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Mindfulness trait mediates between schizotypy and hallucinatory experiences

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Schizotypy is a personality trait in healthy people that is related to schizophrenic symptoms. People with high schizotypy tend to have hallucinatory experiences. The relationship between high schizotypy and hallucinatory experiences could be explained by mindfulness traits and stress. To test our hypothesized model, we conducted a preregistered online survey in a Japanese non-clinical sample. In the preregistered analysis, structural equation modeling revealed that our model insufficiently fit our data and stress did not mediate between schizotypy and hallucinatory experiences. However, consistent with our hypothesis, mindfulness traits mediated between them. Exploratory analysis revealed that the model including three facets of mindfulness traits (i.e., observing, acting with awareness, and non-judging) as mediators fit our data best. These findings suggest that attention to current experiences could be a key factor in understanding the cognitive mechanisms underlying hallucinatory experiences in schizotypy and hallucinations in schizophrenia.

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Introduction

Patients with schizophrenia often have hallucinations, a false perceptual experience that is generated even when an external input does not exist. Hallucination can occur in any modality, particularly in auditory (Zhuo et al., 2019). Altered activity in the anterior insula, the region widely related to the psychological and bodily self, has been found in schizophrenia patients with auditory hallucination, and this points to evidence of deficits in self-monitoring underlying hallucination: the ability to judge whether a sensory signal is of internal or external origin (Yang et al., 2020). Schizophrenia patients also have deficits in reality monitoring (Mondino et al., 2019), resulting in the misattribution of internal events or signals as external sources. These results suggest that there is a mechanism for discriminating between the internal and external events underlying hallucinations. For instance, in auditory hallucinations, patients misattribute their own vocalization as others, and then they hear voices chronically; nevertheless, nobody is talking to them. Such misattribution is explained by a motor control system called the comparator model, where these misattributions and hallucinations are deficits in the prediction of one's own actions (Frith et al., 2000). However, discriminating between self and others involves many regions and complex connectivity in the brain (Murray et al., 2012), therefore it may be difficult to understand how we distinguish between internal sources and external sources of information to create a model by neurological findings. Thus, the cognitive mechanisms of hallucination are unclear, and the present study focused on other possible factors of hallucination using an analog study with non-clinical people.

Non-clinical people also have experiences like hallucinations, which are referred to as hallucinatory experiences (Moseley et al., 2021). Schizotypy, a personality trait in healthy people related to schizophrenic symptoms (Raine, 1991), includes three subtypes, each of which correlates with positive, negative, and disorganized symptoms in schizophrenia. Notably, people with high schizotypy tend to have hallucinatory experiences (de Leede-Smith and Barkus, 2013). Therefore, it is thought that higher schizotypy is a risk factor for schizophrenia (Ettinger et al., 2015). In addition, studying healthy individuals with psychopathological traits allows us to examine relationships between psychological variables specific to that psychopathology while removing potential confounding effects of medication and concurrent disorders. Thus, studies of schizotypy are useful analog studies for understanding the perception of schizophrenia. The present study aimed to reveal the cognitive mechanisms of hallucinatory experiences in highly schizotypal people, and it may be beneficial for understanding hallucinations.

There is some evidence that helps to reveal the relationship between schizotypy and hallucinatory experiences. Some previous studies have shown an association between positive schizotypy and hallucinatory experiences (e.g., Tsakanikos and Reed, 2005). Reed et al. (2016) partly explained this association. They conducted an experiment using short-term mindfulness training and found that hallucinatory experiences in positive schizotypy were reduced by mindfulness training. Mindfulness is defined as paying attention in a particular way: on purpose, in the present moment, and non-judgmentally (Kabat-Zinn, 1994). Mindfulness trait is composed of five facets: observing (attending to or noticing internal and external stimuli, such as sensations, emotions, cognitions, sights, sounds, and smells), describing (noting or mentally labeling these stimuli with words), acting with awareness (attending to one's current actions, as opposed to behaving automatically or absent-mindedly), non-judging (refraining from evaluation of one's sensations, cognitions, and emotions), and non-reactivity (allowing thoughts and feelings to come and go, without attention getting caught up in them) (Carmody and Baer, 2008). Mindfulness training, which is generally based on meditation, enhances mindful experiences or perceptions and then reduces stress or promotes health, mental abilities, and cognitive abilities (Tang et al., 2015). Thus, it is possible that people with high positive schizotypy have low mindfulness traits. Although it is not clear which aspects of mindfulness influence hallucinatory experiences in positive schizotypy in Reed et al. (2016), positive schizotypy is negatively correlated with non-judging (Bronchain and Chabrol, 2020).

A previous study showed that negative and disorganized schizotypy also affects hallucinatory experiences. Stress generally leads to illness or psychosis (Howes and Murray, 2014), and schizotypy and hallucinatory experiences are also shown to be influenced by stress (diathesis-stress model; Zubin, 1983). When people have a stable psychotic-like trait or personality, such as schizotypy, acute stress can trigger psychotic diseases. Grant and Hennig (2020) suggested that those with negative and disorganized schizotypy tend to have psychotic-like experiences, including hallucinatory experiences as stress is increased, while positive schizotypy correlates with psychotic-like experiences irrespective of stress. Additionally, relationships between hallucinatory experiences and mindfulness traits, especially acting with awareness, non-judging, and non-reactivity, have also been mediated by stress: low mindfulness trait leads to high-level stress and then leads to hallucinations (Hosseini et al., 2021). Regarding relationships with negative and disorganized schizotypy and these three facets, both negative and disorganized schizotypy have negative correlations with acting with awareness and non-judging (Bronchain and Chabrol, 2020).

Thus, both mindfulness traits and stress may be factors involved in the relationship between hallucinatory experiences and schizotypy, but the mechanisms remain unclear. From (Reed et al.'s, 2016) results, it is unclear whether the mindfulness trait is a complete or partial mediator between them. According to the diathesis-stress model, stress may be a partial mediator between them. This study aimed to reveal the roles of each of these two mediators in the relationship between schizotypy and hallucinatory experiences.

In summary, we conducted an analog study using an online survey of non-clinical individuals to identify factors associated with hallucinatory experiences in schizotypy. We hypothesized that mindfulness trait and stress would mediate between schizotypy and hallucinatory experiences (Fig. 1A). In particular, high positive schizotypy increases hallucinatory experiences mediated by low mindfulness traits, especially non-judging, irrespective of stress. High negative and disorganized schizotypy will increase hallucinatory experiences mediated by low mindfulness traits, especially acting with awareness and non-judging, and high-level stress.

Methods

The methods used in this study were preregistered on the Open Science Framework (https://osf.io/ke28h).

Participants. In total, 715 Japanese adults participated in the online survey. Participants were recruited through a crowdsourcing website (Lancers; https://www.lancers.jp/) from the general Japanese population aged ≥18 years. We determined the sample size according to studies that showed the necessary sample size for structural equation modeling (SEM) (e.g., Streiner, 2005; Wolf et al., 2013) and collected data until valid responses reached 450–500. We analyzed data from 458 participants (245 males, 208 females, and 5 unknowns, Age; Mean = 42.56, SD = 10.13, range = 20–76) who reported having no history of neurological

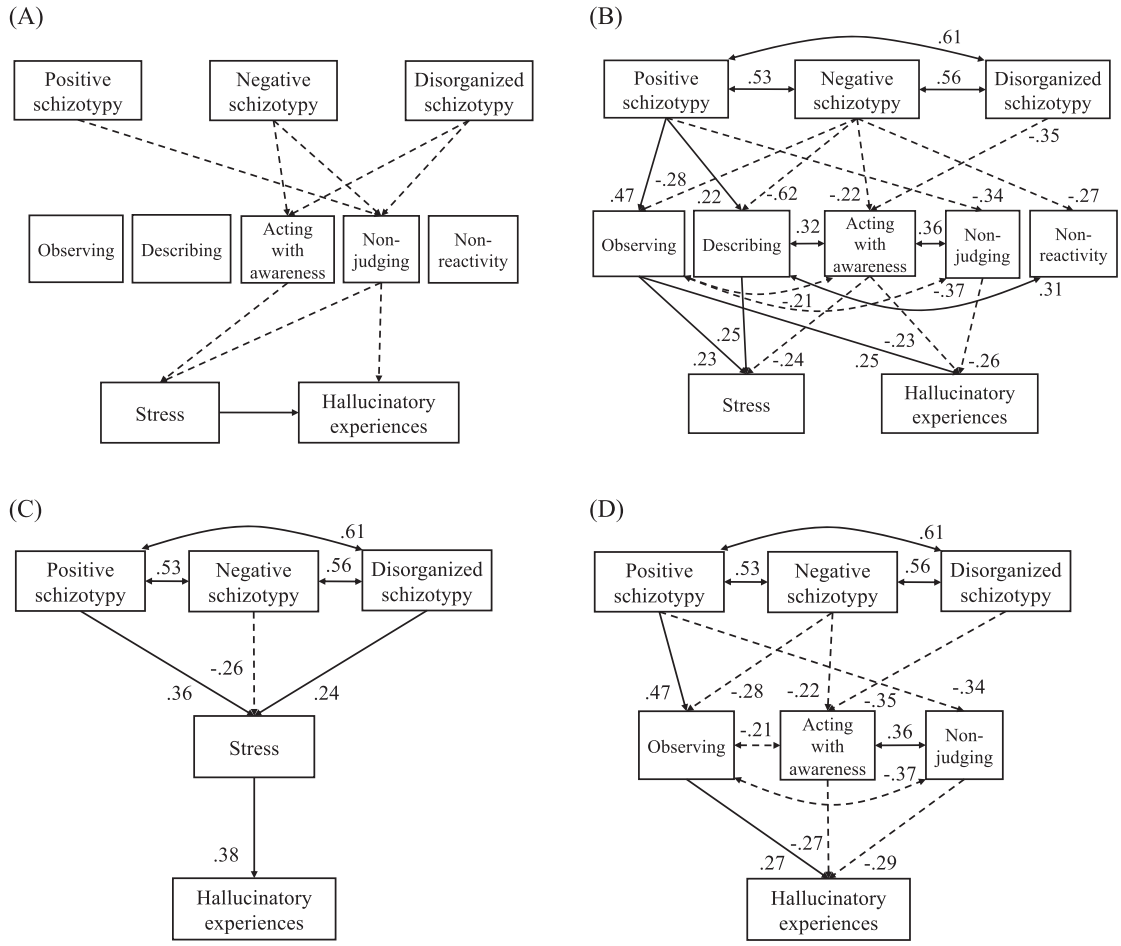

Fig. 1 Models explaining hallucinatory experiences. A Hypothesis of the present study and (**B**) results of structural equation modeling for the hypothesized model, (**C**) stress model, and (**D**) mindfulness three facets model. Solid lines mean positive effects and broken lines mean negative effects. Only significant path coefficients ($p < 0.05$) are shown in (**B–D**).

and psychiatric disorders and passed the instructional manipulation checks (IMC; Oppenheimer et al., 2009). We used one original question about hobbies and habits, according to Oppenheimer et al. (2009) as IMC. The socioeconomic status of the participants was not recorded. This study was approved by the local ethics committee.

Measures

Schizotypy. The Japanese version (Iijima et al., 2010) of the Schizotypal Personality Questionnaire (SPQ; Raine, 1991) was used to assess schizotypy. The convergent validity of the SPQ with the Japanese version (Gregory et al., 2003) of the Schizotypal Personality Scale (Claridge and Broks, 1984) was adequate ($r = 0.70$; Iijima et al., 2010). The SPQ includes three subscales: cognitive-perceptual, interpersonal, and disorganized. Each is an index of positive, negative, and disorganized schizotypy. The SPQ has 74 items and participants responded with yes/no responses (Cronbach's alpha = 0.91; Iijima et al., 2010). The "yes" responses were coded as a score of 1, and the "no" responses were coded as 0. Higher scores indicate higher levels of schizotypy.

Mindfulness trait. We used the Japanese version (Sugiura et al., 2012) of the Five Facets Mindfulness Questionnaire (FFMQ; Carmody and Baer, 2008) including five subscales: observing, describing, acting with awareness, non-judging, and non-reactivity. These five subscales were revealed by factor analysis of some mindfulness scales such as the Mindfulness Attention Awareness Scale (Brown and Ryan, 2003). The convergent validity of the subscales of the FFMQ was confirmed by correlations with cognitive control, metacognition, emotion regulation, and psychopathological symptoms (Sugiura et al., 2012). This scale has 39 items (Cronbach's alpha = 0.80; Sugiura et al., 2012), and each item is rated on a five-point scale (1 = never, 5 = very often). Higher scores indicate higher levels of the mindfulness trait.

Stress. We used the Japanese version (Mimura and Griffiths, 2004, 2008) of the Perceived Stress Scale (PSS; Cohen et al., 1983), which assesses perceived stress over the previous month. Convergent validity of the PSS has been suggested by correlations with psychopathological traits such as depression ($r = 0.76$; Cohen et al., 1983). The PSS has 14 items (Cronbach's alpha = 0.89; Mimura and Griffiths, 2008), and each item is rated on a five-point scale (0 = never, 4 = very often). Higher scores indicate higher levels of perceived stress in daily life.

Hallucinatory experiences. We used a brief version of the Auditory Hallucination-like Experiences Scale (AHES-17; Asai et al., 2011b) based on the Auditory Hallucination-like Experiences Scale (Sugimori et al., 2009). The AHES-17 is a Japanese scale for assessing auditory hallucinatory experiences and its convergent validity was confirmed by correlation ($r = 0.69$; Asai et al., 2011a) with the Launay-Slade Hallucination Scale for measuring hallucinatory experiences (Launay and Slade, 1981). The AHES-17 has

17 items (Cronbach's alpha = 0.85; Asai et al., 2011a), each rated on a five-point scale (0 = never, 4 = very often). Higher scores indicate higher levels of auditory hallucinatory experiences.

Procedures. Participants completed a questionnaire comprising demographic questions, four scales, and IMC items, using the SurveyMonkey website on their own computers. The participants were asked to respond in a quiet environment. Demographic questions (age, sex, mother tongue, history of neurological and psychiatric disorders) were presented first. The order of the scales was randomized, and the IMC items were presented at the end of the questionnaire. Informed consent was obtained from each participant prior to the survey. After completing the survey, all participants were paid 100 yen as a reward.

Data analysis. We calculated descriptive statistics and correlations and conducted SEM to reveal the relationship between the variables of interest. To evaluate the model fit, we used chi-square, comparative fit index (CFI), root mean square error of approximation (RMSEA), standard root mean square error of approximation (SRMR), goodness of fit index (GFI), and adjusted GFI (AGFI). We relied on non-significant chi-square, CFI, GFI, and AGFI of 0.90 or greater, RMSEA, and SRMR of 0.05 or lower as indices of sufficient fit. However, we place importance on indices without chi-square because chi-square tends to show significance (i.e., the hypothesized model does not fit the observed data) in a large sample size study (Gatignon, 2010). In pre-registered analysis, we tested the hypothesized model, and then we conducted an exploratory analysis to test mediations by stress and mindfulness traits separately. SEM was conducted using the lavaan package 0.6-6 (Rosseel, 2012) for R 4.0.2 (R Core Team, 2020). Other analyses were conducted using JASP 0.12.2 (JASP Team, 2020).

Results

Preregistered analysis. Descriptive statistics and correlations are summarized in Tables 1 and 2. As a result of SEM, some fit indices showed that the hypothesized model (Fig. 1B) sufficiently fitted the data (GFI = 0.973, SRMR = 0.042, CFI = 0.963), but others showed that the model was insufficient ($\chi^2(6) = 67.700$, $p < 0.001$, AGFI = 0.752, RMSEA = 0.150).

Exploratory analysis. Our model, which assumes that hallucinatory experiences in schizotypy are mediated by stress and mindfulness, did not perfectly fit the observed data. Contrary to our hypothesis, stress did not have a significant effect on hallucinatory experiences. Thus, we performed an exploratory analysis to examine mediations by stress and mindfulness traits separately and then compared the hypothesized model and exploratory models to judge which model best fitted our data.

Table 1 Descriptive statistics ($n = 458$).

	Mean	SD	Min	Max	α
Schizotypy (SPQ)					
Positive	8.42	5.89	0	29	0.88
Negative	16.84	8.08	0	33	0.92
Disorganized	4.98	3.64	0	16	0.82
Mindfulness trait (FFMQ)					
Observing	21.58	4.69	8	35	0.77
Describing	23.03	5.63	8	40	0.89
Acting with awareness	26.98	5.20	10	40	0.86
Non-judging	25.77	5.27	11	40	0.87
Non-reactivity	20.12	3.88	7	32	0.74
Stress (PSS)	23.14	6.07	4	45	0.74
Hallucinatory experiences (AHES-17)	24.14	11.73	0	57	0.90

Effects of stress. We tested whether hallucinatory experiences in schizotypy were mediated by stress (Fig. 1C). SEM revealed that only GFI was sufficient (GFI = 0.926), and other indices were insufficient ($\chi^2(3) = 102.222$, $p < 0.001$, CFI = 0.855, RMSEA = 0.269, SRMR = 0.136, AGFI = 0.630). Thus, the hypothesized model fitted our data better than this stress model, although the path coefficients from schizotypy to stress and stress to hallucinatory experiences were significant.

Effects of mindfulness. We also tested whether hallucinatory experiences in schizotypy were mediated by mindfulness traits (the mindfulness trait model). SEM revealed that some indices were sufficient (CFI = 0.972, SRMR = 0.033, GFI = 0.980), while others were insufficient ($\chi^2(3) = 44.196$, $p < 0.001$, RMSEA = 0.173, AGFI = 0.700). Additionally, we tested the model excepted two mindfulness facets, describing and non-reactivity, which did not mediate between schizotypy and hallucinatory experiences (Fig. 1D; the mindfulness three facets model), and SEM revealed that some indices were sufficient (CFI = 0.964, SRMR = 0.044, GFI = 0.974), but others were insufficient ($\chi^2(3) = 45.433$, $p < 0.001$, RMSEA = 0.176, AGFI = 0.755).

According to the fit indices, the hypothesized model, the mindfulness trait model, and the mindfulness three facets model fitted our data equivalently. Akaike information criterion (AIC) is the relative index: a smaller value indicates that the model fits the data better than other models. Regarding AIC, the mindfulness three facets model (AIC = 19,425.249) was a good model to explain our observed data compared with the hypothesized model (AIC = 27,348.274) and the mindfulness trait model (AIC = 24,358.496). Thus, the three factors of mindfulness trait, observing, acting with awareness, and non-judging were strong mediators.

Discussion

Summary of results. The present preregistered study collected data from a sample of Japanese adults and tested the hypothesis that mindfulness and stress mediate between schizotypy and hallucinatory experiences. Preregistered analysis revealed that the observed data did not support our hypothesized model and that stress did not explain the relationship between schizotypy and hallucinatory experiences. However, path coefficients suggested that the mindfulness trait was a mediator, consistent with our hypothesis. We then conducted an exploratory analysis to test mediations by mindfulness trait and stress separately. The model that stress alone mediates between schizotypy and hallucinatory experiences did not fit our data. On the other hand, the model with three mindfulness facets (i.e., observing, acting with awareness, and non-judging mediate between schizotypy and hallucinatory experiences) fitted our data the best. Although a completely fitted model was not found.

Mindfulness trait as a mediator. The mindfulness three facets model has three features, suggesting that mindfulness trait mediates between schizotypy and hallucinatory experiences. First, positive schizotypy strengthens attention to internal and external experiences (i.e., increases observing), and then increases hallucinatory experiences. The positive correlation between observing and hallucinatory experiences corresponds with Hosseini et al. (2021). Observing is the aspect of noticing sensation, perception, or emotion, so it may increase the vividness of experiences. The increased vividness of experiences could affect judgements

Table 2 Pearson's *r* correlation coefficients between variables ($n = 458$).

	1	2	3	4	5	6	7	8	9
1. Positive									
2. Negative	0.532								
	<0.001								
3. Disorganized	0.606	0.559							
	<0.001	<0.001							
4. Observing	0.377	0.020	0.219						
	<0.001	0.663	<0.001						
5. Describing	−0.120	−0.505	−0.217	0.189					
	0.016	<0.001	<0.001	<0.001					
6. Acting with awareness	−0.363	−0.433	−0.491	−0.257	0.419				
	<0.001	<0.001	<0.001	<0.001	<0.001				
7. Non-judging	−0.418	−0.307	−0.298	−0.436	0.189	0.465			
	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			
8. Non-reactivity	−0.072	−0.263	−0.185	0.187	0.394	0.213	0.069		
	0.124	<0.001	<0.001	<0.001	<0.001	<0.001	0.142		
9. Stress	0.364	0.062	0.309	0.423	0.180	−0.263	−0.331	0.120	
	<0.001	0.185	<0.001	<0.001	<0.001	<0.001	<0.001	0.010	
10. Hallucinatory experiences	0.520	0.274	0.385	0.464	−0.114	−0.477	−0.533	−0.129	0.383
	<0.001	<0.001	<0.001	<0.001	0.015	<0.001	<0.001	0.006	<0.001

Upper rows are correlation coefficients and the lowers are *p*-value.

regarding whether experiences are externally or internally generated and then leads to hallucinations (Fazekas, 2021). Thus, it is possible that positive schizotypy makes our experiences more vivid, then leads to hallucinatory experiences, or finally develops into hallucinations in schizophrenia.

Second, positive schizotypy decreases the ability to refrain from judging one's own experiences (i.e., decreases non-judging), and then increases hallucinatory experiences. The finding showing the relationships between high positive schizotypy, low mindfulness trait, and hallucinatory experiences is consistent with a previous study (Reed et al., 2016). This may be related to the first point. If perceptual experiences are unusually vivid (i.e., increasing observing) with high positive schizotypy, people may pay close attention to or be sensitive to stimuli. Thus, they will tend to evaluate their sensations, cognitions, and emotions (i.e., decreasing non-judging).

Third, negative and disorganized schizotypy decreases attention to one's actions (i.e., decreases acting with awareness), and then increases hallucinatory experiences. Hosseini et al. (2021) also found a negative correlation between acting with awareness and hallucinatory experiences. Deficits in attending to current actions may affect self-monitoring (i.e., the ability to recognize that a sensory signal has an internal origin and monitor one's own behavior). Some studies have suggested that deficits in self-monitoring explain auditory hallucinations (e.g., Yang et al., 2020). Negative and disorganized schizotypy may lead to problems in monitoring one's own behavior, followed by hallucinatory experiences or hallucinations.

Taken together, attention to current experiences could be a key factor in understanding the cognitive mechanisms underlying hallucinatory experiences in schizotypy and hallucinations in schizophrenia. People with high schizotypy might have disrupted attention to their own actions, while they have been attracted attention to signals, which result from actions. Consequently, some cognitive abilities, such as self-monitoring, which play important roles in normal perception, are reduced.

Stress as a mediator. Contrary to our hypothesis, stress did not fully explain the relationship between schizotypy and hallucinatory experiences. This result may be due to some differences between the previous and present studies. Grant and Hennig (2020) treated stress manipulated by tasks, whereas we used self-reported stress. There was a difference between acute stress during the experiments and chronic stress during the last month. It is possible that a momentary increase in stress temporarily triggers psychotic-like experiences, including hallucinatory experiences, although persistent stress does not have a critical effect on hallucinatory experiences with schizotypy.

However, this result does not contradict the diathesis-stress model, suggesting that stress leads to psychosis, especially in people with a high psychotic-like personality. More rapid or acute stress trigger illness, whereas people will have tolerance for intermediate stress if they are exposed to it for a few weeks or a month. Furthermore, we observed significant paths from schizotypy to stress and from stress to hallucinatory experience. Thus, it is premature to conclude that stress does not affect hallucinatory experiences. Future studies should use experimental approaches to examine the influence of stress on hallucinatory experiences.

Limitations and future studies. First, this study did not affirm the causal relationship between schizotypy, hallucinatory experiences, mindfulness, and stress because our survey was cross-sectional and did not include instrumental variables. Thus, as stated above, future experimental studies are necessary to reveal the cognitive mechanisms underlying hallucinatory experiences. Second, we assessed auditory hallucinatory experiences only; therefore, further studies are needed to examine other modalities and reveal whether a common mechanism underlying some modalities exists. This may help to understand why hallucinations are likely to occur in auditory rather than other modalities. Finally, our findings could be limited to a Japanese sample with an average age of 42 years. The three-factor model of schizotypy we adopted has been found not only in Japan (Iijima et al., 2010) but also in Italy (Fossati et al., 2003) and Mauritius (Reynolds et al., 2000). However, other studies of young men in the Greek Air Force (Stefanis et al., 2004) and college students in the USA and Spain (Fonseca-Pedrero et al., 2014) have suggested a four-factor model (i.e., positive, negative, disorganized, and paranoid). Thus, the relationships between schizotypy, mindfulness trait, stress, and hallucinatory experiences may vary by culture and age. Further studies with other samples should be conducted to examine the

generalizability of our findings. These future studies can be beneficial for revealing hallucinations and developing methods to prevent or treat hallucinations. For instance, mindfulness training may reduce hallucinations because it can reduce stress, depression, and various psychiatric symptoms (Creswell, 2017).

Conclusions. We conducted an online survey to determine the relationships between schizotypy, hallucinatory experiences, mindfulness, and stress. A complete fitted model was not found, and stress did not explain hallucinatory experiences in schizotypy. However, consistent with our hypothesis, the mindfulness trait did mediate between schizotypy and hallucinatory experiences. In particular, three factors of mindfulness traits (observing, acting with awareness, and non-judging) were important mediators. These results indicate that attention to current experiences and actions plays a role in hallucinatory experiences and hallucinations. This implication may be consistent with the theory positing that hallucinations stem from disrupted self-monitoring. Further experimental studies should be conducted to elucidate the cognitive mechanisms of hallucinations.

Data availability

Data associated with this study has been deposited at Open Science Framework (https://osf.io/vx67u/).

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Author contributions

UT conceived the study, collected the data, analyzed the data, and drafted the manuscript. SI supervised the study, and reviewed and edited the manuscript. All authors approved the final version of the manuscript for submission.

Competing interests

The authors declare no competing interests.

Ethical approval

This study was approved by the ethics committee of Ochanomizu University (approval number: 2020-61).

Informed consent

Informed consent about the purpose of the study and the ways the data used was obtained from all participants.

Additional information

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