4±6.1 | 8.4 | <0.001 |
| Dysfunctional beliefs measures | | | | |
| TAFS, total | 30.2±18.4 | 18.9±13.3 | 4.1 | <0.001 |
| GI, trait | 69.0±10.6 | 55.8±9.0 | 7.3 | <0.001 |
| OBQ, responsibility | 57.2±23.0 | 48.8±20.4 | 2.1 | 0.040 |
| Subjective evaluation before and after experiment* | | | | |
| Pre-experiment | | | | |
| Overall anxiety | 2.1±1.4 | 1.8±0.9 | 1.2 | 0.174 |
| Post-experiment | | | | |
| Overall anxiety | 4.2±2.2 | 2.5±1.7 | 4.6 | <0.001 |
| Discomfort | 7.0±2.5 | 6.7±2.3 | 0.5 | 0.578 |
| Unwanted thought intrusion | 4.9±2.6 | 4.3±2.5 | 1.2 | 0.216 |
| Upset | 3.6±2.9 | 2.7±2.0 | 2.1 | 0.039 |

Values are presented as mean±standard deviation. *measured using Likert scale from 0 to 10 (highest intensity) before and after experiment. OCD, obsessive-compulsive disorder; HC, healthy controls; DOCS, Dimensional Obsessive Compulsive Scale; TAFS, Thought-Action Fusion Scale; GI, Guilt Inventory; OBQ, Obsessive Beliefs Questionnaire

medicated patients, most were taking selective serotonin reuptake inhibitors (SSRIs: escitalopram, 37; fluoxetine, 8; paroxetine, 4; sertraline, 2; and fluvoxamine, 2).

Additionally, OCD patients reported more increased overall anxiety ($p<0.001$) and upset behavior ($p<0.05$) using an 11-point Likert scale than HCs after the experiment.

## Statistics of RT and EI within each group

In both groups, the RTs in every conditions were positively skewed. Between the same statement conditions, the RTs in the CP condition were more skewed and pointy than those in the corresponding NP condition, whereas between the same person conditions, the RTs in the NS condition were less skewed and pointy than those in the corresponding PS condition. These trends were directly reflected in the differences between the mean of RT and EI values within each group (Supplementary Table 1 and Supplementary Figure 1 in the online-only Data Supplement). Thus, the normality test indicated a deviation from normality in the NS/CP and NS/NP conditions in HCs, and the NS/CP and PS/CP conditions in the patients (Supplementary Table 2 in the online-only Data Supplement). For all participants, Cronbach's α coefficient of the RT for all four conditions was 0.80.

Regardless of the NS or PS, participants generally rated higher EI for their CPs than for their NPs. Thus, the EI values for CPs were more negatively skewed (closer to Likert scale 4 on the right) than those for NPs (closer to Likert scale 1 on the left). All conditions, except the NS/NP condition in HCs, did not show a normal distribution (Supplementary Table 2 and Supplementary Figure 2 in the online-only Data Supplement). For all participants, Cronbach's α coefficient of EI for all four conditions was 0.50. This small number was because of different distribution patterns in which the EI scores were distributed more broadly than the RTs, especially in the PS or NP conditions.

## Comparison of RT and EI between the two groups

Before we demonstrated the comparison results, the initial Spearman's correlation analyses showed that the depression scores were significantly related to RT in both NS/CP ($r_s$= -0.31, p=0.038) and NS/NP ($r_s$=-0.36, p=0.015) conditions in HCs but not in OCD patients. Therefore, the depression scores were controlled for in all further analyses.

MANCOVA with depression scores as a covariate revealed that the OCD patients showed a significantly longer RT in all three conditions except the PS/NP condition than did HCs ($F_{1,135}$=9.0, p=0.003 for NS/CP; $F_{1,135}$=5.9, p=0.017 for NS/NP; $F_{1,135}$=10.5, p=0.002 for PS/CP), although the patients also demonstrated the same general pattern as HCs, indicating that the NS conditions showed a longer RT than did the PS conditions, and the CP conditions showed a shorter RT than did the NP conditions (Figure 1). The patients showed a significantly lower EI in the NS/NP condition than did the HCs ($F_{1,135}$=5.1, p=0.026) (Figure 1).

## Relationships between RT and EI and TAF and other dysfunctional beliefs

The results of Spearman's partial correlation analysis are presented in Table 2.

In HCs, the RT in both the NS/CP and NS/NP conditions showed significant relationships with the total score of the TAFS ($r_s$=0.60, p<0.001 for NS/CP; $r_s$=0.48, p=0.001 for NS/NP), whereas those in the other two PS conditions did not show any significant relationship. Between the NS/CP and NS/NP conditions, the RT in the NS/CP condition was found to have a higher correlation with the TAFS scores than the RT in the NS/NP condition. In terms of EI, no significant relationship was observed between EI and the total TAFS score. The RT and EI in all conditions were not related to trait guilt or an inflated sense of responsibility.

In the OCD patients, RT in any conditions did not show correlation with the total TAFS score. Instead, RT in the NS/NP condition showed a trend toward a positive relationship

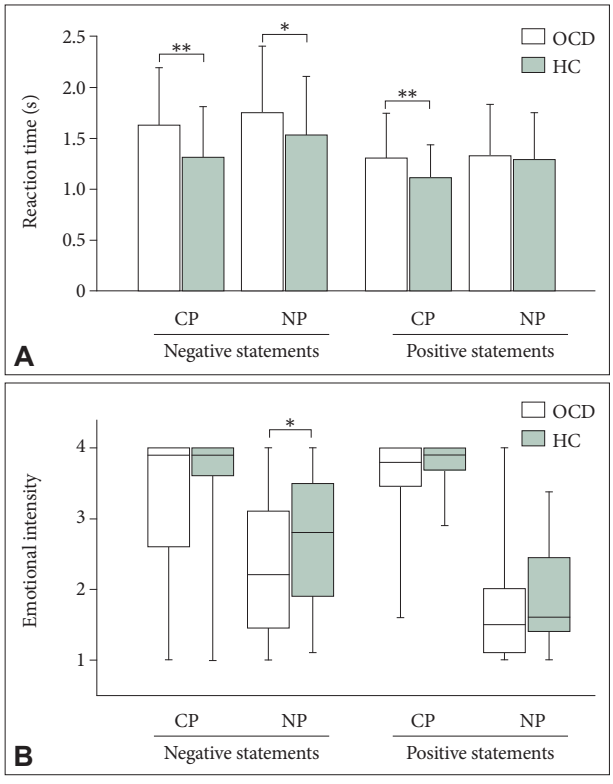


**Figure 1.** Comparisons of reaction time (A) and emotional intensity (B) in a multiple trial version of thought-action fusion experiment between patients with obsessive-compulsive disorder (OCD) and healthy controls (HC). *p<0.05; **p<0.01. CP, close person; NP, neutral person.

**Table 2.** Spearman's partial correlation between experimental variables and dysfunctional beliefs

| | Reaction time | | | | Emotional intensity | | | |
|---|---|---|---|---|---|---|---|---|
| | NS/CP | NS/NP | PS/CP | PS/NP | NS/CP | NS/NP | PS/CP | PS/NP |
| HC (N=45) | | | | | | | | |
| TAFS-T | | | | | | | | |
| $r_s$ | 0.601* | 0.478* | 0.098 | 0.242 | -0.112 | -0.191 | 0.238 | 0.263 |
| p | <0.001 | 0.001 | 0.526 | 0.113 | 0.467 | 0.214 | 0.119 | 0.084 |
| Guilt-T | | | | | | | | |
| $r_s$ | 0.089 | 0.092 | 0.190 | 0.319 | 0.169 | -0.002 | 0.111 | 0.073 |
| p | 0.565 | 0.553 | 0.216 | 0.035 | 0.272 | 0.988 | 0.474 | 0.639 |
| OBQ-R | | | | | | | | |
| $r_s$ | 0.269 | 0.232 | 0.269 | 0.176 | -0.155 | -0.189 | 0.034 | -0.238 |
| p | 0.077 | 0.129 | 0.078 | 0.253 | 0.314 | 0.220 | 0.829 | 0.119 |
| OCD (N=93) | | | | | | | | |
| TAFS-T | | | | | | | | |
| $r_s$ | -0.020 | 0.154 | -0.020 | 0.093 | -0.048 | 0.098 | 0.123 | 0.172 |
| p | 0.853 | 0.144 | 0.847 | 0.378 | 0.649 | 0.354 | 0.243 | 0.101 |
| Guilt-T | | | | | | | | |
| $r_s$ | 0.080 | 0.250 | 0.151 | 0.164 | -0.054 | 0.087 | -0.003 | -0.151 |
| p | 0.449 | 0.016 | 0.151 | 0.118 | 0.610 | 0.409 | 0.978 | 0.150 |
| OBQ-R | | | | | | | | |
| $r_s$ | 0.073 | 0.107 | -0.169 | -0.145 | -0.107 | -0.025 | 0.108 | -0.049 |
| p | 0.489 | 0.309 | 0.107 | 0.167 | 0.312 | 0.814 | 0.308 | 0.643 |

Partialling out the effect of depression measured by the Beck Depression Inventory. *Values are denote statistical significance at the false discovery rate (FDR)-adjusted p<0.1 level using Benjamini-Hochberg procedure. HC, healthy controls; OCD, obsessive-compulsive disorder; NS, negative statement; PS, positive statement; CP, close person; NP, neutral person; TAFS-T, Thought-Action Fusion Scale-Total; Guilt-T, Guilt Inventory-Trait; OBQ-R, Obsessive Beliefs Questionnaire-Responsibility

with trait guilt ($r_s$=0.25, p=0.016). In contrast, EI showed no correlation.

### Relationships between RT and EI and OC symptom dimensions

The HCs showed that RT in the NS/NP and PS/CP conditions was correlated with the symmetry/ordering dimension ($r_s$=0.40, p=0.007 for NS/NP; $r_s$=0.46, p=0.002 for PS/CP). No correlation was observed between the EI in any condition and the four-dimensional scores of the DOCS, except for a significant negative correlation between the EI in the NS/CP condition and contamination dimension (Table 3).

In the OCD patients, RT did not show any significant relationship in any condition. However, RT in the NS/CP and NS/NP conditions showed trends toward positive relationships with the same two symptom dimensions of responsibility for harm and unacceptable thoughts. In contrast, EI in the NS/NP condition showed a significant negative correlation with the symmetry dimension ($r_s$=-0.34, p=0.001 for NS/NP) (Table 3).

Overall, the OC symptoms tended to have a positive correlation with RT and a negative correlation with EI in both the groups.

### Comparison of RT and EI between medicated and non-medicated OCD patients

No significant differences were observed in the RT or EI in any conditions between the medicated (n=54) and non-medicated (n=39) patients (Supplementary Table 3 in the online-only Data Supplement). The only exception was that the EI in the medicated patients was significantly higher than that in the non-medicated patients in the PS/NP condition (1.8±0.8 vs. 1.5±0.6, t=2.4, p=0.016).

## DISCUSSION

The OCD patients demonstrated longer RT in all three conditions, except the PS/NP condition, and lower EI in the NS/NP condition than did the HCs. In each group, HCs showed a significant relationship between RT in both NS conditions and the total TAFS score, while the patients did not, although

**Table 3.** Spearman's partial correlation between experimental variables and obsessive-compulsive symptom dimensions

| Symptom dimension | Reaction time | | | | Emotional intensity | | | |
|---|---|---|---|---|---|---|---|---|
| | NS/CP | NS/NP | PS/CP | PS/NP | NS/CP | NS/NP | PS/CP | PS/NP |
| HC (N=45) | | | | | | | | |
| Contamination | | | | | | | | |
| $r_s$ | 0.261 | 0.334 | 0.206 | -0.016 | -0.434* | -0.096 | -0.154 | -0.011 |
| p | 0.087 | 0.027 | 0.180 | 0.920 | 0.003 | 0.536 | 0.320 | 0.942 |
| Responsibility for harm | | | | | | | | |
| $r_s$ | 0.303 | 0.339 | 0.129 | 0.041 | -0.212 | -0.073 | 0.025 | 0.171 |
| p | 0.045 | 0.025 | 0.404 | 0.793 | 0.168 | 0.636 | 0.872 | 0.267 |
| Unacceptable thoughts | | | | | | | | |
| $r_s$ | 0.187 | 0.224 | 0.314 | 0.110 | -0.183 | -0.180 | -0.110 | 0.033 |
| p | 0.223 | 0.145 | 0.038 | 0.477 | 0.235 | 0.243 | 0.478 | 0.830 |
| Symmetry/ordering | | | | | | | | |
| $r_s$ | 0.244 | 0.399* | 0.461* | 0.199 | -0.217 | 0.020 | 0.043 | -0.019 |
| p | 0.110 | 0.007 | 0.002 | 0.194 | 0.156 | 0.898 | 0.782 | 0.900 |
| Total | | | | | | | | |
| $r_s$ | 0.364 | 0.399* | 0.309 | 0.088 | -0.373* | -0.139 | -0.039 | 0.047 |
| p | 0.015 | 0.007 | 0.042 | 0.569 | 0.012 | 0.368 | 0.802 | 0.760 |
| OCD (N=93) | | | | | | | | |
| Contamination | | | | | | | | |
| $r_s$ | -0.136 | -0.184 | 0.099 | -0.093 | 0.005 | -0.136 | 0.054 | -0.086 |
| p | 0.195 | 0.077 | 0.344 | 0.375 | 0.961 | 0.193 | 0.606 | 0.412 |
| Responsibility for harm | | | | | | | | |
| $r_s$ | 0.232 | 0.223 | 0.045 | 0.016 | 0.062 | -0.017 | -0.008 | -0.051 |
| p | 0.025 | 0.031 | 0.667 | 0.883 | 0.555 | 0.875 | 0.939 | 0.626 |
| Unacceptable thoughts | | | | | | | | |
| $r_s$ | 0.240 | 0.230 | -0.026 | -0.028 | -0.048 | -0.098 | 0.019 | -0.052 |
| p | 0.021 | 0.027 | 0.805 | 0.787 | 0.646 | 0.349 | 0.858 | 0.619 |
| Symmetry/ordering | | | | | | | | |
| $r_s$ | 0.092 | 0.076 | 0.106 | 0.029 | -0.039 | -0.344* | -0.035 | -0.279 |
| p | 0.380 | 0.466 | 0.313 | 0.781 | 0.713 | 0.001 | 0.736 | 0.007 |
| Total | | | | | | | | |
| $r_s$ | 0.190 | 0.154 | 0.045 | -0.058 | 0.018 | -0.252 | 0.033 | -0.234 |
| p | 0.068 | 0.139 | 0.669 | 0.581 | 0.862 | 0.015 | 0.751 | 0.024 |

Partialling out the effect of depression measured by the Beck Depression Inventory. *Values are denote statistical significance at the false discovery rate (FDR)-adjusted p<0.1 level using Benjamini-Hochberg procedure. HC, healthy controls; OCD, obsessive-compulsive disorder; NS, negative statement; PS, positive statement; CP, close person; NP, neutral person

they had higher TAFS scores than did HCs. The patients showed a trend towards a correlation between RT in the NS/NP condition and guilt. Among the OC symptom dimensions, only the symmetry/ordering dimension had positive relationships with the RT in HCs, and a negative relationship with the EI in the OCD patients.

## Measurability of two experimental variables

TAF involves multiple complex cognitive components, including imagination, predictive processes, guilt, empathy for social pain, and familiarity or closeness.[6] By adjusting the valence (PS and NS) and personal closeness (CP and NP), we developed four conditions, including the NS/CP condition, which exactly corresponded with the classic TAF experiment.[19] The healthy participants in this study showed slower and emotionally more intense responses to NS than to PS. Under the same statement condition, they responded more quickly and intensely to CPs than to NPs. Moreover, the RT in both the NS/

CP and NS/NP conditions was significantly correlated with the TAFS scores, indicating a higher correlation with the NS/CP condition. It is notable that the correlation coefficients between the RT in the NS/CP condition and TAFS scores were higher ($r_s$=0.60) than those in the original paper[19] which only showed the relationships between the subjective measures of evoked anxiety, estimates of control, and feelings of responsibility and TAFS scores (r ranging from 0.26 to 0.38), with no correction for depression. No correlations between the RTs in both PS conditions and TAFS scores also indicate that the RT in the NS/CP and NS/NP conditions has different aspects of negative TAFS. In the same context, the RT and EI hardly correlated with trait guilt or inflated responsibility in HCs. Taken together, these findings might suggest that the average RT from multiple trials may be a better measure than a global subjective assessment for TAF, which has been used in previous experimental studies.[16,18-21]

## Delayed RT in OCD patients and its clinical relevance

One of the novel findings of the present study was delayed RT in the OCD patients in our modified TAF task. The patients showed a longer RT in the NS/CP and NS/NP conditions as well as in the PS/CP condition. In a previous study, a difference was observed only in the NS/CP condition,[32] whereas in the present study, both the NS/NP and PS/CP conditions showed additional differences. As the number of OCD patients doubled compared with that in the previous study, it suggests that this phenomenon can appear in the PSs as well as the NSs, suggesting that the delayed response in TAF situations may not be limited to negative TAF situations in OCD.

Many complex variables can affect the RT. First, we should consider the factors affecting this result independent of this experiment, such as age, depression, and medication. In this study, RT was not correlated with age in either group but with depression only in HCs, which we statistically controlled for in all analyses. Although medications, such as benzodiazepines and SSRIs, may also affect the results, almost no differences were observed in the RT and EI between the medicated and non-medicated patients in the present study. In fact, three meta-analyses did not confirm that the use of psychotropic drugs influences cognitive performance.[30,31,42]

In terms of the influences of OC symptoms, the patients showed trends toward positive relationships between the RTs in both NS conditions and the two symptom dimensions of responsibility for harm and unacceptable thoughts in this study. These findings are in concordance with those of a previous report indicating that the TAFS scores were exclusively associated with the same two dimensions in the OCD sample.[27] These patients have intrusive thoughts or fears that may cause harm or bad luck to others because our NS include wishes for other people's misfortune. In the context of the present experiment, they may be more reluctant to respond to TAF statements, especially negative ones, than patients without these symptoms or HCs. Considering each individual symptom, several symptoms, such as doubtfulness, the "just right" feeling, and perfectionism, may make OCD patients perform the experiment tediously. For example, the patients may do things slowly, so that they can be excessively aware of what they are doing or attempt to reach certainty by having to always make perfect decisions. Overall, slower RT in a TAF task may be understood in the notion that OCD patients may overuse cognitive strategies at the expense of mental speed or efficiency, especially in the two symptom dimensions.

Another unexpected finding was that the RT in both NS conditions was moderately positively correlated with the TAFS scores in HCs, while no correlations were found in the OCD patients. More importantly, the discrepancy between the two groups suggests that in OCD patients, even if their TAF scores are high, this increase is not adequately reflected in their behavior, such as RT. Thus, it can be assumed that the TAF tendency would rather not primarily but secondarily increase because this reaction system is impaired, suggesting an "inefficiently" high TAF in OCD.

## Inconsistent emotional response in OCD patients

The participants in this study were also asked to repeatedly measure their emotional reactions on a subjective level to record individual experience in response to PSs or NSs (i.e., affective-social stimuli). Our hypothesis that the patients would show higher emotional responses than HCs was only partially supported because the patients generally reported more increased anxiety than did the HCs after this experiment, while lower mean EI scores were recorded for the OCD patients only in the NS/NP condition than for the HCs during the experiment. Specifically, OCD patients may make more of an effort to inhibit their emotional responses to NSs than to PSs. However, this effort may only work for NPs in catastrophic statements, as emotional responses to CPs may exceed the extent of patients' ability to inhibit their emotional responses. From a perspective of diminished emotional experience, previous studies have observed that OCD individuals show less facial expressivity and less appropriate emotional experiences in response to social scenarios eliciting various basic emotions.[43] In contrast, other studies have indicated that OCD patients show increased personal distress (self-oriented feelings of anxiety and distress in interpersonal situations).[44,45] These discrepancies may be explained by the attempt to suppress or resist unpleasant emotions, interference of other social emotions, such as guilt and shame, and experiencing less emotional contagion in OCD patients.[43] More generally, these results

may be because of a range of emotion regulation difficulties, particularly intolerance of internal experiences, lack of emotional clarity, and impulse control difficulties.[46,47] As the participants were not instructed to differentiate between self-directed and other-oriented emotions, further research is needed to understand affective responses related to TAF conditions.

However, EI did not seem to provide as much clinical information as RT. In this study, EI in both NS conditions showed no correlations with TAFS scores in either group. Regarding OC dimensions, EI in the NS/NP and PS/NP conditions was negatively correlated with the symmetry dimension in OCD patients. That is, a potential relationship was observed between the case of feeling less emotional reaction toward others and the OC symptoms, especially symmetry. In addition, as shown in a Supplementary Figure 2 in the online-only Data Supplement, a significant deviation in EI scores can weaken or cause confusion in the correlation results. In the HCs, the EI in the NS/CP condition was negatively correlated with the contamination dimension. Although the dimensions differed between groups, it should be noted that the correlation between EI and OC symptoms was negative direction.

This study has an important implication. To date, RT or processing speed have almost exclusively been studied in the neuropsychological domain of OCD.[30,31] There was relatively little interest in RT in studies on the affective domain and cognitive theory, particularly dysfunctional cognitive appraisals, in terms of OC psychopathology. Therefore, RT validated in this TAF study might be a potential variable in the study of the relationship between neurocognitive impairment and dysfunctional cognitive appraisal in OCD.

This study has several limitations. First, as the meta-analyses revealed that OCD patients showed significant impairment in processing speed, it is possible that this effect also affected the RT examined in this study.[30,31] In future research, to control for this effect, we need to evaluate and compare the response time to that of non-TAF neutral statements. Second, although we provided results indicating no differences in experimental variables between medicated and non-medicated patients in this study, further research on drug-naïve OCD patients is needed. Third, the statement paradigm has its own limitations because it does not directly manipulate thought-event fusion beliefs but rather attempts to induce pre-existing beliefs.[12] Thus, further studies are needed in a different paradigm to experimentally manipulate TAF.[12,48]

In conclusion, the present study revealed that the OCD patients generally responded less quickly and exhibited emotions less intensely than did the HCs in the modified TAF task. Moreover, although the patients showed higher TAFS scores, they did not show any relationship between the RT and TAFS scores, unlike HCs. These findings may indicate our multiple-trial version of the classical TAF showed reliable results of the two new variables, especially RT, in the task and may allow to newly identify paradoxical patterns in which the TAF scores are high but actual performance is impaired, indicating the inefficient activation of TAF in OCD.

## Supplementary Materials

The online-only Data Supplement is available with this article at https://doi.org/10.30773/pi.2022.0262.

## Availability of Data and Material

The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

## Conflicts of Interest

Seung Jae Lee, a contributing editor of the *Psychiatry Investigation*, was not involved in the editorial evaluation or decision to publish this article. All remaining authors have declared no conflicts of interest.

## Author Contributions

Conceptualization: Sang Won Lee, Seung Jae Lee. Formal analysis: Sang Won Lee, Tae Yang Jang, Seung Jae Lee. Funding acquisition: Seung Jae Lee. Investigation: all authors. Methodology: Sang Won Lee, Seungho Kim, Seung Jae Lee. Project administration: Seung Jae Lee. Writing—original draft: all authors. Writing—review & editing: Sang Won Lee, Seungho Kim, Seung Jae Lee.

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**Supplementary Table 1.** Paired t-test between conditions

| Condition | Variable | Mean | SD | Mean difference | t | p |
|---|---|---|---|---|---|---|
| HC (N=45) | | | | | | |
| Same statement, different person | NS/CP_RT (ms) | 1315.5 | 497.6 | -230.0 | -3.4 | 0.001 |
| | NS/NP_RT (ms) | 1545.5 | 577.9 | | | |
| | NS/CP_EI | 3.4 | 1.1 | 0.8 | 4.6 | <0.001 |
| | NS/NP_EI | 2.7 | 0.9 | | | |
| | PS/CP_RT (ms) | 1126.5 | 314.1 | -178.9 | -3.3 | 0.002 |
| | PS/NP_RT (ms) | 1305.4 | 461.4 | | | |
| | PS/CP_EI | 3.8 | 0.3 | 2.0 | 20.3 | <0.001 |
| | PS/NP_EI | 1.9 | 0.7 | | | |
| Same person, different statement | NS/CP_RT (ms) | 1315.5 | 497.6 | 189.0 | 2.2 | 0.035 |
| | PS/CP_RT (ms) | 1126.5 | 314.1 | | | |
| | NS/NP_RT (ms) | 1545.5 | 577.9 | 240.1 | 3.1 | 0.003 |
| | PS/NP_RT (ms) | 1305.4 | 461.4 | | | |
| | NS/CP_EI | 3.4 | 1.1 | -0.4 | -2.3 | 0.026 |
| | PS/CP_EI | 3.8 | 0.3 | | | |
| | NS/NP_EI | 2.7 | 0.9 | 0.8 | 6.5 | <0.001 |
| | PS/NP_EI | 1.9 | 0.7 | | | |
| OCD (N=93) | | | | | | |
| Same statement, different person | NS/CP_RT (ms) | 1635.2 | 558.8 | -130.9 | -2.7 | 0.007 |
| | NS/NP_RT (ms) | 1766.1 | 655.3 | | | |
| | NS/CP_EI | 3.2 | 1.1 | 0.8 | 6.8 | <0.001 |
| | NS/NP_EI | 2.3 | 1.0 | | | |
| | PS/CP_RT (ms) | 1317.4 | 433.6 | -19.1 | -0.4 | 0.657 |
| | PS/NP_RT (ms) | 1336.4 | 504.5 | | | |
| | PS/CP_EI | 3.6 | 0.5 | 1.9 | 19.8 | <0.001 |
| | PS/NP_EI | 1.7 | 0.7 | | | |
| Same person, different statement | NS/CP_RT (ms) | 1635.2 | 558.8 | 317.8 | 5.9 | <0.001 |
| | PS/CP_RT (ms) | 1317.4 | 433.6 | | | |
| | NS/NP_RT (ms) | 1766.1 | 655.3 | 429.7 | 7.2 | <0.001 |
| | PS/NP_RT (ms) | 1336.4 | 504.5 | | | |
| | NS/CP_EI | 3.2 | 1.1 | -0.4 | -3.5 | 0.001 |
| | PS/CP_EI | 3.6 | 0.5 | | | |
| | NS/NP_EI | 2.3 | 1.0 | 0.6 | 6.5 | <0.001 |
| | PS/NP_EI | 1.7 | 0.7 | | | |

SD, standard deviation; HC, healthy controls; OCD, obsessive-compulsive disorder; RT, reaction time; EI, emotional intensity; NS, negative statement; PS, positive statement; CP, close person; NP, neutral person

**Supplementary Table 2.** Normality test of RT and EI in the TAF experiment

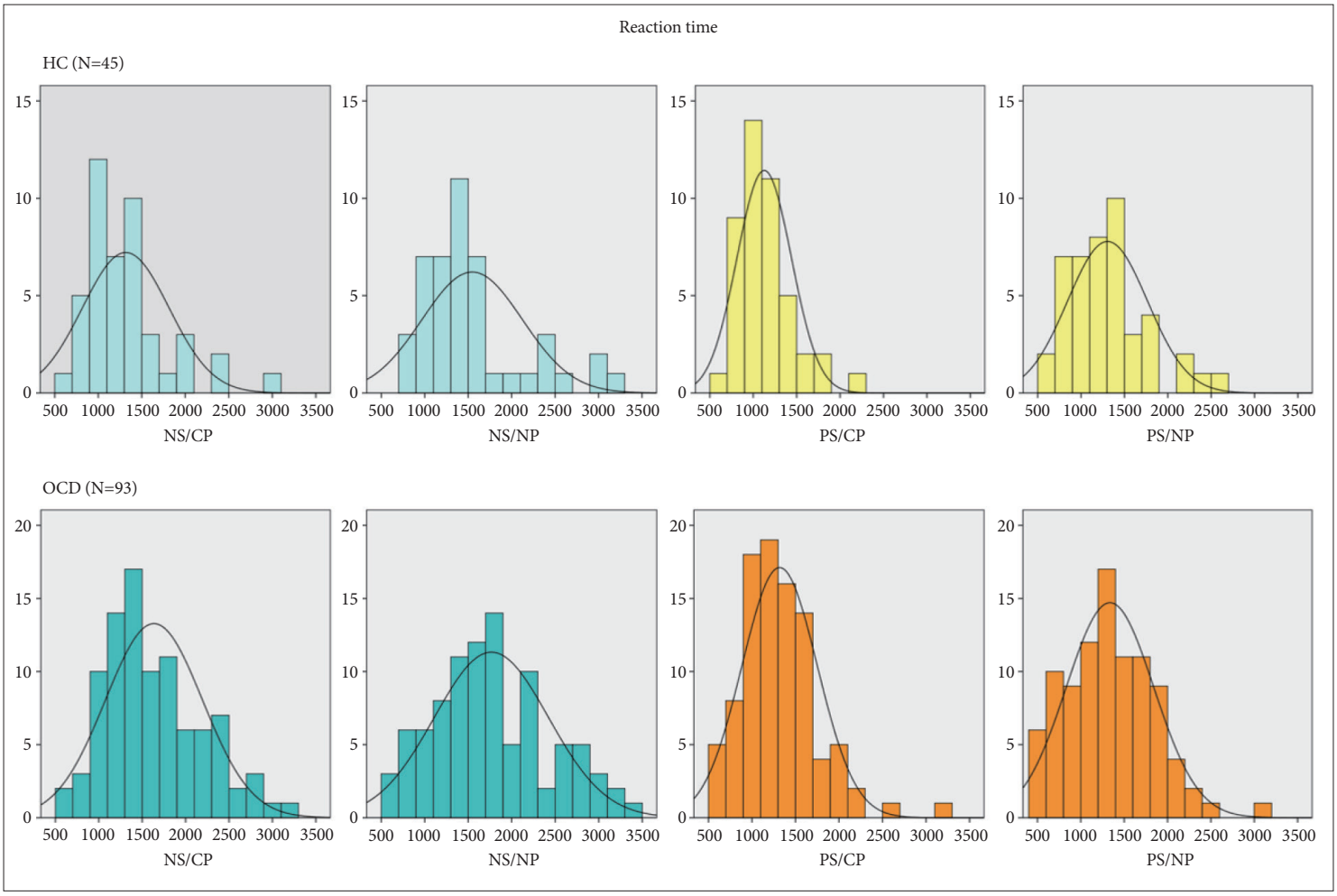
| Condition | Variable | Skewness | Kurtosis | Kolmogorov-Smirnov* | | |
|---|---|---|---|---|---|---|
| | | | | Statistic | df | p |
| HC (N=45) | | | | | | |
| RT | NS/CP | 1.43 | 2.37 | 0.14 | 45 | 0.033 |
| | NS/NP | 1.27 | 1.03 | 0.20 | 45 | <0.001 |
| | PS/CP | 1.28 | 2.30 | 0.12 | 45 | 0.117 |
| | PS/NP | 0.92 | 0.80 | 0.11 | 45 | 0.195 |
| EI | NS/CP | -1.82 | 1.54 | 0.36 | 45 | <0.001 |
| | NS/NP | -0.08 | -1.22 | 0.11 | 45 | 0.196 |
| | PS/CP | -1.89 | 3.58 | 0.25 | 45 | <0.001 |
| | PS/NP | 0.81 | -0.50 | 0.21 | 45 | <0.001 |
| OCD (N=93) | | | | | | |
| RT | NS/CP | 0.62 | -0.16 | 0.11 | 93 | 0.013 |
| | NS/NP | 0.39 | -0.39 | 0.08 | 93 | 0.200 |
| | PS/CP | 1.24 | 3.37 | 0.11 | 93 | 0.009 |
| | PS/NP | 0.45 | 0.15 | 0.05 | 93 | 0.200 |
| EI | NS/CP | -1.13 | -0.37 | 0.25 | 93 | <0.001 |
| | NS/NP | 0.25 | -1.14 | 0.12 | 93 | 0.002 |
| | PS/CP | -1.83 | 3.37 | 0.23 | 93 | <0.001 |
| | PS/NP | 1.25 | 0.92 | 0.18 | 93 | <0.001 |

*lilliefors significance correction. RT, reaction time; EI, emotional intensity; TAF, thought-action fusion; HC, healthy controls; OCD, obsessive-compulsive disorder; NS, negative statement; PS, positive statement; CP, close person; NP, neutral person

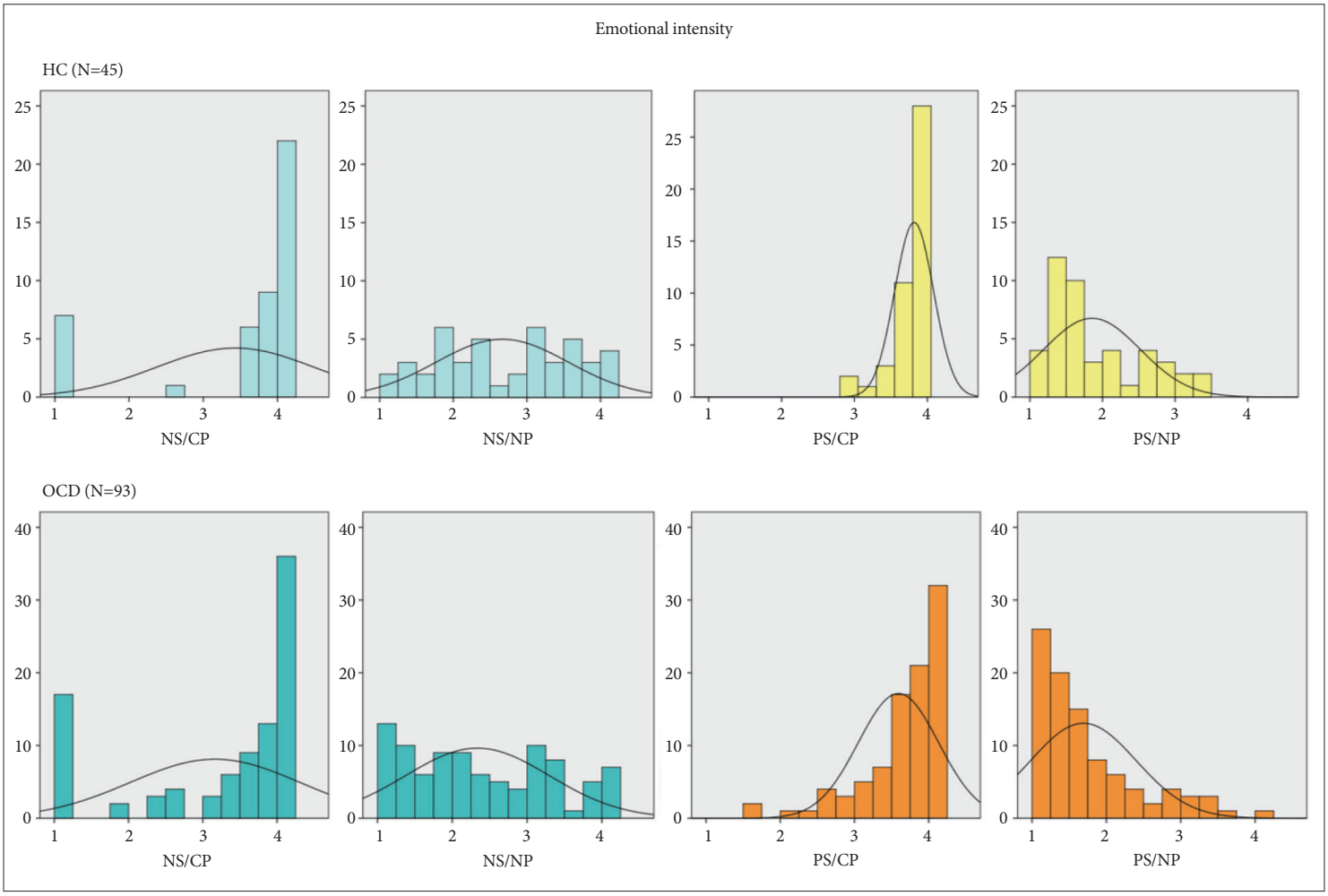
**Supplementary Table 3.** Comparison of RT and EI between medicated and non-medicated patients with OCD

| Condition variable | Medicated (N=54) | | Non-medicated (N=39) | | t | p |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | |
| NS/CP_RT (ms) | 1610.3 | 566.7 | 1669.7 | 553.2 | -0.5 | 0.616 |
| NS/NP_RT (ms) | 1703.1 | 659.0 | 1853.4 | 648.3 | -1.1 | 0.277 |
| NS/CP_EI | 3.3 | 1.0 | 3.0 | 1.3 | 0.8 | 0.416 |
| NS/NP_EI | 2.4 | 1.0 | 2.3 | 0.9 | 0.2 | 0.831 |
| PS/CP_RT (ms) | 1267.5 | 377.6 | 1386.5 | 497.9 | -1.3 | 0.193 |
| PS/NP_RT (ms) | 1290.2 | 472.6 | 1400.4 | 545.3 | -1.0 | 0.301 |
| PS/CP_EI | 3.5 | 0.6 | 3.7 | 0.4 | -1.6 | 0.118 |
| PS/NP_EI | 1.8 | 0.8 | 1.5 | 0.6 | 2.5 | 0.016 |

RT, reaction time; EI, emotional intensity; OCD, obsessive-compulsive disorder; NS, negative statement; PS, positive statement; CP, close person; NP, neutral person; SD, standard deviation




**Supplementary Figure 1.** Distribution of reaction time in a multiple trial version of thought-action fusion experiment. X-axis represents reaction time (ms) while y-axis represents frequency. HC, healthy controls; OCD, obsessive-compulsive disorder; NS, negative statement; PS, positive statement; CP, close person; NP, neutral person.




**Supplementary Figure 2.** Distribution of emotional intensity in a multiple trial version of thought-action fusion experiment. X-axis represents emotional intensity on a Likert scale from 1 (very little) to 4 (very much) while y-axis represents frequency. HC, healthy controls; OCD, obsessive-compulsive disorder; NS, negative statement; PS, positive statement; CP, close person; NP, neutral person.