Manuscript title: Associations between intrusive thoughts, reality discrimination, and hallucination-proneness in healthy young adults

Running head: Hallucination-proneness and intrusions

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ABSTRACT

Introduction. People who experience intrusive thoughts are at increased risk of developing hallucinatory experiences, as are people who have weak reality discrimination skills. No study has yet examined whether these two factors interact to make a person especially prone to hallucinatory experiences. The present study examined this question in a non-clinical sample.

Methods. Participants were 160 students, who completed a reality discrimination task, as well as self-report measures of cannabis use, negative affect, intrusive thoughts, and auditory hallucination-proneness. The possibility of an interaction between reality discrimination performance and level of intrusive thoughts was assessed using multiple regression.

Results. The number of reality discrimination errors and level of intrusive thoughts were independent predictors of hallucination-proneness. The reality discrimination errors × intrusive thoughts interaction term was significant, with participants who made many reality discrimination errors and reported high levels of intrusive thoughts being especially prone to hallucinatory experiences.

Conclusions. Hallucinatory experiences are more likely to occur in people who report high levels of intrusive thoughts and have weak reality discrimination skills. If applicable to clinical samples, these findings suggest that improving patients' reality discrimination skills and reducing the number of intrusive thoughts they experience may reduce the frequency of hallucinatory experiences.

Keywords: reality discrimination; signal detection; intrusive thoughts; hallucination-proneness.

INTRODUCTION

Cognitive models propose that auditory hallucinations (AH) occur when an internal mental event is misattributed to an external source (e.g., Bentall, 1990; Waters et al., 2013). It has been suggested that intrusive thoughts may be the mental events that are misattributed to become AH (Morrison, Haddock, & Tarrier, 1995). In part, this is because both intrusive thoughts and AH have been described as being unwanted, uncontrollable, and distressing (Rachman, 1978, 1981; Nayani & David, 1996). In addition, it has been argued (e.g., Bentall, 2003) that the unbidden nature of intrusive thoughts means that they tend to lack features that suggest to a person that they were the author of that thought (i.e., they are not associated with any cognitive effort). Thus, intrusive thoughts are more likely to be attributed to an external source, and so be experienced as an AH. Empirical evidence is consistent with these claims. For example, studies with clinical populations have shown that patients who experience AH report more intrusive thoughts than do patients who do not experience AH (Lobban, Haddock, Kinderman, & Wells, 2002; Morrison & Baker, 2000). Meanwhile, studies with non-clinical participants have shown that participants who report high levels of intrusive thoughts also report high levels of AH-proneness (Jones & Fernyhough, 2006, 2009). There are, therefore, good theoretical and empirical reasons to believe that intrusive thoughts may be the ‘raw materials’ of AH.

Another factor that appears to play a role in the development of AH is reality discrimination. Reality discrimination refers to the process by which a person distinguishes between internal, self-generated and external, other-generated events (Bentall, 1990). One way of assessing reality discrimination is through an auditory signal detection task (SDT). In such a task, participants must try to detect a signal (typically a small amount of speech) in an ambiguous auditory stimulus (typically white noise). On some trials the signal is present; on other trials the signal is absent. Reality discrimination errors occur when a participant makes a false alarm – that is when they perceive speech to be present in the white noise when it is absent. Presumably, when a false alarm occurs, participants have mistaken their internal representation of the signal (the speech) for the external signal. A recent meta-analysis (Brookwell, Varese, & Bentall, 2013) has shown that psychotic participants who experience AH, and non-clinical participants who are prone to AH, have biased reality discrimination, so that they make more false alarms than do control participants when performing these tasks, suggesting that they have a tendency to misattribute internally-generated events to an external source.

Bentall (2003) has argued that a person who experiences high levels of intrusive thoughts *and* has poor reality discrimination abilities should be especially prone to AH, as they will frequently experience cognitions that lack the characteristics of self-generated events, and they will be predisposed towards mistaking internal, self-generated events for external, other-generated events. No study has yet examined whether this is the case. Therefore, in the present study we examined this possibility by investigating, in an analogue sample, whether a combination of poor reality discrimination skills and intrusive thoughts placed a person at an especially high risk of AH.

METHOD

Participants

Participants were 160 university students (137 women), aged 18-38 years (M = 21.08, SD = 3.44), who received course credit or a small payment in return for their time. Participants had a good understanding of English, did not have a history of head injury of neurological problems, and did not have any hearing problems.

Procedure

The study was approved by a departmental ethics committee and was conducted in accordance with the principles of the Declaration of Helsinki. After providing informed consent, participants completed the signal detection task and a questionnaire battery, which included the measures below.

Demographics. Participants provided their age, gender, ethnicity, and reported their perceptions of their parents' income during childhood on a 5-item scale (1 = *Much less than enough money to meet our needs*; 5 = *Much more than enough money to meet our needs*; Teicher, Samson, Sheu, Polcari, & McGreenery, 2010).

Intrusive thoughts. Participants' susceptibility to intrusive thoughts was assessed using the 5-item intrusions subscale of the White Bear Suppression Inventory (WBSI; Muris, Merckelbach, & Horselenberg, 1996; Wegner & Zanakos, 1994). These five items describe various aspects of thought intrusions (e.g., "I have thoughts I cannot stop") and participants indicate to what extent they agree with each statement on a 5-point scale (1 = *Strongly disagree*; 5 = *Strongly agree*). Thus, scores can range from 5–25, with higher scores reflecting a higher level of intrusive thoughts. The scale had good internal reliability (α = .84).

AH-proneness. AH-proneness was assessed using the nine items from the Cardiff Anomalous Perceptions Scale (CAPS; Bell, Halligan, & Ellis, 2006) that assess unusual auditory experiences. These nine items ask whether participants have experienced various unusual auditory percepts (e.g., "Do you ever hear noises or sounds when there is nothing around to explain them?"). Participants rate how often they have had these experiences on a 6-point scale (0 = *Never*; 5 = *Happens all the time*), so that scores can range from 0–45, with higher scores reflecting greater AH-proneness. The scale had good internal reliability (α = .81).

Negative affect. Negative affect was assessed using items from the Positive and Negative Affect Schedule (Watson, Clark, & Tellegen, 1988). This scale consists of words that describe negative affect (e.g., scared, irritable, distressed) and participants are asked to indicate to what extent they generally feel each affective descriptor on a 5-point Likert scale (1 = *Very slightly or not at all*; 5 = *Extremely*). Scores on the negative affect subscale range from 10 to 50, with higher scores reflecting higher levels of negative affect. The scale had good internal reliability (α = .88).

Cannabis use. Cannabis use was assessed using the revised Cannabis Use Disorders Identification Test (CUDIT-R; Adamson et al., 2010). Cannabis use is not a variable of central interest in this study, but should be controlled for, given the associations between cannabis use and hallucinatory experiences in non-clinical populations (Kelleher & Cannon, 2011). For the present analysis, only data collected from the first item of the CUDIT-R was used. This item asks about the frequency of cannabis use over the past six months and participants respond on a 5-point Likert scale (0 = *Never*; 4 = *Four or more times per week*).

Auditory signal detection task. To assess reality discrimination, participants completed the auditory signal detection task (SDT) described in Barkus, Stirling, Hopkins, McKie, and Lewis (2007). This task consisted of 60 trials, with each trial consisting of a five second burst of white noise followed by three seconds of silence. In 34 of the bursts of white noise, one second of speech was presented. In the remaining 26 bursts of white noise, no speech was presented. In 12 of the trials when speech was presented, the speech was clearly audible. In the remaining 22 trials, the speech was presented at an auditory threshold. This threshold was determined prior to the start of testing by establishing the volume of speech that was perceived by 50% of a small sample (n = 10) of participants who were around the same age as the experimental participants. The task was presented to participants on a laptop computer, using the audio recording and playback software package Cakewalk (www.cakewalk.com). Stimuli were presented using standard Sony headphones. Participants were asked to decide whether or not speech had been presented in each burst of white noise, and to respond via a button press during the three seconds of silence that followed the white noise.

Following Barkus et al. (2011), the number of false alarms made (i.e., trials where participants had responded that the speech was present in the white noise when it was in fact absent) was used as our primary measure of reality discrimination. In addition, the number of hits a participant made (i.e., trials where a participant correctly responded that the speech was present in the white noise), *d'* (or perceptual sensitivity; i.e., a participant's ability to discriminate between trials where speech was present and trials where speech was absent), and non-parametric β (or response bias; i.e., a participant's tendency, across all trials, to respond that speech was present in the white noise) were recorded. β and *d'* were calculated using the formulae described in Barkus et al. (2007). The number of false alarms made could range from 0 to 26, with a larger number of false alarms indicating weaker reality discrimination. The number of hits made could range from 0 to 34. Non-parametric β could vary between -1 and 1, with negative values indicating a more liberal response bias (i.e., a bias towards responding that speech is present in the white noise) and positive values indicating a more conservative response bias (i.e., a bias towards responding that speech is not present in the white noise). *d'* values of zero indicate an inability to discriminate between trials where speech is present and trials where speech is absent, with more positive values indicating a better ability to discriminate between trials where speech is present and trials where speech is absent.

RESULTS

Descriptive statistics and preliminary analyses

For all demographic variables, dichotomous groups were created. In terms of ethnicity, the sample was divided into those who reported being White British (*n* = 121), and those who reported belonging to another ethnic group (*n* = 39). In terms of perceived parental income, participants were divided into one group who reported that their parents' income was less than, or much less than enough to meet their needs (n = 18) and a second group who reported that their parents' income was enough, more than enough, or much more than enough to meet their needs (n = 141; one participant did not report perceived parental income). In terms of cannabis use, participants were divided into those who had used cannabis in the past six months (n = 131) and those who had not (n = 28; one participant did not report their cannabis use). Differences between these groups in terms of level AH-proneness were not significant (all p-values > .18). Descriptive statistics for all variables are presented in Table 1.

(Table 1 about here)

Correlational and multiple regression analyses

Correlations between variables are also presented in Table 1. A Bonferroni correction was applied, meaning that a significance level of α' = .008 was employed. Not all participants provided complete data. As a result, the size of N varies from 153 to 159 for the correlational analyses. Higher levels of negative affect, intrusive thoughts, more false alarms, more hits, lower values of β, and lower values of d' were all associated with higher levels of AH-proneness.

A linear regression was conducted to identify independent predictors of AH-proneness. As shown in Table 2, age, gender, ethnicity, perceived parental income, cannabis use, and negative affect were entered as predictors in the first block. In the second block, intrusive thoughts and number of false alarms were entered, with the intrusive thoughts × number of false alarms interaction term entered in the third block. Collinearity diagnostics for this regression were satisfactory (minimum tolerance = .72; average VIF = 1.22), and residuals appeared to be both independent and normally distributed. The initial model was significant, $F(6, 146) = 5.45$, $p < .001$, adjusted $R^2 = .15$. In this model, only negative affect was an independent predictor of AH-proneness. Inclusion of intrusive thoughts and number of false alarms improved the model, $F(8, 144) = 11.55$, $p < .001$, $\Delta R^2 = .21$. In this revised model, intrusive thoughts and number of false alarms were independent predictors of AH-proneness. Inclusion of the interaction term also improved the model. $F(9, 143) = 11.03$, $p < .001$, $\Delta R^2 = .02$. In this revised model, intrusive thoughts, number of false alarms, and the interaction term were independent predictors of AH-proneness.

(Table 2 about here)

To interpret the intrusive thoughts × number of false alarms interaction effect, ModGraph (Jose, 2013)—a programme that graphically displays interaction effects—was employed. As shown in Figure 1, when participants experienced low levels of intrusive thoughts, they were unlikely to be AH-prone. This was true for participants who made a low, moderate, or high number of false alarms. However, as participants reported more intrusive thoughts, good reality discrimination abilities were associated with a reduction in the risk that participants would be AH-prone. That is, participants who reported high levels of intrusive thoughts, but made few false alarms, were less likely to be AH-prone than were participants who experienced high levels of intrusive thoughts and made many false alarms.

The above regression analysis was repeated using *d'* and β, rather than number of false alarms, as measures of reality discrimination. The results of these additional analyses were similar to the original analysis. However, while β was an independent predictor of AH-proneness ($p = .017$), *d'* was an independent predictor of AH-proneness at a trend level only ($p = .07$), and while the intrusive thoughts × *d'* interaction term was significant ($p = .012$), the intrusive thoughts × β interaction term was only significant at a trend level ($p = .09$).

(Figure 1 about here)

DISCUSSION

The present study showed that high levels of intrusive thoughts and weak reality discrimination abilities are independent predictors of AH-proneness in non-clinical participants. Importantly, the present study also showed these two factors interact, so that people who report high levels of intrusive thoughts *and* have weak reality discrimination abilities are especially prone to AH. These findings are consistent with a number of previous studies and with current models of AH, as outlined below.

The association between intrusive thoughts and AH-proneness reported here is consistent with findings from a number of other non-clinical studies (Jones & Fernyhough, 2006, 2009). These findings from analogue studies are consistent with data from studies that have employed clinical samples, where patients who experience AH report more frequent intrusive thoughts than do patients who do not experience AH (e.g., Lobban et al., 2002; Morrison & Baker, 2000). Together, these studies provide support for the idea that intrusive thoughts may be the raw material of AH, as suggested by Morrison et al. (1995).

The relation between reality discrimination problems and AH-proneness reported here is concordant with a number of analogue (e.g., Barkus et al., 2007) and clinical studies (e.g., Varese, Barkus, & Bentall, 2012), as well as a recent meta-analysis that synthesized this data (Brookwell et al., 2013). Together, these findings support the argument that people who experience AH tend to misattribute internal, self-generated events to an external, non-self source, a claim that is central to most models of AH (e.g., Bentall, 1990; Waters et al., 2013). In addition, the interaction effect reported here supports Bentall's (2003) prediction that a person who experiences high levels of intrusive thoughts *and* who has weak reality discrimination skills will be at especially high risk of developing AH. This result extends current models of AH in important ways, by emphasizing that AH are most likely to occur when multiple risk factors are present, and by suggesting that, in the absence of intrusive cognitions that can form the raw material of an AH, weak reality discrimination abilities may not elevate a person's risk of experiencing AH.

The present study suffered from a number of limitations. First, the data are cross-sectional, meaning that the causal links between variables are difficult to interpret. Second, while the measure of AH-proneness employed here does not suffer from some of the weaknesses of other measures of hallucination-proneness (e.g., the lack of face validity of the subscales of Morrison, Wells, & Nothard's (2000) Revised Launay-Slade Hallucination Scale, or the relatively low internal reliability of McCarthy-Jones & Fernyhough's, 2011, Revised Hallucination Scale), some of its psychometric properties (e.g., test-retest reliability) have not yet been established. Third, and most importantly, we have employed a non-clinical sample, and so it is unclear whether these findings will be helpful in understanding AH experienced by clinical populations (David, 2010). In a recent review, Badcock and Hugdahl (2012) outlined areas of continuity and discontinuity in the cognitive mechanisms thought to underlie AH in clinical and non-clinical groups. While they identify some apparently shared mechanisms (including the role of intrusive cognitions in both groups), Badcock and Hugdahl emphasize aspects of discontinuity (e.g., contextual binding seems to be weak in clinical, but not in non-clinical, groups). Badcock and Hugdahl, therefore, recommend that researchers adopt a more critical stance towards the continuum model of AH, and so should not assume that findings from analogue studies will be replicated in clinical populations. Consequently, one should be cautious and not assume that the present results can aid our understanding of AH in clinical groups. Research that examines the associations between intrusive thoughts, reality discrimination, and AH in a clinical sample is, thus, required.

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TABLE 1

Descriptive statistics for, and correlations between, measures of negative affect, intrusive thoughts, number of false alarms, number of hits, β, *d'*, and auditory hallucination-proneness

Variable	Mean	SD	Minimum – maximum	2	3	4	5	6	7
1. Negative affect	20.02	6.81	10 – 40	.45*	.22*	.10	-.11	-.14	.41*
2. Intrusive thoughts	16.15	4.59	5 – 25		.19	.09	-.12	-.15	.54*
3. False alarms	4.36	4.32	0 – 25			.58*	-.84*	-.81*	.38*
4. Hits	19.82	4.49	12 – 32				-.62*	-.05	.26*
5. β	0.41	0.38	-0.39 to 1					.74*	-.26*
6. *d'*	1.38	0.56	-0.20 to 3						-.25*
7. Auditory hallucination-proneness	7.02	6.21	0 – 32						

*$p < .008$

TABLE 2

Summary of hierarchical analysis for auditory hallucination-proneness

Variable	B	SE B	β
Block 1			
Age	0.01	0.01	.04
Gender	-0.48	1.43	-.03
Ethnicity	1.47	1.16	.10
Parental income	-2.18	1.52	-.11
Cannabis use	-0.57	1.24	-.04
Negative affect	0.38	0.07	.08***
Block 2			
Age	0.00	0.01	.02
Gender	-1.21	1.25	-.07
Ethnicity	0.30	1.02	.02
Parental income	-1.51	1.36	-.08
Cannabis use	-0.04	1.08	.00
Negative affect	0.14	0.07	.15
Intrusive thoughts	0.57	0.10	.42***
False alarms	0.37	0.10	.25***
Block 3			
Age	0.00	0.01	.02
Gender	-1.13	1.23	-.06

Ethnicity	-0.04	1.02	.00
Parental income	-1.48	1.34	-.07
Cannabis use	-0.05	1.07	.00
Negative affect	0.13	0.07	.15
Intrusive thoughts	0.60	0.10	$.42^{***}$
False alarms	0.29	0.10	$.25^{***}$
Intrusive thoughts × false alarms	0.04	0.02	$.15^{*}$

$^{*}p < .05$, $^{***}p < .001$

FIGURE 1

Interaction between level of intrusive thoughts and number of false alarms made during a reality discrimination task.