Impact of interpretation bias on depression in ambiguous situations: A panel survey with a three-month interval

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Abstract
The negative interpretation of ambiguous situations is understood as interpretation bias, which is a core factor that causes and prolongs depression. However, not many studies have examined the causal influence of interpretation bias on depression. Accordingly, we developed the Japanese version of AST-D-II in which ambiguous scenarios are employed to measure interpretation bias related to depression. A survey was conducted among 247 participants at two time points, with a three-month interval (Time 1 and Time 2). Subsequently, the reliability and validity of the Japanese version of AST-D-II were verified. Thereafter, the depression and AST-D-II scores at both time points were put into structural equation modeling and the cross-lagged panel model was examined. Although the Japanese version of AST-D-II had a different factor structure to that found in previous studies, it is a useful scale to measure interpretation bias in Japanese people. In addition, the cross-lagged panel model revealed that interpretation bias is not only related to current depression, but interpretation bias at Time 1 has an impact on depression at Time 2. Therefore, one may deduce that interventions on interpretation bias are important in the prevention of depression.

Keywords
Ambiguous scenario test, depression, interpretation bias, panel survey

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Introduction
The cognitive theory of depression explains negative cognition related to depression. Furthermore, cognitive distortion in information processing has been identified as a factor of depression and anxiety as cognitive bias (Beck & Clark, 1997). A type of cognitive bias related to depression, the problem of interpretation bias, has been proposed (Lawson et al., 2002). Interpretation bias related to depression refers to interpreting ambiguous situations, which could be interpreted either negatively or positively, negatively by perceiving such situations as a threat to one’s safety and/or self. Disregarding the manner in which one interprets ambiguous situations or whether such
interpretation is an adaptive behavior, negative interpretation bias facilitates the maintenance of rumination and influences psychological processes that cause and prolong depression (Krähé et al., 2019; Mor et al., 2014). The advancement of interpretation bias that is not negative is an important element of successful cognitive behavioral therapy to treat depression. In addition, research has shown that training to rectify negative interpretation bias reduces the risk of depression (Hollon et al., 2005). On the contrary, studies have questioned the role of interpretation bias in depression (Bisson & Sears, 2007; Mogg et al., 2006). However, a recent meta-analysis (Everaert et al., 2017) revealed that regardless of the methodology such as questionnaires and experimental tasks, negative interpretation bias of patients with major depressive disorder or depression has more than a moderate effect size ($g = .72$). Furthermore, when employing a stimulus with self-relevance ($g = .90$) or manifest indicators rather than latent indicators ($g = .88$), the effect size is larger. Thus, the difference in measurement methods of interpretation bias influences its relationship with depression. Hence, when measuring interpretation bias related to depression, self-relevance should be considered in the interpretation and measurement. Furthermore, it is imperative that the latter is based on manifest indicators.

However, many studies have examined the effect of short-term interpretation bias by employing cross-sectional surveys or interpretation bias correction training, and only a few studies have examined the long-term causal role of interpretation bias on depression. Among them, longitudinal studies (Everaert et al., 2015; Rude et al., 2010; Rude et al., 2002) have revealed that interpretation bias is a predictive factor for the onset of depression and major depressive disorder. These studies employed a study design in which the onset of depression or major depressive disorder was examined at Time 2 based on interpretation bias measured at Time 1. Although cognitive bias, including interpretation bias, is an aspect of depressive symptoms, the level of interpretation bias that leads to depression was not controlled. Thus, whether negative interpretation bias causes depression has not been sufficiently tested.

Many studies on interpretation bias related to depression have utilized the Scrambled Sentences Test (SST) to measure interpretation bias (Everaert et al., 2015; Rude et al., 2002, 2010). In the SST, multiple words are presented in random order under a certain cognitive load and time constraint. Respondents are subsequently asked to create a sentence. Words are selected so that they can be rearranged to create a negative or positive sentence. The creation of negative sentences reflects negative interpretation bias. Meta-analysis has shown that the internal consistency of SST is good (Würtz et al., 2022). In addition, the interpretation bias modification intervention for general anxiety disorder and depression reduced negative interpretation bias (measured by SST), and reduction of interpretation bias by intervention mediates improvement of negative thinking and depressive mood (Hirsch et al., 2018). The interpretation bias measured by SST may have some causal effect on depression. However, quantifying interpretation bias measured by SST, along with its implementation procedures, has proven to be difficult (Berna et al., 2011). Thus, the properties of the SST as a scale have not been sufficiently clarified (Rohrbacher & Reinecke, 2014). Therefore, the AST-D (Ambiguous Scenarios Test relevant to Depressed mood; Berna et al., 2011) was developed as a measurement method that is easy to implement and allows the quantification of interpretation bias. The AST-D uses ambiguous scenarios that have been used to measure catastrophic interpretations in anxiety disorder, adapted to depression. The AST-D scenarios were created by comparing positive and negative ratings of 50 scenarios for anxiety disorder and depression between a clinical depression group and a normal group, with 24 scenarios interpreted more negatively by the clinical depression group (Berna et al., 2011). The respondents imagine these scenarios happening to them, assess the level of pleasant-unpleasant emotions at the time, and evaluate their subjective interpretation bias. However, because the AST-D is not suited to measure the same group multiple times, its longitudinal use has not been anticipated. Therefore, Rohrbacher and Reinecke (2014) added new scenarios and developed the AST-D-II, which comprises 30 items. The AST-D-II can be divided into two versions with 15 items each: AST-D-II(A) and AST-D-II(B). Interpretation bias measured by AST-D-II has revealed a moderate correlation with depression by utilizing the Center for Epidemiologic Studies Depression Scale (AST-D-II(A): $r = .47$; AST-D-II(B): $r = .48$). However, the predictive validity of the AST-D-II has not been verified. Kleim et al. (2014) measured interpretation bias in interns by employing the AST-D and demonstrated that depression at 6 months was predicted with statistical significance ($OR = 6.41, p = .027$). However, there were only 47 participants. Currently, it is difficult to ascertain whether interpretation bias measured by AST-D-II has a causal effect on depression. Accordingly, it is crucial that the effect of interpretation bias measured by AST-D-II on depression is elucidated and its predictive validity is verified.

Based on the background as elucidated thus far, in this study, we conducted a panel survey at two points in time with a three-month interval to examine if there is a causal relationship between interpretation bias and depression. During the surveys at these two points in time, the participants completed the AST-D-II(A) and AST-D-II(B) alternately and interpretation bias related to depression was measured twice. Because there is no Japanese translation of the AST-D-II, we examined the reliability and validity of the Japanese version of AST-D-II by employing the data obtained from the panel survey. Rohrbacher and Reinecke (2014) conducted Confirmatory Factorial Analysis (CFA) of the
factor structure of AST-D-II in accordance with a hypothesis that interpretation bias related to depression corresponds to Beck’s cognitive triad of major depressive disorder and confirmed a three-factor structure that is consistent with Beck’s cognitive triad for the AST-D-II and AST-D-II(A)/(B). As such, we conducted CFA assuming the three-factor structure in the previous study for both AST-D-II(A)/(B) in the Japanese version of the AST-D-II. Subsequently, by employing the longitudinal data obtained from the panel survey, we examined the causal relationship between interpretation bias and depression by utilizing the cross-lagged panel model. We predicted that interpretation bias measured with the AST-D-II would have an effect on depression 3 months later.

Methods

Participants

By employing the eligibility criteria of males and females between 20 and 60 years of age who were living in Japan and registered with a survey company (Cross Marketing Inc.), we recruited 444 participants (213 males and 221 females; mean age = 40.2 years, SD = 11.14) to complete a survey twice, with a 3-month interval. Finally, 247 participants (126 males and 121 females) answered the survey at both points, without making any errors.

Measures

- Japanese version of the AST-D-II

We obtained permission from the original authors to translate the AST-D-II into Japanese. Accordingly, the lead author of this study translated each scenario into Japanese. The validity thereof was subsequently assessed by the second author. We commissioned a professional English proofreading service to acquire the services of a native speaker to reverse translate our translation. Thereafter, we placed emphasis in the translation on expressing the nuances of the original version rather than on direct translation for each item. The AST-D-II comprises 30 scenarios (e.g., “You give a speech at your friend’s wedding. When you have finished, you observe the audience’s reaction.”; “It is the end of December. You reflect upon the year behind of you.”), which can each be interpreted positively or negatively. The instructions were the same as those in the original version. Instructions were provided before each scenario so that the participants could relate it to themselves, thus allowing interpretation bias to be measured, as it has been noted that it is difficult to measure interpretation bias related to others (Lawson & MacLeod, 1999). After reading each scenario and imagining the described situation, the participants evaluated their emotional state on a 9-point scale, ranging from 1 (very unpleasant) to 9 (very pleasant). A low AST-D-II score indicates negative interpretation bias. Thus, in this study, we used the reverse score to indicate negative interpretation bias to simplify the interpretation of the score. When translating the scale into Japanese, the AST-D-II(A) and AST-D-II(B) were classified using the same items as those of Rohrbacher and Reinecke (2014).

- Japanese version of Center for Epidemiologic Studies Depression Scale (Shima et al., 1985; hereinafter “CES-D”)

We employed CES-D to measure the level and frequency of depression. CES-D comprises 20 questions that evaluate depressive tendencies. Specifically, the questions assess depression in the most recent week by employing a 4-point scale. Scores range from 0 to 60, with higher scores indicating more symptoms of depression.

- Japanese version of Dysfunctional Attitude Scale-24 (Tajima et al., 2007; hereinafter “DAS-24”)

We used the Japanese version of the DAS-24 that measures non-functional cognition unique to people with depressive tendencies in order to examine the concurrent validity of the AST-D-II. The DAS-24 consists of 24 questions that participants evaluate on a 7-point scale, ranging from 1 to 7.

Procedure

We recruited participants to complete a survey twice, with a 3-month interval. This was referred to as Time 1 (beginning) and Time 2 (end). We randomly assigned the participants to Group 1 (126 participants; 65 males and 61 females; mean age = 40.1 years, SD = 11.34) or Group 2 (121 participants; 65 males and 56 females; mean age = 41.6 years, SD = 10.65). Participants completed online surveys through the survey platform of the above-mentioned company. The online surveys consisted of demographic questions (sex, age) and self-report measures including the Japanese version of the AST-D-II (either (A) or (B)), CES-D, and DAS-24. To control response bias due to memory regarding AST-D-II scenarios and responses 3 month ago, this study used different versions of AST-D-II (AST-D-II(A) and AST-D-II(B)) before and after 3 months into the panel survey. Furthermore, to deal with order effects, Group 1 completed AST-D-II(A) at Time 1 and AST-D-II(B) at Time 2, and Group 2 completed the scales in the opposite order. The procedure of this study was approved by the research ethics review committee of Otemon Gakuin University (approval number: 2019-13). Prior to the surveys, the participants provided informed consent. Participants could click the survey link and were directed to an informed consent page where they could choose to participate. Participation was voluntary, participation could be discontinued at any time without disadvantaging the participants, and that their private information would remain confidential. Furthermore, we only used the information that was necessary for
the analysis of the survey items and took care to protect their personal privacy.

**Data analytic plan**

Structural equation modeling (SEM) was employed to conduct CFA to confirm whether the present version had the same factor structure as the original AST-D-II (Rohrbacher & Reinecke, 2014). Amos.v24 was utilized to conduct SEM. We performed CFA on both the AST-D-II(A) and AST-D-II(B). We calculated the correlation coefficient of the AST-D-II and other variables by employing spss.v16.0.

Finally, we used the multi-group (Group1, Group2) cross-lagged panel model to examine the interrelationship between depression and interpretation bias. We put the AST-D-II score (indicator of interpretation bias) and CES-D score (indicator of depression) from Time 1 and Time 2 into the cross-lagged panel model. We hypothesized that the interpretation bias of Time 1 would have a positive effect on depression of Time 2, which was stronger than the effect of depression of Time 1 on the interpretation bias of Time 2. The goodness of fit of the employed models was not examined because these are saturated models.

**Results**

We presented descriptive statistics for each variable in Table 1. CES-D scores of 16 or greater were reported by 32.0% at Time1, and by 32.3% at Time2. Paired t-test revealed no significant differences between AST-D-II (A) and (B) in both Group1 and Group2 (Group1: $t = 1.84, p > .05$; Group2: $t = .72, p > .05$).

**Confirmatory factorial analysis**

We examined whether the split version of the Japanese AST-D-II, AST-D-II(A) and AST-D-II(B) have a three-factor structure identical to that of Rohrbacher and Reinecke (2014) by conducting CFA. The results revealed that the goodness of fit of the three-factor structure model was inadequate (AST-D-II(A): $CFI = .657, RMSEA = .435$; AST-D-II(B): $CFI = .674, RMSEA = .455$). AST-D-II is based on questions from AST-D (Berna et al., 2011), where AST-D is not a scale with a multi-factor structure. Thus, the goodness of fit of data would be enhanced if we assumed a one-factor structure for the AST-D-II as well. Consequently, we conducted CFA assuming a one-factor structure for the AST-D-II(A) and AST-D-II(B). To improve the goodness of fit of the model by referring to the correction index, we excluded some questions from the analysis. Accordingly, the 15 questions that each constitutes AST-D-II(A) and AST-D-II(B) were reduced to 10 each. The results revealed that both the AST-D-II(A) and AST-D-II(B) have a one-factor structure (AST-D-II(A): $CFI = .914, GFI = .906, RMSEA = .099$, AST-D-II(B): $CFI = .934, GFI = .941, RMSEA = .072$). We subsequently examined reliability.

| Descriptives | Group | N  | Mean | SD  | Minimum | Maximum |
|--------------|-------|----|------|-----|---------|---------|
| AST-D-II(A)_Time1 | 1 | 130 | 5.13 | 1.10 | 1.00 | 8.93 |
|               | 2 | 0  | NaN  | NaN | NaN    | NaN    |
| AST-D-II(B)_Time1 | 1 | 130 | 5.14 | 0.91 | 1.80 | 8.60 |
|               | 2 | 0  | NaN  | NaN | NaN    | NaN    |
| AST-D-II(A)_Time2 | 1 | 0   | NaN  | NaN | NaN    | NaN    |
|               | 2 | 117 | 5.08 | 0.91 | 1.53 | 8.80 |
| AST-D-II(B)_Time2 | 1 | 130 | 4.97 | 0.89 | 2.60 | 8.13 |
|               | 2 | 0   | NaN  | NaN | NaN    | NaN    |
| AST-D-II(full)   | 1 | 130 | 5.05 | 0.88 | 2.80 | 8.07 |
|               | 2 | 117 | 5.11 | 0.81 | 2.33 | 8.70 |
| ESD_Time1       | 1 | 130 | 15.01 | 10.42 | 0 | 47 |
|               | 2 | 117 | 15.09 | 10.39 | 0 | 47 |
| CESD_Time2      | 1 | 130 | 14.45 | 10.94 | 0 | 47 |
|               | 2 | 117 | 14.41 | 10.47 | 0 | 49 |
| CES-D_ave       | 1 | 130 | 14.73 | 9.84 | 0.00 | 45.50 |
|               | 2 | 117 | 14.75 | 9.90 | 0.00 | 46.50 |
| DAS_Time1       | 1 | 130 | 3.73 | 0.75 | 2.08 | 5.92 |
|               | 2 | 117 | 3.76 | 0.68 | 1.25 | 5.67 |
| DAS_Time2       | 1 | 130 | 3.70 | 0.67 | 1.54 | 5.38 |
|               | 2 | 117 | 3.72 | 0.60 | 2.21 | 5.75 |
| DAS_ave         | 1 | 130 | 3.72 | 0.65 | 1.81 | 5.60 |
|               | 2 | 117 | 3.74 | 0.59 | 1.90 | 5.71 |
coefficient of each scale. The full AST-D-II was an $\alpha$ of .89. The AST-D-II(A) was an $\alpha$ of .88 and the AST-D-II(B) was an $\alpha$ of .87.

**Correlation analysis**

We calculated the Pearson’s correlation coefficient between the AST-D-II(A), AST-D-II(B), and full version AST-D-II (AST-D-II (full)). As a result, the correlation coefficients between the AST-D-II(A) and (B) was $r = .562$ ($p < .001$) for Group 1 (Table 2) and $r = .600$ ($p < .001$) for Group 2 (Table 3). Furthermore, the correlation coefficients between the AST-D-II (full) and (A) was $r = .909$ ($p < .001$), and $r = .856$ ($p < .001$) for the (B) in Group 1 (Table 2). In Group 2, the correlation coefficient between the AST-D-II (full) and (A) was $r = .894$ ($p < .001$) and $r = .895$ ($p < .001$) for the AST-D-II (B) (Table 3).

Next, we conducted correlation analysis between each variable at each time point. Table 2 indicated correlation matrix of each variable in Group1. All versions of AST-D-II had small to moderate significant correlation for CES-D and DAS-24. Table 3 indicated correlation matrix of each variable in Group2. All versions of AST-D-II had small to moderate significant correlation for CES-D. However, AST-D-II(A) at Time 2 was not significantly correlated with DAS-24 at time 2.

**Cross-lagged panel analysis**

Subsequently, we performed path analysis with the cross-lagged panel model by employing SEM to examine the causal relationship between interpretation bias and depression. Before performing SEM, we performed Pearson’s correlation analyses between the scales measured at Time 1 and Time 2 (Tables 2 and 3). The results revealed that there was correlation between AST-D-II and CES-D at Time 1 (AST-D-II(A): $r = .420$, $p < .001$; AST-D-II(B): $r = .458$, $p < .001$), AST-D-II and CES-D at Time 2 (AST-D-II(A): $r = .334$, $p < .001$; AST-D-II(B): $r = .479$, $p < .001$), AST-D-II(A) at Time 1 and CES-D at Time 2 ($r = .488$, $p < .001$), and AST-D-II(B) at Time 1 and CES-D at Time 2 ($r = .479$, $p < .001$). Thus, we employed the cross-lagged panel model and examined the causal relationship between depression and interpretation bias. To examine the group differences in this cross-lagged model, we conducted a multi-group analysis grouped by Group (order of versions of AST-D-II). We constructed constrained model (all parameters) based on model fit indices including AIC and BIC (un-constrained model: AIC = 2210, BIC = 2273; constrained model: AIC = 2208, BIC = 2239). The model fits data well ($\chi^2 = 15.68$, $p > .05$, CFI = .980, TLI = .978 and RMSEA = .078(95% CI = [.000-.140]). In the cross-lagged panel model of this study, we hypothesized that if the path to the interpretation bias at Time 1 (AST-D-II) and the depression score at Time 2 (CES-D) revealed a significantly positive effect, there would be a causal relationship in which a strong tendency to interpret ambiguous situations negatively would likely cause depression. First, we analyzed the Group1 (Figure 1(a)). The results showed that CES-D at Time 1 significantly predicted CES-D at Time 2 ($\beta = .659$, $p < .001$), but not AST-D-II(B) at time 2 ($\beta = .103$, $p > .05$). The AST-D-II(A) at Time 1 significantly predicted AST-D-II(B) at time 2 ($\beta = .559$, $p < .001$) and CES-D at Time 2 ($\beta = .211$, $p < .001$). Thus, we examined the difference in the path from AST-D-II at Time 1 to CES-D at Time 2 and the path from CES-D at Time 1 to AST-D-II(B) at Time 2 and found a significant difference between the two paths ($Z = 4.384$, $p < .01$). Subsequently, we analyzed the Group2 (Figure 1(b)). The results showed that CES-D at Time 1 significantly predicted CES-D at Time 2 ($\beta = .666$, $p < .001$), but not AST-D-II(A) at time 2 ($\beta = .108$, $p > .05$). The AST-D-II(B) at Time 1 significantly predicted AST-D-II(A) at time 2 ($\beta = .488$, $p < .001$) and CES-D at Time 2 ($\beta = .177$, $p < .001$). Thus, an examination of the path from

![Table 2: Correlation matrix of each variable in Group1.](image-url)
The appropriateness of translation. In this study, we assumed Reinecke (2014) may have been due to cultural differences and the factor structure was different from that of Rohrbacher and jokes.

A one-factor structure could be used as an index to measure depression. The Japanese version of the AST-D-II(A) and AST-D-II(B) had a significant moderate correlation with CES-D. This correlation was consistent with previous studies (Berna et al., 2011; Rohrbacher & Reinecke, 2014).

Therefore, the convergent validity of the Japanese version of the AST-D-II as a scale of interpretive bias may be supported. However, the scores of the AST-D-II(A), (B), and full version showed a weak correlation with dysfunctional cognition measured with DAS-24. It has not been examined whether the AST-D-II is associated with the DAS-24, but other scales of interpretive bias have been reported to correlate with the DAS (Micco et al., 2014). We examined the causal role of interpretation bias on depression by conducting a panel survey that employed the Japanese AST-D-II. In accordance with the results, we examined the relationship between interpretation bias measured with AST-D-II and depression measured with CES-D by employing the cross-lagged panel model. The main results were that interpretation bias is positively correlated with future depression and that its effect is stronger than the effect of depression on future interpretation bias.

First, we developed a Japanese version of the AST-D-II to measure interpretation bias by translating and culturally transposing the original AST-D-II prepared by Rohrbacher and Reinecke (2014). The results of the confirmatory factor analysis of a Japanese version of the AST-D-II demonstrated that while both the AST-D-II(A) and AST-D-II(B) had a poor goodness of fit for the three-factor structure model confirmed by Rohrbacher and Reinecke (2014), the model’s goodness of fit was adequate for a one-factor structure. The reason that the factor structure was different from that of Rohrbacher and Reinecke (2014) may have been due to cultural differences and the appropriateness of translation. In this study, we assumed that the Japanese version of AST-D-II(A) and AST-D-II(B) with a one-factor structure could be used as an index to measure interpretation bias related to depression. However, the scores of Japanese version of the AST-D-II revealed that the AST-D-II(A) and AST-D-II(B) had a significant moderate correlation with CES-D. This correlation was consistent with previous studies (Berna et al., 2011; Rohrbacher & Reinecke, 2014).

Therefore, the convergent validity of the Japanese version of the AST-D-II as a scale of interpretive bias may be supported. However, the scores of the AST-D-II(A), (B), and full version showed a weak correlation with dysfunctional cognition measured with DAS-24. It has not been examined whether the AST-D-II is associated with the DAS-24, but other scales of interpretive bias have been reported to correlate with the DAS (Micco et al., 2014). We examined the causal role of interpretation bias on depression by conducting a panel survey that employed the Japanese AST-D-II. In accordance with the results, we examined the relationship between interpretation bias measured with AST-D-II and depression measured with CES-D by employing the cross-lagged panel model. The main results were that interpretation bias is positively correlated with future depression and that its effect is stronger than the effect of depression on future interpretation bias. We also demonstrated that interpretation bias could have an effect on depression in a time interval of 3 months. Therefore, one may deduce that interpretation bias is not only related to current depression but also with future depression. This is consistent with the cognitive theory of depression. It is also consistent with Kleim et al.’s (2014) longitudinal study that measured interpretation bias with AST-D and examined its relationship with depression. Normansell and Wisco (2017) also showed that interpretation mediates rejection sensitivity and depression. Considering the findings of these previous studies and the results of the present study, it is suggested that interpretation bias as measured by the AST-D-II predicts depression. That is, people who tend to interpret ambiguous situations, which could be positive or negative, negatively tend to have high depressive tendencies and a risk of experiencing increased depression over a long period. Negative interpretation bias on life events and stressors invokes negative emotional states. This implies that interpretation bias is not limited to temporary cognitive processing that accompanies specific events, but rather is a cognitive tendency that drives continuous negative information processing (Everaert et al., 2015).

### Table 3. Correlation matrix of each variable in Group 2.

|                        | AST-D-II(B) _Time1 | AST-D-II(A) _Time1 | AST-D-II(B) _Time2 | AST-D-II(A) _Time2 | AST-D-II(B) _Group2 | AST-D-II(A) _Group2 | CESD_Time1 | CESD_Time2 | DAS_Time1 | DAS_Time2 |
|------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|------------|------------|-----------|-----------|
| AST-D-II(B) _Time1     | —                  | —                  | —                  | —                  | —                  | —                  | —          | —          | —         | —         |
| AST-D-II(A) _Time1     | 0.600***           | —                  | —                  | —                  | —                  | —                  | —          | —          | —         | —         |
| AST-D-II(B) _Time2     | 0.894***           | 0.895***           | —                  | —                  | —                  | —                  | —          | —          | —         | —         |
| AST-D-II(A) _Time2     | 0.450***           | 0.263**            | 0.403***           | —                  | —                  | —                  | —          | —          | —         | —         |
| CESD_Time1             | 0.479***           | 0.334***           | 0.454***           | 0.747***           | —                  | —                  | —          | —          | —         | —         |
| CESD_Time2             | 0.195*             | 0.206*             | 0.224*             | 0.375***           | 0.394***           | —                  | —          | —          | —         | —         |
| DAS_Time1              | 0.231*             | 0.172              | 0.226*             | 0.288***           | 0.388***           | 0.676***           | —          | —          | —         | —         |
| DAS_Time2              | —                  | —                  | —                  | —                  | —                  | —                  | —          | —          | —         | —         |

**Note.** *p < .05, **p < .01, ***p < .001.

AST-D-II(B) at Time 1 to CES-D at Time 2 and the path from CES-D at Time 1 to AST-D-II(A) at Time 2 revealed a significant difference between the two paths (Z = 2.299, *p < .05).

These results indicate that negative interpretation bias predicts depression in both Group 1 and 2.

### Discussion

The objective of the present study was to examine the causal role of interpretation bias on depression by employing the Japanese version of the AST-D-II. By employing a survey that was conducted twice, with a 3-month interval, we examined the relationship between interpretation bias measured with AST-D-II and depression measured with CES-D by employing the cross-lagged panel model. The primary results revealed a positive relationship between interpretation bias and future depression. Furthermore, the effect thereof was stronger than that of depression on future interpretation bias.

First, we developed a Japanese version of the AST-D-II to measure interpretation bias by translating and culturally transposing the original AST-D-II prepared by Rohrbacher and Reinecke (2014). The results of the confirmatory factor analysis of a Japanese version of the AST-D-II demonstrated that while both the AST-D-II(A) and AST-D-II(B) had a poor goodness of fit for the three-factor structure model confirmed by Rohrbacher and Reinecke (2014), the model’s goodness of fit was adequate for a one-factor structure. The reason that the factor structure was different from that of Rohrbacher and Reinecke (2014) may have been due to cultural differences and the appropriateness of translation. In this study, we assumed that the Japanese version of AST-D-II(A) and AST-D-II(B) with a one-factor structure could be used as an index to measure interpretation bias related to depression. However, the scores of Japanese version of the AST-D-II revealed that the AST-D-II(A) and AST-D-II(B) had a significant moderate correlation with CES-D. This correlation was consistent with previous studies (Berna et al., 2011; Rohrbacher & Reinecke, 2014).

Therefore, the convergent validity of the Japanese version of the AST-D-II as a scale of interpretive bias may be supported. However, the scores of the AST-D-II(A), (B), and full version showed a weak correlation with dysfunctional cognition measured with DAS-24. It has not been examined whether the AST-D-II is associated with the DAS-24, but other scales of interpretive bias have been reported to correlate with the DAS (Micco et al., 2014). We examined the causal role of interpretation bias on depression by conducting a panel survey that employed the Japanese AST-D-II. In accordance with the results, we examined the relationship between interpretation bias measured with AST-D-II and depression measured with CES-D by employing the cross-lagged panel model. The main results were that interpretation bias is positively correlated with future depression and that its effect is stronger than the effect of depression on future interpretation bias. We also demonstrated that interpretation bias could have an effect on depression in a time interval of 3 months. Therefore, one may deduce that interpretation bias is not only related to current depression but also with future depression. This is consistent with the cognitive theory of depression. It is also consistent with Kleim et al.’s (2014) longitudinal study that measured interpretation bias with AST-D and examined its relationship with depression. Normansell and Wisco (2017) also showed that interpretation mediates rejection sensitivity and depression. Considering the findings of these previous studies and the results of the present study, it is suggested that interpretation bias as measured by the AST-D-II predicts depression. That is, people who tend to interpret ambiguous situations, which could be positive or negative, negatively tend to have high depressive tendencies and a risk of experiencing increased depression over a long period. Negative interpretation bias on life events and stressors invokes negative emotional states. This implies that interpretation bias is not limited to temporary cognitive processing that accompanies specific events, but rather is a cognitive tendency that drives continuous negative information processing (Everaert et al., 2015).
Accordingly, changes in negative interpretation bias that have a continuous effect are imperative for improving depression or, further, preventing it. In recent cognitive bias modification training, the importance of interpretation bias as an intervention target has been noted (Everaert et al., 2017). Although the intervention effect on interpretation bias remains unclear, in interventions of interpretation bias to improve depression, a split-half test, AST-D-II, may be beneficial as a process variable.

Limitations and recommendations for future research

This study has several limitations. First, the duration of this longitudinal study was relatively short, namely 3 months. Second, the assessment of depressive symptoms was based on the participants’ subjective assessment. Third, the mitigating factors of interpretation bias were not examined. Therefore, it is recommended that future studies attempting to replicate the results should be conducted over a longer period, major depressive disorder should be assessed in accordance with diagnostic criteria, and preventive factors that mitigate the effect of interpretation bias should be examined.

However, since AST-D-II evaluates the degree of positivity and negativity in emotions when experiencing an ambiguous situation, the scale cannot clearly differentiate whether the scenario is causing depression or anxiety. Therefore, interpretation bias measured by AST-D-II may be related to both anxiety and depression. Indeed, items of AST-D were derived from the ambiguous scenario test for anxiety (Berna et al., 2011). However, it has not been investigated whether AST-D and AST-D-II are related with anxiety. Furthermore, a measurement method that rates emotions by imagining a scenario may not necessarily measure interpretation bias directly. Rather, it may measure an emotional reaction to positive or negative interpretation bias, such that the assessment of emotion includes interpretation bias and the emotional reaction born thereof. It is recommended that concurrent validity and discriminative validity should be examined with other methods both related and unrelated to measuring interpretation bias.
Conclusions

Present findings suggest interpretation bias may lead to depression symptoms, not only related to current depression. Therefore, one may deduce that interpretation bias has a long-term effect on depression, thus indicating that interventions on interpretation bias are important in the prevention of depression. Further research is needed to reveal causal relationships between interpretation bias and depression.

Author contributions

Asuka Sugita, contributed to conception, contributed to analysis and interpretation, drafted manuscript; Shimpei Yoshimura, contributed to conception and design, contributed to acquisition, analysis, and interpretation, drafted manuscript, critically revised manuscript, gave final approval, agrees to be accountable for all aspects of work ensuring itegrity and accuracy.

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