Depression, Rumination, and Impulsive Action: A Latent Variable Approach to Behavioral Impulsivity

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ABSTRACT
Previous research on the relationship between rumination and behavioral impulsivity has been limited because impulsivity was assessed by using individual tasks. This study examined the concurrent associations of a latent variable named impulsive action with rumination and depression to alleviate the task-impurity problem and the low reliability of laboratory tasks assessing impulsivity. This study also examined whether stressors mediated the association between impulsive action and rumination. University students in Japan (N = 176) conducted three laboratory tasks assessing impulsive action: the Go/No-Go Task, the Stop Signal Task, and the Conners Continuous Performance Test 3rd Edition. They also completed self-report measures of rumination, stressors, and depression. Results indicated that the latent variable named impulsive action constructed from the performance in these three tasks was positively associated with rumination. Moreover, stressors mediated this association. Also, impulsive action was positively associated with depression via the increase in stressors and rumination. These findings and those of previous studies examining associations between rumination and self-reported impulsivity suggest that impulsivity might be a determinant of rumination.

Rumination and impulsivity are two major psychological correlates and vulnerability factors for depression (for reviews, Berg et al., 2015; Nolen-Hoeksema et al., 2008; Saddichha & Schuetz, 2014; Wright et al., 2014). From theoretical and practical perspectives, it is crucial to determine if rumination and impulsivity are related to each other or whether they intensify depression independently. However, the relationship between rumination and impulsivity has only recently been investigated, and little is known about this relationship. Therefore, this study examined this association by using a new methodology to overcome the limitations of previous studies.

Rumination is defined as “behaviors and thoughts that focus one’s attention on one's depressive symptoms and on the implications of these symptoms” (Nolen-Hoeksema, 1991, p. 569), which is conceptualized as a form of repetitive negative thinking (Ehring & Watkins, 2008). Numerous studies have shown that trait rumination assessed by the total score on the Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 2008).
predicts more severe depression (Butler & Nolen-Hoeksema, 1994; Nolan et al., 1998; Nolen-Hoeksema & Morrow, 1991) and the onset of major depressive episodes (Nolen-Hoeksema, 2000; Nolen-Hoeksema et al., 2007; Spasojević & Alloy, 2001). Also, the induction of rumination in dysphoric and depressed individuals amplifies their depressive mood (Donaldson & Lam, 2004; Nolen-Hoeksema & Morrow, 1993). Induced rumination also leads to deleterious consequences such as ineffective problem solving (Donaldson & Lam, 2004; Lyubomirsky et al., 1999; Lyubomirsky & Nolen-Hoeksema, 1995), negative interpretations about the self, one's situation, and future events (Lavender & Watkins, 2004; Lyubomirsky et al., 1999; Lyubomirsky & Nolen-Hoeksema, 1995), and frequent retrieval of negative autobiographical memories and increased memory-related distress (Lyubomirsky et al., 1998; Williams & Moulds, 2010). These findings suggest that rumination is a vulnerability factor for depressive disorders and a core cognitive process maintaining depression.

Subsequent factor analysis of the RRS showed that rumination consists of two subcomponents: Brooding, which is “a passive comparison of one's current situation with some unachieved standard,” and reflection, which is “a purposeful turning inward to engage in cognitive problem solving to alleviate one's depressive symptoms” (Treynor et al., 2003, p. 256). Brooding is associated with increased depression after 6–12 months, whereas reflection is associated with less depression or has no association with depression (Pearson et al., 2010; Schoofs et al., 2010; Treynor et al., 2003; but see Hasegawa et al., 2015 for negative findings on predictions regarding the effects of brooding on depression). Inspecting items in the brooding and reflection subscales of the RRS suggests that brooding has more negative valence than reflection, and differences in the valence of thoughts explains the relationships between the two RRS subscales and depression.

Impulsivity is assumed to consist of heterogeneous clusters categorized as self-reported impulsivity, assessed by self-report measures, and behavioral impulsivity, assessed by laboratory tasks. Lynam and his colleagues proposed the widely used dimensions of self-reported impulsivity (Cyders et al., 2007; Whiteside & Lynam, 2001), which includes negative urgency, lack of premeditation, lack of perseverance, sensation seeking, and positive urgency. On the other hand, many researchers have suggested that behavioral impulsivity could be classified as impulsive action, which represents the inability to inhibit a prepotent response, and impulsive choice, which represents the preference for smaller immediate rewards over larger, delayed rewards (Grant & Chamberlain, 2014; Wang et al., 2016; Weafer & de Wit, 2014).

Previous studies have shown that rumination is associated with specific dimensions of self-reported impulsivity. It has been consistently demonstrated that rumination and its brooding subcomponent have concurrent positive associations with negative urgency, which is the tendency to act rashly when experiencing negative affect. In contrast, the association between reflection and negative urgency has been nonsignificant or weaker than the association with brooding (Hasegawa et al., 2018; Valderrama & Miranda, 2017; Valderrama et al., 2016; Wang & Borders, 2018). In addition, rumination is positively associated with positive urgency, which is the tendency to act rashly when experiencing positive affect (Hasegawa et al., 2018). Hasegawa et al. (2018) demonstrated that negative and positive urgency predicts the increase in rumination assessed
four weeks later, even after controlling for baseline rumination and depression, and that rumination predicts the increase in negative urgency. Similarly, higher hyperactivity-impulsivity symptoms in ADHD have been positively related to rumination directly and indirectly via interpersonal conflicts (Horibe & Hasegawa, 2020). These findings suggest that urgency, which represents the dimension of impaired response inhibition among the dimensions of self-reported impulsivity, is primarily associated with increased rumination.

The literature also suggests that rumination is positively related to behavioral impulsivity when an emotional stimulus is used in the task (e.g. affective Go/No-Go Task (GNG) in Hilt et al., 2014). However, rumination was not related to behavioral impulsivity when using the impulsivity task with non-emotional stimuli, which is the better strategy for avoiding confounding by altered emotional processing (Snyder et al., 2015). For example, Aker et al. (2014) showed that the performance in the Stop Signal Task (SST) using a neutral stimulus was not associated with brooding or reflection sub-components of rumination. The SST is a task that represents impulsive action (MacKillop et al., 2016), and conceptually, impulsive action and urgency are assumed to assess the same facet of impulsivity (Cyders & Coskunpinar, 2011; Dick et al., 2010). However, previous studies have shown that self-reported impulsivity and behavioral impulsivity have inconsistent relationships with rumination.¹

Research on the relationship between rumination and behavioral impulsivity has been limited because behavioral impulsivity has been assessed using individual tasks. It has been suggested that the latent variable approach is appropriate for executive function studies (Friedman & Miyake, 2017; Miyake & Friedman, 2012; Miyake et al., 2000) because commonly used executive function tasks are complex and typically place heavy demands on executive and non-executive processes within which the executive processing requirements are embedded. This task-impurity problem, and the low reliability of executive function tasks can be alleviated if researchers construct a latent variable from multiple tasks assumed to assess the same executive function and statistically extract commonalities across these tasks. Therefore, a latent variable approach was used to examine the associations between the uncontaminated executive function processes and other variables of interest, including psychopathological symptoms (Snyder et al., 2015).

The task-impurity problem might be observed in impulsivity studies because laboratory tasks assessing behavioral impulsivity such as the GNG and the SST are also categorized as tasks assessing the executive function (Snyder et al., 2015). Also, specific laboratory tasks assessing behavioral impulsivity, such as the SST, have low test-retest reliability (Enkavi et al., 2019; Hedge et al., 2018; Weafer et al., 2013; Wöstmann et al., 2013). These methodological limitations could make it challenging to identify associations between behavioral impulsivity and rumination. Recently, MacKillop et al. (2016) conducted a confirmatory factor analysis (CFA) and extracted a latent variable named impulsive action from the performances in the GNG, the SST, and the Conners Continuous Performance Test (CCPT). Adopting this latent variable might enable us to make a purer assessment of impulsive action that could identify the association between impulsive action and rumination.

The lack of a clear explanation about the association between rumination and impulsivity is another limitation of previous studies. Stress generation might be a
possible pathway of the relationship between these two variables. The stress generation hypothesis assumes that individuals with maladaptive characteristics related to depression as well as depression itself tend to generate stressful events (Hammen, 1991). Based on this hypothesis, previous studies have demonstrated that childhood maltreatment, negative inferential styles, and excessive reassurance-seeking are associated with increased stressors (Liu & Alloy, 2010, for review). Other studies have demonstrated that self-reported impulsivity, including negative urgency, is prospectively associated with increased stressors (Liu & Kleiman, 2012; Molz et al., 2013). These studies suggest that the stress generation hypothesis might apply to impulsivity.

Previous studies did not examine whether impulsive action is a factor increasing stressors; however, specific evidence supports this possibility. It has been indicated that impulsive action assessed by GNG performance is associated with increased aggressive behaviors (Qiao et al., 2016; Raaijmakers et al., 2008). Individuals with inadequate performance in tasks assessing impulsive action, including the GNG and the SST, also tend to suffer from substance abuse, alcohol dependence, and pathological gambling (Lee et al., 2019, for review). These behavioral problems could lead to an increase in interpersonal conflicts and functional impairments at school or work.

Moreover, according to the goal progress theory of rumination (Martin et al., 2004), stressors can prevent a person from attaining goals, which leads to rumination about goals that are yet to be attained. Consistent with this theory, previous studies have demonstrated that frequent exposure to stressors is prospectively associated with increased rumination (Hamilton et al., 2015; Michl et al., 2013). Therefore, stressors generated by impulsive action might prolong rumination.

This study’s primary purpose was to examine the concurrent association between the latent variable of impulsive action and trait rumination and investigate whether stressors mediate this association. The current study had a cross-sectional design, which did not examine causal relationships between the study variables. However, structural equation modeling based on the stress generation hypothesis (Hammen, 1991; Liu & Alloy, 2010) and the goal progress theory of rumination (Martin et al., 2004) was conducted to examine the hypothesis that impulsive action assumed to be an exogenous variable has an indirect positive association with rumination via stressors. We also hypothesized that the relationship between impulsive action and rumination weakened after controlling for the influence of stressors. Furthermore, we examined whether impulsive action, stressors, or rumination intensified depression after controlling for the influences of other variables because all these variables are known to be associated with increased depression (for reviews, Hammen, 2005; Monroe et al., 2014; Nolen-Hoeksema et al., 2008; Wright et al., 2014). Finally, we examined a model that replaced rumination in general with the brooding and reflection sub-components of rumination.

**Method**

**Participants**

Undergraduate and graduate students aged 18 to 30 years were recruited from Kyoto Gakuen University, Senshu University, Tokai Gakuin University, and the University of
Tsukuba. We recruited students of the same age range as in the study by MacKillop et al. (2016) to avoid any age effects. Participants in this study were 176 students (89 men and 87 women; Mean age = 20.38, SD=1.88; age ranged from 18 to 28 years). All the participants were Japanese, except five participants (one American, one Australian, one Chinese, one Korean, and one Japanese and Taiwanese dual nationals).  

**Self-Report Measures**

*Beck Depression Inventory-Second Edition* (BDI-II; Beck et al., 1996). The BDI-II is a well-validated, 21-item self-report questionnaire assessing the severity of depressive symptoms experienced in the past two weeks. Participants respond using a 0–3 scale, with higher scores indicating greater severity of depression. The Japanese translation of the BDI-II by Kojima and Furukawa (2003) was used in this study. The BDI-II showed good internal consistency (α = .89) in our sample.

*Ruminative Responses Scale* (RRS; Nolen-Hoeksema & Morrow, 1991). The RRS includes 22 items, each rated on a 4-point rating scale anchored between 1 (almost never) and 4 (almost always). Five items in the RRS assess brooding (e.g. “Think ‘Why do I have problems other people don’t have?’”), five items assess reflection (e.g. “Analyze recent events to try to understand why you are depressed”), and 12 depression-related items (e.g. “Think about how sad you feel”). We calculated the brooding and reflection subscale scores and the total RRS score. Adequate psychometric properties of the RRS, including good internal consistency and construct validity, and the moderate test-retest reliability of the total and subscale scores have been reported (Schoofs et al., 2010; Treynor et al., 2003). The Japanese translation of the RRS by Hasegawa (2013) was used in this study. Good internal consistencies of the overall RRS (α = .92) and the brooding (α = .80) and reflection (α = .73) subscales were obtained in our sample.

*Scale of Life Events in Interpersonal and Achievement Domains* (Takahira, 1998). This scale assesses positive and negative events in interpersonal and achievement domains that students might possibly experience in their daily life. The subscales assessing negative interpersonal events and negative achievement events, each consisting of 15 items, were used in this study. The negative interpersonal events subscale includes items such as “I quarreled with a family member, friend, or romantic partner” and “I was criticized or teased by friends or associates.” Also, the negative achievement events subscale includes items such as “I got bad grades in my exams or reports” and “there were many tasks such as reports that should be come to grips with.” In the original scale, participants responded whether they had experienced such events during the last three months on a 2-point scale (i.e. yes or no). However, some participants might have frequently encountered an event, whereas others did so rarely. Therefore, we asked participants to indicate how often they encountered each event on a 4-point scale anchored between 1 (not at all) and 4 (often) to increase each subscale variance. Negative interpersonal events and negative achievement events subscale scores and total negative events score were calculated. Good internal consistencies were obtained for negative interpersonal events (α = .79), negative achievement events (α = .80) subscales, and the total negative events score (α = .86) in our sample.
Behavioral Measures

Go/No-Go Task (GNG). We used a GNG based on the procedure adopted by Gutiérrez-Cobo et al. (2017). This task was composed of go trials in which a green circle with a diameter of approximately 5 cm appears and no-go trials in which a red circle of the same size appears in the center of a black screen. The stimuli appeared for 500 ms, with 1000 ms between trials, during which the participants could respond. The GNG began with the presentation of a fixation cross for 1000 ms, followed by a blank screen that was presented for 2000 ms. Then, the go and the no-go trials were presented in random order. The participants were instructed to respond by pressing the “b” key in go trials and refrain from pressing any key in no-go trials. The participants completed a practice phase composed of 10 trials with an equal number of go and no-go trials to familiarize themselves with the task before the trial phase. After confirming that participants understood the task, one block of 120 trials was conducted, 70% of which were go trials, and 30% were no-go trials. We used the erroneous response rate in no-go trials (i.e. the commission error rate) as an indicator of impulsive action.

Stop Signal Task (SST). We used the SST based on the procedure described by Verbruggen et al. (2008), which is provided in the Millisecond Test Library (Millisecond Software, LLC.) with the minor modification that all the instructions were written in Japanese. The task included one practice block with 32 trials and three test blocks with 64 trials per block. There was a 10-second interval between blocks when participants were given feedback on their performance regarding the percentage of correct responses and the mean reaction time on the previous block. This feedback was designed to encourage the participants to maintain speed and accuracy when responding throughout the task.

A trial started with presenting a fixation circle for 250 ms, followed by an arrow pointing to the right or left within the circle, presented in white on the center of a black screen. Participants were instructed to respond as quickly as possible by pressing the “d” key when presented with a left arrow and the “k” key when presented with a right arrow (go trial). However, an auditory beep was sounded in 25% of the trials to indicate that the response should be withheld on that particular trial (stop trial). The difficulty of stop trials was continuously adjusted by a tracking procedure that varied the stop signal delay (SSD; the latency between the go stimulus onset and the stop stimulus onset). The SSD increased by 50 ms in the subsequent stop trial if participants inhibited a response, whereas the SSD decreased by 50 ms if they failed to inhibit responses in stop trials. The SSD in the practice block was initially set to 250 ms and was carried over to the next block. The SSD ranged from 50 ms to 1150 ms and did not exceed this range.

We used the stop-signal reaction time (SSRT) as an indicator of impulsive action. The SSRT is a timed estimate of the effectiveness with which a participant can inhibit an initiated motor response (Logan et al., 1984). The SSRT was calculated according to the block-based integration method described by Verbruggen et al. (2013), in which SSRT is estimated by subtracting the mean SSD from the percentile of the go reaction time distribution that corresponds to the participant’s proportion of failed stops. If a participant fails to stop on 60% of the stop trials, the mean SSD is subtracted from
the reaction time at the 60th percentile of that participant’s reaction time distribution for correct go trials. This assumes that the finishing time of the stop process corresponds to the reaction time at this point (Logan et al., 1984; Verbruggen et al., 2013). The integration SSRT was calculated for each of the three test blocks, and the mean SSRTs were used as each participant’s SSRT. We assumed that longer SSRT indicated greater impulsive action.

Conners Continuous Performance Test 3rd Edition (CCPT). This task was developed by Conners (2014). In this task, 16 uppercase alphabetical letters are displayed successively in black on the center of a white screen for 250 ms, such that the inter-stimulus interval changes between 1, 2, or 4s every 20 trials. Participants were instructed to press the space bar as fast as possible when a letter other than an “X” was displayed (go trials) but to inhibit that response when an “X” was shown (no-go trials). The test phase composed of 361 trials was administered after a brief practice phase, such that 80% of the test trials were go trials and the others were no-go trials. The first trial was not scored, and we used the commission error rate in the rest of the trials as an indicator of impulsive action.

Although the CCPT’s format is similar to the GNG, there are specific differences between the two tasks, such that letters of the alphabet are used in the CCPT, whereas colored circles are presented in the GNG. Also, the types of go stimuli (15 stimuli in the CCPT versus only one in the GNG) and the fluctuation length of the inter-stimulus intervals (1, 2, or 4s in the CCPT versus 1s in the GNG) are different between the two tasks.

Procedure

Students that were interested in this study were individually invited to the authors’ laboratory. First, participants gave their informed consent for participating in the study. Then, participants completed the GNG, the SST, and the CCPT in a fixed order. Three tasks were administered on a computer screen using 1366 × 768 pixels. The GNG and the SST were administered via Inquisit 5 (Millisecond Software, LLC.), and the CCPT was administered using special software for conducting this task (Multi-Health Systems Inc.). Participants could take a short break between tasks and between the SST blocks. After completing the three tasks, the participants responded to a packet of questionnaires, including those described above. The participants were debriefed and were given a gift certificate worth 1500 yen (approximately 13 US dollars) after completing the study. The study took approximately 60 min for each participant to complete. The Ethics Committee of Tokai Gakuin University approved this study.

Statistical Analysis

Statistical analyses were conducted on raw data and allowed for missing data. Descriptive statistics were conducted using SPSS ver. 23 (IBM Corporation), and all other analyses were conducted using Mplus 8.1 (Muthén & Muthén, 1998–2017). CFA was conducted to examine whether a single latent variable could be constructed from the three laboratory task performances assumed to assess impulsive action (the GNG, the SST, and
the CCPT). Also, structural equation modeling (SEM) was conducted to examine the
correlations between the latent variable and other variables and the assumed model.
Missing data in conducting CFA, correlation analysis, and SEM were handled with the
Full Information Maximum Likelihood (FIML) method. The bootstrapped standard
errors were computed using 10,000 bootstrap re-samples to determine the significance
of each standardized partial coefficient and indirect effects in the path analysis.

Results

Observations of participants conducting the SST and the SST data indicated that spe-
cific participants deliberately delayed pressing keys in every trial so as not to make
errors in stop trials. It is inappropriate to assess impulsive action using the SST when
participants intentionally delay pressing a key (Leotti & Wager, 2010). Therefore, data
of 19 participants were excluded because their go trial reaction times in the SST
exceeded 700 ms. Also, the CCPT data of four participants were excluded: one partic-
ipant because the experimenter failed to save the data, one participant because of a
computer problem during the CCPT, one participant because of an outlier in go trials
error rate (38.54%, whereas the mean error rate was less than 1%), and one participant
because of sleeping during the CCPT. No participants had their data excluded from
more than one task.

Table 1 displays descriptive statistics of each measure. Because the distribution of
the commission error rate in the GNG was highly skewed, square root transformation
was applied to the GNG data. The distribution of the GNG performance was normally
distributed after the transformation (Skewness = 0.68, Kurtosis = −0.58), and therefore,
the transformed data were used in all the analyses described below. The correlations
between each measure are shown in Table 2.

CFA with FIML was conducted to examine a model that assumed a single latent
variable constructed from the performances of the three laboratory tasks that assessed
impulsivity. There was no test of the overall model fit because the model was just
identified (zero degrees of freedom). Factor loadings of the GNG, the SST, and the
CCPT were .41, .34, and .83, respectively, and all loadings were significant (all \( p < .005 \)).
Although factor loading of the SST was relatively low, the previous studies using the
latent variable approach did not exclude task performances with similar factor loadings
from the manifest variables constructing the latent variable (e.g. Engelhardt et al., 2015;

Table 1. Descriptive Statistics of Each Measure.

| Measure                           | n  | M     | SD    | Range      | Skewness | Kurtosis |
|-----------------------------------|----|-------|-------|------------|----------|----------|
| BDI-II                            | 176| 14.03 | 8.95  | 0.00–43.00| 0.88     | 0.28     |
| Brooding                          | 176| 12.01 | 4.05  | 5.00–20.00| 0.15     | −0.98    |
| Reflection                        | 176| 9.36  | 3.42  | 5.00–19.00| 0.67     | −0.15    |
| RR total                          | 176| 46.66 | 13.49 | 22.00–80.00| 0.27     | −0.73    |
| Negative interpersonal events     | 176| 28.28 | 7.37  | 15.00–51.00| 0.62     | −0.02    |
| Negative achievement events       | 176| 31.24 | 7.42  | 16.00–53.00| 0.41     | −0.05    |
| Total negative events             | 176| 59.52 | 12.77 | 34.00–90.00| 0.26     | −0.50    |
| GNG                               | 176| 2.76  | 4.09  | 0.00–25.00| 2.23     | 6.51     |
| SST                               | 157| 229.17| 36.14 | 146.08–337.21| 0.24     | −0.13    |
| CCPT                              | 172| 30.54 | 15.93 | 2.78–84.72| 0.64     | 0.03     |

Note: BDI-II = Beck Depression Inventory-Second Edition; RRS = Ruminative Responses Scale; GNG = Go/No-Go Task;
SST = Stop Signal Task; CCPT = Conners Continuous Performance Test 3rd Edition.
Table 2. Correlation between Each Variable.

|       | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1. BDI-II |       |       |       |       |       |       |       |       |       |
| 2. Brooding |       | .51*** |       |       |       |       |       |       |       |
|        |       | [.40, .62] |       |       |       |       |       |       |       |
| 3. Reflection |       | .19*  | .50*** |       |       |       |       |       |       |
|        |       | [.04, .33] | [.39, .61] |       |       |       |       |       |       |
| 4. RRS total |       |       | .87*** | .76*** |       |       |       |       |       |
|        |       | [.39, .61] | [.84, .91] | [.69, .82] |       |       |       |       |       |
| 5. Negative interpersonal events | .39*** | .32*** | .16*  | .31*** |       |       |       |       |       |
|        | [.27, .52] | [.20, .46] | [.01, .30] | [.17, .44] |       |       |       |       |       |
| 6. Negative achievement events |       | .38*** |       | .33*** | .49*** |       |       |       |       |
|        |       | [.26, .51] | [.19, .46] | [.05, .24] | [.20, .46] | [.38, .60] |       |       |       |
| 7. Total negative events | .45*** | .38*** | .15*  | .37*** | .86*** | .86*** |       |       |       |
|        | [.33, .57] | [.25, .51] | [.00, .29] | [.24, .50] | [.82, .90] | [.83, .90] |       |       |       |
| 8. GNG | .10   | .19** | .23** | .22** | .13   | .01   |       | .09   |       |
|        | [.04, .25] | [.05, .33] | [.09, .37] | [.08, .36] | [-.01, .28] | [-.13, .16] | [-.06, .23] |       |       |
| 9. SST | .05   | .06   | .02   | .03   | .07   | .03   | .06   | .14   |       |
|        | [-.11, .21] | [-.21, .10] | [-.18, .13] | [-.18, .12] | [-.09, .24] | [-.13, 19] | [-.10, .22] | [-.02, .29] |       |
| 10. CCPT | .10   | .14   | .10   | .16*  | .11   | .19** | .18   | .34*** | .28*** |
|        | [.05, .25] | [.00, .29] | [.05, .24] | [.02, .31] | [.04, .26] | [.05, .34] | [.03, .32] | [.21, .47] | [.13, .43] |
| 11. Impulsive action | .14   | .19   | .22   | .24*  | .18*  | .18   | .20*  |       |       |
|        | [.05, .34] | [.01, .40] | [.03, .46] | [.03, .46] | [.02, .35] | [.02, .38] | [.02, .39] |       |       |

Note: Numbers in parentheses indicate 95% confidence intervals. BDI-II = Beck Depression Inventory—Second Edition; RRS = Ruminative Responses Scale; GNG = Go/No-Go Task; SST = Stop Signal Task; CCPT = Conners Continuous Performance Test 3rd Edition. * p < .05, ** p < .01, *** p < .001.
Miyake et al., 2000; Tiego et al., 2018). Also, the latent variables deriving from the performance in the same three tasks were used by MacKillop et al. (2016). Therefore, we used this latent variable, named “impulsive action,” in the following analyses.4

As shown in Table 2, impulsive action had significant positive correlations with total RRS score, negative interpersonal events, and total negative events scores, but not with other variables, including the BDI-II score. The magnitude of impulsive action’s correlations with other variables was similar or slightly higher than that of each single task performance of impulsivity. SEM using the FIML method was conducted to examine if impulsive action was related to rumination assessed by the total RRS score directly or indirectly via stressors. SEM also examined the above variables to identify those that increased depression assessed by the BDI-II score. Total negative events were used as an indicator of stressors because the correlation between negative interpersonal events and negative achievement events was relatively strong, and correlations between these and other variables were similar (See Table 2). Results indicated that the model had an excellent fit for the data: $\chi^2 (6) = 7.31, p = .30; \text{CFI} = .99; \text{RMSEA} = .04$. As shown in Figure 1, impulsive action was positively associated with stressors, and stressors were positively associated with rumination. In addition, stressors and rumination were positively related to depression. In contrast, impulsive action had no significant direct association with rumination or depression.

A bias-corrected bootstrap test was conducted to determine the significance of indirect effects, which indicated that impulsive action had an indirect positive association with rumination via stressors ($\beta = .07, 95\% \text{ CI: [.01, .18]}$). In addition, there was a significant indirect association from impulsive action to stressors to depression ($\beta = .07, 95\% \text{ CI: [.01, .15]}$), and a significant indirect association from impulsive action to stressors to rumination to depression ($\beta = .03, 95\% \text{ CI: [.00, .08]}$).

We also examined a model without the paths from impulsive action to rumination and depression, which showed excellent fit indices: $\chi^2 (8) = 10.01, p = .27; \text{CFI} = .99$.

**Figure 1.** Path model examining the assumed model. All values except $R^2$ are standardized regression coefficients. The error variables were omitted. *$p < .05$, **$p < .01$, ***$p < .001$. 
RMSEA = .04. Moreover, the fit indices of this model and those of the model with these paths did not differ significantly (Δχ^2 (2) = 2.70, p = .26). These results indicated that direct relationships of impulsive action with rumination and depression were negligible.\textsuperscript{5,6}

Next, we examined the model using the brooding subscale score instead of the RRS total scale, but with other variables and paths being identically to the model in Figure 1. This model had an excellent fit for the data: χ^2 (6) = 7.87, p = .25; CFI = .99; RMSEA = .04. Consistent with the analysis using the RRS total scale, impulsive action was positively associated with stressors (β = .21, p = .05), and stressors were positively associated with brooding (β = .36, p < .001), but impulsive action did not have a significant direct association with brooding (β = .11, p = .35). Stressors and brooding were positively associated with depression (β = .30, .39, p < .001), whereas impulsive action did not (β = .00, p = .98). A bias-corrected bootstrap test showed that impulsive action had a positive indirect association with brooding via stressors (β = .08, 95% CI: [.01, .18]), and that the indirect association from impulsive action to stressors to brooding to depression was also significant (β = .03, 95% CI: [.01, .08]). Each variable explained 4.5% of the variances of stressors, 15.5% of brooding, and 33.3% of depression.

We repeated the analysis using the reflection subscale instead of the RRS total scale. This model had an excellent fit for the data: χ^2 (6) = 7.69, p = .27; CFI = .98; RMSEA = .04. The results indicated that neither impulsive action nor stressors were significantly related to reflection (β = .17, 11, p > .19), and reflection was not significantly associated with depression (β = .12, p = .10). A bias-corrected bootstrap test showed that impulsive action did not have an indirect association with reflection via stressors (β = .02, 95% CI: [-.00, .10]). Each variable explained 4.9% of the variances for stressors, 4.7% for reflection, and 21.6% for depression.

**Discussion**

This study investigated whether the latent variable of impulsive action was related to rumination directly and indirectly via stressors and the relationships between these variables and depressive symptoms. We constructed a latent variable from the performances in the GNG, the SST, and the CCPT following the procedure described by MacKillop et al. (2016). The latent variable named impulsive action had significant positive correlations with stressors and rumination but not with depression. The magnitude of the latent variable’s correlations with the other variables was not very different from that of the single-task performance in the GNG and the CCPT. However, the SST performance was not significantly correlated with any of the variables assessed by self-report measures, which was consistent with Aker et al. (2014) that showed no association between the SST performance and trait rumination.

The nonsignificant negative correlation between SST performance and rumination that is in contrast to the significant correlations between the two go/no-go type tasks and rumination, might have resulted from the effect of participants’ strategically slowing their SST responses on SSRT, which is an indicator of impulsive action. Leotti and Wager (2010) showed that the more the participants delayed a keypress, the shorter was their SSRT. The influence of participants’ strategic slowdown on their SSRT might
have prevented us from detecting pure impulsive action (i.e. task-impurity), even though we excluded data of participants with extremely prolonged reaction times in go trials. The GNG and the CCPT, on the other hand, were simple tasks in which participants were instructed to respond in go trials and to withhold responses in no-go trials. Participants could understand whether each trial was a go trial or a no-go trial immediately after the stimulus was presented in these tasks. Therefore, they might have been less likely to intentionally slow their responses in the GNG and the CCPT compared to the SST. These task-impurity differences between the tasks might have caused the differences in correlations between each task with rumination and stressors.

It has been suggested that the task-impurity problem could be improved using the latent variable approach (Friedman & Miyake, 2017; Miyake & Friedman, 2012; Snyder et al., 2015). This approach recommended that researchers choose multiple tasks that capture the target function but seem different on the surface. Therefore, it is theoretically desirable to construct a latent variable using a task based on the go/no-go paradigm and a task based on the stop-signal paradigm.

This study could not clearly show that using a latent variable of impulsive action was superior to the single-task performance in detecting associations between impulsive action, rumination, stressors, and depression. Although we interpreted our findings using the latent variable in the following discussion, future studies should reexamine whether the latent variable approach is appropriate for detecting the associations between impulsive action and psychopathological variables.

Consistent with our prediction, SEM indicated that impulsive action was indirectly associated with rumination via stressors. Also, the significant association between impulsive action and rumination disappeared after controlling for the influence of stressors, suggesting that stressors might explain the association between impulsive action and rumination. The significant association between impulsive action and stressors identified in this study was consistent with previous studies reporting that self-reported impulsivity, including negative urgency, is prospectively associated with increased stressors (Liu & Kleiman, 2012; Molz et al., 2013). Previous studies have also shown that impulsive action assessed by the performance in a single task was associated with increased aggressive behaviors (Qiao et al., 2016; Raaijmakers et al., 2008), and substance abuse, alcohol dependence, and pathological gambling (Lee et al., 2019, for review). It is plausible that these behavioral problems could increase interpersonal conflicts and functional impairments at school and work. Also, stressors can prevent a person’s goals from being attained and lead to rumination about the unattained goals or lacked progress to attaining them (Martin et al., 2004). This study used a cross-sectional design, which prevented us from identifying the direction of causality between stressors and rumination. Nevertheless, previous studies have shown that frequent exposure to stressors is prospectively associated with increased rumination, even after controlling for baseline rumination (Hamilton et al., 2015; Michl et al., 2013).

We examined a model assuming that impulsive action increased the exposure to stressors, which increased rumination. However, previous studies’ findings suggest another possible causal connection among impulsivity, stressors, and rumination. For example, Hasegawa et al. (2018) demonstrated that trait rumination was positively associated with future negative urgency, a dimension of self-reported impulsivity representing the tendency to act rashly when experiencing negative affect, even after
controlling for baseline rumination and depression. Their result indicates the possibility that rumination might increase impulsive action, not the opposite direction as assumed in this study. However, Hasegawa et al. (2018) showed that trait rumination had a nonsignificant association with future positive urgency, representing rash action during positive affect. Their results suggest that rumination increases rash action during negative affect experiences but not rash action in general. Hasegawa et al. (2018) suggested that rumination could increase negative urgency via increased negative attention and interpretation bias caused by rumination. Because the current study used impulsive action tasks consisting of non-emotional stimuli, it is implausible that negative cognitive bias caused by rumination impaired the impulsive action tasks' performance.

Furthermore, previous longitudinal studies have examined whether trait rumination is a factor that generates stressors. These studies have provided mixed findings: Some studies have indicated that rumination generates stressors, particularly in the interpersonal domain (Flynn et al., 2010; McLaughlin & Nolen-Hoeksema, 2012; Shapero, Hamilton, et al., 2013; Stroud et al., 2018), and other studies have shown no association between rumination and stressors (Hamilton et al., 2013, 2017; Shapero, Hankin, et al., 2013), although caution is needed in interpreting these results because participants' characteristics, follow-up periods, and covariates in the analyses were different between studies. A longitudinal study has also reported that trait rumination and aggressive behaviors have a mutually enhancing relationship in boys but not girls (McLaughlin et al., 2014), while another longitudinal study showed that rumination did not predict the later composite score derived from delinquent behavior items and aggressive behaviors items of female adolescents (Nolen-Hoeksema et al., 2007). Furthermore, prospective studies have shown that ruminative women were likely to suffer from alcohol-related problems (Nolen-Hoeksema & Harrell, 2002) and substance abuse symptoms (Nolen-Hoeksema et al., 2007). Therefore, it is plausible that rumination leads to stress generation via problematic behaviors, even though the findings were inconsistent.

This study could not identify causal relationships among study variables because of its cross-sectional design, and we could only conclude that stressors mediated the association between impulsive action and rumination. A longitudinal study is needed to identify causal relationships. The current finding of a significant association between impulsive action and rumination is consistent with concurrent and longitudinal associations between self-reported impulsivity and rumination (Hasegawa et al., 2018; Horibe & Hasegawa, 2020; Valderrama & Miranda, 2017; Valderrama et al., 2016; Wang & Borders, 2018). Future longitudinal research is expected to clarify whether impulsivity is one cause of rumination.

This study indicated that stressors and rumination were positively associated with depression after controlling for the influences of other variables. In contrast, impulsive action was not significantly and directly associated with depression. The results also showed that stressors and rumination mediated the association between impulsive action and depression, although caution is needed because the simple correlation between impulsive action and depression was nonsignificant. A meta-analysis has reported a small deficit in individual task performance assessing impulsive action in depressed individuals (Wright et al., 2014). However, it is plausible that impulsive action might not be directly associated with depression, whereas it could strengthen depression through increased stressors and rumination.
The results also indicated that impulsive action had significant indirect associations with brooding via stressors, which was not the case for reflection. As described above, brooding is a thought process having a more negative valence than reflection. It is plausible that increased stressors resulting from impulsive action prolong negative thoughts but not thoughts that are less negative and more focused on problem-solving.

The present findings suggest that interventions to decrease rumination would effectively prevent or alleviate depression in individuals showing higher impulsive action. Several empirically supported therapies target rumination, including mindfulness-based cognitive therapy (Segal et al., 2002), metacognitive therapy (Wells, 2009), and rumination-focused cognitive-behavioral therapy (Watkins, 2016). Interestingly, recent randomized controlled trials have indicated that mindfulness-based cognitive therapy decreases hyperactivity-impulsivity symptoms in ADHD adults (Gu et al., 2018; Hepark et al., 2019), although the effect on the performance in laboratory tasks assessing impulsive action was not strong enough for group differences to be statistically significant (Schoenberg et al., 2014). Also, a small open trial showed that interventions adapted from mindfulness-based cognitive therapy decreased negative urgency, lack of perseverance, rumination, and depression among adolescents with difficulties in emotion regulation (Deplus et al., 2016). Mindfulness-based cognitive therapy may be an effective treatment for decreasing rumination directly or indirectly by reducing impulsive action, which is expected to prevent or alleviate depression.

There are limitations to the present study in addition to the issue discussed above. Firstly, the sample was composed only of university students. Therefore, it is unclear whether these findings would generalize to other age groups and clinical samples. Future studies should replicate the present findings in samples other than university students. Secondly, this study did not control the possible confounding influence of family factors such as the parents' socio-economic status and parental rearing style. For example, maladaptive parenting styles, including over-controlling parenting and lack of positive maternal support, are associated with increased rumination (Gaté et al., 2013; Hilt et al., 2012; Manfredi et al., 2011; Spasojević & Alloy, 2002). The parenting style might also be one cause of impulsive action and stressors, and the significant associations among impulsive action, stressors, and rumination might disappear after controlling for the influence of parenting styles. Therefore, future studies should examine whether family factors confound the association among the variable examined in this study. Thirdly, this study did not assess behaviors that might mediate the association between impulsive action and stressors. Problematic behaviors such as aggressive behaviors, alcohol and drug dependence, and pathological gambling might mediate this association. It is necessary to examine the possible pathways from impulsive action to stressors, rumination, and depression. Finally, this study did not use a scale dedicated to assessing dependent stressors, which according to the stress generation hypothesis (Hammen, 1991; Liu & Alloy, 2010), are generated by individuals with maladaptive characteristics. Scales for separately assessing independent and dependent stressors are not available in Japan. Therefore, future studies should develop a self-report or an interview-based method for separately evaluating independent and dependent stressors and examine whether impulsive action increases rumination via an increase in dependent stressors without affecting independent stressors.
Notes

1. A previous meta-analysis has indicated that the correlation between the performance of tasks assessing impulsive action and negative urgency was low ($r = .11$; Cyders & Coskunpinar, 2011). This result has cast doubt on the assumption that impulsive action and negative urgency assess the same construct. However, as described below, the processes by which impulsive action and urgency increased rumination were considered to be identical.

2. Other assumptions about causal relationships among each study variable could be made from previous findings. We have described these possibilities in detail in the Discussion.

3. The sample of this study was identical to the one investigated by Hasegawa et al. (2019), which examined the relationship between self-reported impulsivity and behavioral impulsivity.

4. It seemed to be inappropriate to construct a latent variable only based on the performance in the GNG and the CCPT because the factor loading of the GNG performance was 1.79 and that of the CCPT performance was -.09 when a latent variable was constructed derived from these two variables using SEM described in the following two paragraphs. Therefore, using the performance in three tasks for constructing a latent variable was reasonable. This was identical to the procedure of previous studies using the latent variable approach (e.g., Miyake et al., 2000; Engelhardt et al., 2015; Tiego et al., 2018).

5. Standardized regression coefficients and $R^2$ in this model were highly similar to those shown in Figure 1. These values are available from the corresponding author upon request.

6. We also conducted SEM with depression as an exogenous variable that influenced stressors and rumination rather than as a dependent variable because of the possibility that depression was a confounding factor in the relationship between other variables. This model had an excellent fit for the data: $\chi^2 (7) = 9.53$, $p = .22$; CFI = .98; RMSEA = .05. Results showed that impulsive action was not significantly associated with stressors ($\beta = .15$, $p = .11$), or rumination ($\beta = .12$, $p = .28$); nor were stressors associated with rumination ($\beta = .16$, $p = .06$). These results were in the same direction as the results for depression as a dependent variable. However, the sample size might have been insufficient to detect any significant associations between impulsive action and stressors or between stressors and rumination.

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