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Reasoning biases and delusional ideation in the general population: A longitudinal study

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ABSTRACT

Background: Reasoning biases have been suggested as risk factors for delusional ideation in both patients and non-clinical individuals. Still, it is unclear how these biases are longitudinally related to delusions in the general population. We hence aimed to investigate longitudinal associations between reasoning biases and delusional ideation in the general population.
Methods: We conducted an online cohort study with 1184 adults from the German and Swiss general population. Participants completed measures on reasoning biases (jumping-to-conclusion bias [JTC], liberal acceptance bias [LA], bias against disconfirmatory evidence [BADE], possibility of being mistaken [PM]) and delusional ideation at baseline, and delusional ideation 7 to 8 months later.
Results: A greater JTC bias was associated with a greater increase in delusional ideation over the following months. This association was better described by a positive quadratic relationship. Neither BADE, LA nor PM were associated with subsequent changes in delusional ideation.
Conclusions: This study suggests that jumping-to-conclusions predicts delusional ideation in the general population but that this association may follow a quadratic trajectory. While no other associations turned significant, future studies with shorter temporal distances may shed further light on the role of reasoning biases as risk factors for delusional ideation in non-clinical samples.

1. Introduction

Delusions are a core symptom of psychotic disorders (American Psychiatric Association, 2013), a group of disorders that are linked to severe impairments. Over the last decades, various psychological models have posited that next to factors such as negative emotions, self-schemata or disturbed dopaminergic function, distorted cognitive processes may be relevant to understand delusions (Broyd et al., 2017; Freeman, 2016; Garety and Freeman, 2013; Moritz et al., 2017a). Specifically, a growing body of evidence has suggested that reasoning biases may be drawn upon as one set of factors that favor the formation and maintenance of delusions (Everaert et al., 2020; Freeman, 2016; Sastre-Buades et al., 2021). Reasoning biases are systematic distortions within human reasoning, manifesting for instance in aberrant information collection and (mostly) erroneous conclusions (Garety and Freeman, 1999). Meta-analytical literature suggests that delusional individuals tend to jump to conclusions (JTC bias; Dudley et al., 2016; McLean et al., 2017), although more recent evidence seems less conclusive (Moritz et al., 2020; Pytlik et al., 2020; Tripoli et al., 2021). At the same time, studies have acknowledged that delusional individuals display a liberal acceptance (LA) bias, the propensity to accept unsteady working hypotheses (Broyd et al., 2017; McLean et al., 2017), show a stronger bias against integrating disconfirmatory evidence (BADE; Eisenacher and Zink, 2017; Moritz et al., 2017b), and are less willing to consider themselves as being mistaken in their beliefs (reduced possibility of being mistaken, "PM", So et al., 2012).

Interestingly, reasoning biases are also linked to delusion-like experiences in non-psychotic individuals. For instance, a recent meta-analysis by (Livet et al., 2020) indicates that the JTC bias and belief inflexibility bias relate to psychotic-like experiences in individuals with little delusional ideation. Similarly, studies report that a higher BADE (Bronstein and Cannon, 2017; Eisenacher et al., 2016) and LA bias

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(Eisenacher et al., 2016; Reininghaus et al., 2016) can be observed with greater delusion-like experiences. Such findings are often cited as support of the so-called psychosis continuum hypothesis (Van Os et al., 2009): In this dimensional perspective on psychotic symptoms, delusion-like experiences are found with different degrees of conviction, frequency, and distress within humans, ranging from slight delusional experiences (e.g., "I feel like people are watching me") to clinically relevant, distressing delusions (e.g., "The government has installed cameras in my apartment to observe me"). Taking this continuum idea further, one could speculate that manifestations of delusions across this spectrum are linked to similar risk factors such as reasoning biases. To test this risk factor assumption, i.e. that stronger reasoning biases are associated with stronger subsequent manifestations of delusional ideation, longitudinal research designs are required (Hill, 1965; Kraemer et al., 1997). There are some studies scrutinizing the temporal associations between reasoning biases and subsequent delusions in clinical samples (e.g., Andreou et al., 2018; Moritz et al., 2018; So et al., 2012). Longitudinal studies that evaluate these associations in non-clinical samples are, however, lacking so far.

Furthermore, new evidence raises doubts as to whether the differences between non-clinical and clinical individuals regarding reasoning biases are as pronounced as previously assumed (e.g., Moritz et al., 2020; Pytlik et al., 2020; Ward et al., 2018). One explanation that has been put forth for these findings is that the association between delusion-like experiences and reasoning biases may be better captured by a non-linear association (Kuhn et al., 2021; McLean et al., 2020a, 2020b). In other words, individuals with very little or very extreme reasoning biases may exhibit similarly high levels of delusion-like experiences, displaying for example a quadratic relationship. In this case, a quadratic relationship could manifest as a u-shaped association between biases and delusional experiences. From a theoretical perspective, this could emerge, for example, if a sample included not only individuals with high delusional ideation and a high JTC bias, but also individuals with high delusional ideation and a *low* JTC bias. In the latter case, the low JTC bias present with high ideation could e.g., reflect a latent experience of insecurity which may foster both increased data gathering and delusional ideation. As delusions are considered to underlie a multifactorial etiology (e.g., Freeman, 2016), reasoning biases are not a necessary factor for strong delusional ideation. If for example, a patient group contained both individuals with very little and very extreme reasoning biases, the means of this group's reasoning biases may cancel out and may thus be similar to the means of a healthy group. Differential analysis to explore quadratic associations across the psychosis continuum is hence needed.

1.1. Aims of this study

Delusion-associated reasoning biases such as the JTC, BADE, or LA bias have not been studied longitudinally in individuals on the lower range of the continuum. Responding to suggestions by several authors (Eisenacher et al., 2016; Livet et al., 2020; McLean et al., 2017), we aim to close this gap by investigating whether reasoning biases are associated with subsequent delusional ideation in individuals from the general population. Given a postulated continuum of delusions, our results may serve as a blueprint for risk factors of delusional ideation across the psychosis spectrum. Based on prior findings (So et al., 2012), we expect that such associations can be found in the range of months. We hence hypothesize that (H1) a higher prior jumping-to-conclusions bias (JTC) is associated with higher subsequent delusional ideation, that (H2) that a higher prior bias against disconfirmatory evidence (BADE) is associated with higher subsequent delusional ideation, that (H3) a lower prior self-stated possibility of being mistaken (PM) and (H4) a higher prior liberal acceptance bias (LA) is associated with higher subsequent delusional ideation. Scrutinizing these associations further, we explore whether quadratic associations describe these relationships better than linear associations.

2. Methods

2.1. Participants

Participants were recruited using Respondi, an ISO-certified panel facilitating recruitment via online campaigns. Data was collected in two waves, denoted as 'T1' and 'T2'. Inclusion criteria were an age of 18–69 years (due to panel characteristics), provision of informed consent, a permanent residency in Germany or the German-speaking part of Switzerland, and good proficiency in the German language. At both time points, recruitment was based on country-specific quota for age and gender groups for the German (Statistisches Bundesamt, 2020a, 2020b) and Swiss (Bundesamt für Statistik, 2019) population of interest.

At T1, $N = 1829$ individuals were recruited of which $N = 1684$ were included for T1 analysis. Individuals excluded at T1 were excluded due to drop-out or in two cases, due to uniform responding.

Of the $N = 1'684$ T1 participants, $N = 1'220$ participants were recontacted using the country-specific quota. Recruitment was predefined to end when $N = 1'220$ participants had participated in the study due to budgeting reasons. Of these, $N = 1'184$ participants (denoted as 'full sample'; $N = 822$ German participants, $N = 362$ Swiss participants) provided complete data which were used for analysis. Of the excluded participants, 32 participants aborted the study, three participants were excluded due to a uniform responding style and one participant exhibited missing data in relevant variables at T1. Participants of the full sample did not differ from the 36 excluded participants, see Supplemental Materials in S1. Sampling quotas at T1 for both countries are presented in the Supplemental Materials in S2.

2.2. Procedure

This study was conducted as a longitudinal online study using UniPark software (Questback GmbH) and was approved by the local ethics committee of the Faculty of Psychology, University of Basel. Data collections took place between 2 July 2020 and 7 July 2020 (T1), and between 15 February 2021 and 5 March 2021 (T2). All measures were collected in one web-based session per wave. In both sessions, participants provided demographic information and completed different questionnaires and experimental paradigms, which assessed reasoning biases and delusional ideation as well as further constructs not relevant for the study at hand.

2.3. Measures

2.3.1. Jumping-to-conclusions bias

JTC bias was assessed with the established Fish Task (Speechley et al., 2010). In the task, participants were presented with two lakes containing orange and grey fish (lake A 80 % orange: 20 % grey fish; lake B reverse ratio), and were informed that a fisherman had chosen one lake to catch fish. Up to ten fish were successively displayed until participants wanted to make a final decision from which lake all fish were being caught. After each new fish, participants indicated the probability that the fish had been caught from Lake A or Lake B (on a scale from 0 to 100 %), and whether they wanted to make a final decision regarding the lake from which fish were caught. All presented fish remained visible until the end of the task to minimize working memory demand. The JTC bias was defined by the number of fish requested until participants made their final decision ('draws to decision', DTD). A DTD score of 11 was given if no final decision had been made by the tenth fish. A lower DTD score indicates a higher JTC bias.

2.3.2. Liberal acceptance bias

The LA bias was assessed within the 'fish task' paradigm, drawing on the indicated probability for the chosen option when making the final decision for a lake. LA bias was thus assessed via the (lowered) decision threshold (Moritz et al., 2016). The value for the LA bias ranges from 0 to

100, with a low value indicating a higher LA bias. Where no final decision was made for either lake until after the tenth fish, no value for LA bias was collected.

2.3.3. Bias against disconfirmatory evidence

We assessed BADE using a fictitious scenario task (e.g. Veckenstedt et al., 2011; Woodward et al., 2007), a German variant of the original BADE task (Eisenacher et al., 2016; Woodward et al., 2006). This study's task comprised two randomly drawn written scenarios which described delusion-neutral situations. Each scenario began with an ambiguous sentence and became gradually disambiguated as more information was provided over two further sentences. For each scenario, four possible interpretations were given: one true, two lures, and one absurd interpretation. With each sentence, participants provided probability estimates for each interpretation using an 11-point slider scale (0–100 % probability in steps of 10 %). The main variable of interest, i.e., BADE, was obtained via the mean change in probability for the lure interpretations from sentence one to sentence three. The two scenarios comprised one scenario with an emotionally charged correct interpretation and one scenario with a neutral correct interpretation. A total BADE score was calculated via the mean BADE score across both scenarios (i.e., emotional scenario score, neutral scenario score). Both the scenario-specific and the overall BADE score can range from −11 to 11, where a negative score indicates a non-adaptive increase (from sentence one to three) in the plausibility assigned to lure interpretations, and a positive score indicates an adaptive decrease in the plausibility assigned to these interpretations.

2.3.4. Possibility of being mistaken

PM was measured by first presenting a randomly drawn statement for which participants had indicated earlier how strongly they endorsed it. The statement was a conspiracy belief item that was not relevant to this study. Participants indicated the likelihood that they were mistaken in their judgment of the specific statement. Likelihood was indicated with a slider scale ranging from 0 (='very unlikely') to 100 (='very likely'). A higher score indicates a higher possibility of being mistaken.

2.3.5. Delusional ideation

Delusional ideation was assessed at T1 and T2 with the German translation of the conviction subscale of the Paranoia Checklist (PCL; Lincoln et al., 2009); original by (Freeman et al., 2005). The PCL measures paranoid ideation, the most common manifestation of delusional ideation (e.g., Kim et al., 2011) along 18 self-report items. Participants rated each item using 5-point Likert scales on the PCL subscales of conviction (1 = 'not convinced at all', 5 = 'very convinced'), frequency (1 = 'less often [than once per month]', 5 = 'At least once per day') and distress (1 = 'not distressing', 5 = 'very distressing'). To measure delusional ideation at T2, we used the sum score of the paranoid conviction subscale assessed at T2. Cronbach's alpha for the PCL conviction subscale was excellent in our study ($\alpha_{T1} = 0.95$, $\alpha_{T2} = 0.98$).

2.4. Statistical analyses

Addressing hypotheses 1 to 4, we set up multiple regression models involving the respective reasoning bias at T1 as predictor variable, delusional ideation at T1 as potential confounding variable, and delusional ideation at T2 as outcome variable. For models involving PM as predictor, we also included endorsement of the presented statement (ranging from 0 as no endorsement to 100 as complete endorsement) as covariable. For reasons of completeness, equivalent models with paranoia frequency and distress as other outcomes are presented in Supplement S4. We derived 95 % confidence intervals of regression coefficients using bootstrapping with 1000 samples.

In exploratory analyses, we also set up quadratic models for each of the hypotheses, where each model included a quadratic term of the respective predictor variable. For each hypothesis and outcome, log-likelihood ratio statistics were run to test whether the quadratic model exhibited a better statistical model fit than the linear model.

Data analysis was conducted using R (R Core Team, 2020) and relied upon $p < .05$ for hypothesis tests. All data have been made publicly available and can be accessed via the Open Science Framework website (https://osf.io/pa39f/).

3. Results

3.1. Demographic and descriptive data

Mean scores for major variables for the full sample at T1 are presented in Tables 1 and 2, respectively. Average delusional ideation differed significantly between T1 and T2, with a higher median delusional ideation at T2 ($Median_{T1} = 31.0$, $Median_{T2} = 40.0$, $Z = -12.5$, $p < .001$). Delusional ideation increased by 48.85 % over time when calculated across all participants. Overall, 57.35 % of participants ($N = 679$) displayed a numerical increase in delusional ideation over time, 38.26 % ($N = 453$) displayed a decrease and 4.39 % ($N = 52$) maintained a stable value.

Participants from both countries did not differ regarding any predictor or outcome variable. Descriptives by country can be found in Supplemental Materials S3. Zero-order correlations of predictor and outcome variables are presented in S4.

3.2. Associations between reasoning biases at T1 and delusional ideation at T2

Testing hypothesis 1, we found that a higher JTC bias (represented by fewer DTD) at T1 predicted higher subsequent delusional ideation at T2. Hypothesis 2 to 4, in turn, could not be confirmed: Neither LA bias, BADE nor PM at T1 significantly predicted higher subsequent delusional ideation at T2. The same held true when differentiating the BADE predictor for scenarios where the correction interpretation was neutral versus emotionally charged. Results of all multiple regression analyses are presented in Table 3. Results of analyses with delusional frequency and distress are presented in Supplemental Materials S5.

Exploratory analyses indicated that a quadratic regression model performed better than a linear model only when inspecting JTC as a predictor: Here, adding a quadratic term to the regression model improved overall model fit significantly ($F(1, 1180) = 4.686$, $p = .031$). While in this model, JTC bias at T1 remained a significant linear predictor of higher subsequent delusional ideation at T2 ($b = -2.55$, 95 % CI [−4.42, −0.85], $p = .006$), the quadratic term of JTC bias at T1 also emerged as a significant predictor of delusional ideation at T2 ($b = 0.18$, 95 % CI [0.02, 0.35], $p = .031$). In other words, participants at the extremes of the predictor JTC bias (i.e., with high or low JTC) at T1 exhibited on average the highest levels of subsequent delusional ideation at T2, with participants with rather high JTC exhibiting slightly

Table 1
Demographic characteristics of the full sample, as assessed at T1.

Characteristic	Mean (SD)/N (%)
Age	46.01 (13.62)
Sex	
Women	576 (48.65 %)
Men	607 (51.27 %)
Diverse	1 (0.08 %)
Country of residence	
Germany	820 (69.26 %)
Switzerland	364 (30.74 %)
Native language	
German	1141 (96.37 %)
English	3 (0.25 %)
Other	40 (3.38 %)
Education in no. of years	13.28 (3.12)

Note. $N = 1184$.

Table 2
Descriptives of the full sample, as assessed at T1 and T2.

Characteristic	*Mean*	*SD*	*Range*
T1			
JTC Bias (DTD)	2.73	2.69	1–11
LA bias[a]	72.79	20.11	1–100
BADE: total score	2.87	2.34	−4–10
BADE: emotional scenario score	2.47	2.71	−5–10
BADE: neutral scenario score	3.28	3	−5.5–10
Possibility of being mistaken	29.26	32.37	0–100
Delusional ideation	34.14	12.02	18–90
T2			
Delusional ideation	46.63	23.59	18–90

Note. $N = 1184$. Range describes all observed values.
[a] $N = 1121$, as participants who made no decision until the end of the fish task did not indicate a decision threshold and hence cause missing data.

higher levels of delusional ideation at T2 than participants with rather low JTC. The lowest mean level of delusional ideation at T2 was observed for individuals with eight draws to decision ($M = 40.60$, $SD = 15.87$). An illustration of both model fits is depicted in Fig. 1. Other than in the case of JTC bias, quadratic models involving any other reasoning bias predictor did not show a better model fit than linear models. To depict non-linear associations more accurately, locally estimated scatterplot smoothing curves for all associations are presented in Supplemental Materials S6. Distributions of reasoning biases are shown in Supplemental Materials S7.

4. Discussion

The present study contributes both to theoretical conceptions of a psychosis continuum as well as to current empirical discussions on the role of the JTC bias in delusions, relying on a general population sample. We demonstrated that only one specific reasoning bias, the JTC bias, was longitudinally associated with delusional ideation, and that this association may be better captured by quadratic models than commonly used linear models.

As expected, we found that a higher jumping-to-conclusions bias was associated with higher delusional ideation seven months later. While this finding aligns with a large body of cross-sectional evidence (e.g., Livet et al., 2020; McLean et al., 2017), it differs from findings of longitudinal studies conducted within individuals with clinically relevant delusions (So et al., 2012) or with subclinical psychotic experiences (Catalan et al., 2020; Winton-Brown et al., 2015): these studies could not demonstrate associations at the 5 % significance level. As longitudinal studies are scarce, we cannot tell if these mixed results are rather due to methodological differences across studies or due to different roles of the JTC bias across the psychosis continuum. Still, in our study the observed overall effect size was rather small. Observational studies in this field are hence strongly encouraged. It is moreover of interest whether the JTC bias may not only be a risk factor but also a *causal* risk factor (according to (Kraemer et al., 1997). Therefore, future studies may now experimentally test whether targeting JTC bias in non-clinical individuals can help to reduce delusional ideation (e.g., Brown et al., 2019) or even reduce the risk of transitioning into more severe delusions (analogue Catalan et al., 2020). Also, further research is warranted to understand why in some individuals an increased data-gathering pattern is linked to higher subsequent delusional ideation. One explanation could be that excessive anxiety-driven, yet psychosis-specific processes favor both more cautious data gathering and delusional ideation (Lincoln et al., 2010; So et al., 2016). Findings of such empirical endeavors may contribute to refining low-threshold intervention programs.

Another interesting finding of this study manifested on a conceptual level: that while a JTC bias was associated with a subsequent increase in delusional ideation, a LA bias was not. This finding contradicts the notion that a LA bias may indirectly underlie the JTC bias (Bronstein et al., 2019; Broyd et al., 2017; Moritz et al., 2006) and favors the assumption of the LA bias and JTC bias being distinct predictors. As noted elsewhere (Moritz et al., 2017b), associations between LA bias and delusional experiences have been mostly small, questioning whether LA bias is a trait vulnerability for delusions, as has been repeatedly proposed for the JTC bias (e.g. Catalan et al., 2015; Lüdtke et al., 2017). Instead, considering other factors underlying a trait-like JTC bias, such as maladaptive intuition (Broyd et al., 2017; Garety et al., 2021; Ward and Garety, 2019) or general cognitive impairments (Tripoli et al., 2021), may be a fruitful avenue for further studies in less symptomatic individuals.

Concerning our third and fourth hypotheses, we could not find evidence that a BADE nor a reduced PM were associated with higher subsequent delusional ideation. Regarding the unexpected PM finding, one explanation lies in the way that PM was measured: As individuals indicated how likely it was that they were mistaken in their judgment of a delusion-like belief, it is rather adaptive for individuals with low levels of delusional ideation to indicate that it is unlikely that they are mistaken. Thus, low levels of PM may be frequently found both in individuals with little delusional ideation and in individuals with strong delusions, but reduced PM may only represent a maladaptive risk factor for delusions in the latter case. Regarding BADE, our results stand in contrast to longitudinal clinical studies (e.g., Garety et al., 2021; So

Table 3
Multiple regression analyses: Reasoning bias and delusional ideation outcomes at T1 predicting delusional ideation at T2.

Effect	Delusional ideation at T2						
			95% CI				
	B	SE	*LL*	*UL*	β	*p*	Δ*R2*
Intercept[a]	36.364	2.041	32.122	40.568		<.001	–
Reasoning biases at T1							
JTC Bias (DTD)	−0.618	0.251	−1.095	−0.132	−0.070	.014	0.004
LA Bias[b]	−0.054	0.035	−0.121	0.007	−0.046	.124	0.005
BADE: total score	−0.042	0.293	−0.611	0.539	−0.004	.887	−0.001
BADE: emotional scenario score	−0.223	0.252	−0.72	0.291	−0.026	.375	−0.0002
BADE: neutral scenario score	0.133	0.228	−0.321	0.563	0.017	.560	−0.001
Possibility of being mistaken	−0.010	0.022	−0.054	0.035	−0.014	.640	0.001
Delusional ideation at T1[a]	0.301	0.056	0.194	0.405	0.153	<.001	0

Note. The change in R squared represents the difference in adjusted R squared between the corresponding multiple regression model (containing PCL conviction at T1 as control variable and the predictor of interest) and a reference regression model (containing only the control variable). B refers to the unstandardized regression coefficient. β refers to the standardized regression coefficient. $N = 1184$.
BADE = Bias against disconfirmatory evidence, CI = Confidence Interval, DTD = Draws to decision, JTC = Jumping-to-conclusions, LA = Liberal acceptance, LL = Lower limit (2.5%percentile), UL = Upper limit (97.5%percentile).
[a] For reasons of parsimony, only the values for the model involving PCL conviction at T1 as predictor are reported here.
[b] $N = 1121$, as participants who made no decision until the end of the fish task did not indicate a decision threshold and hence cause missing data.

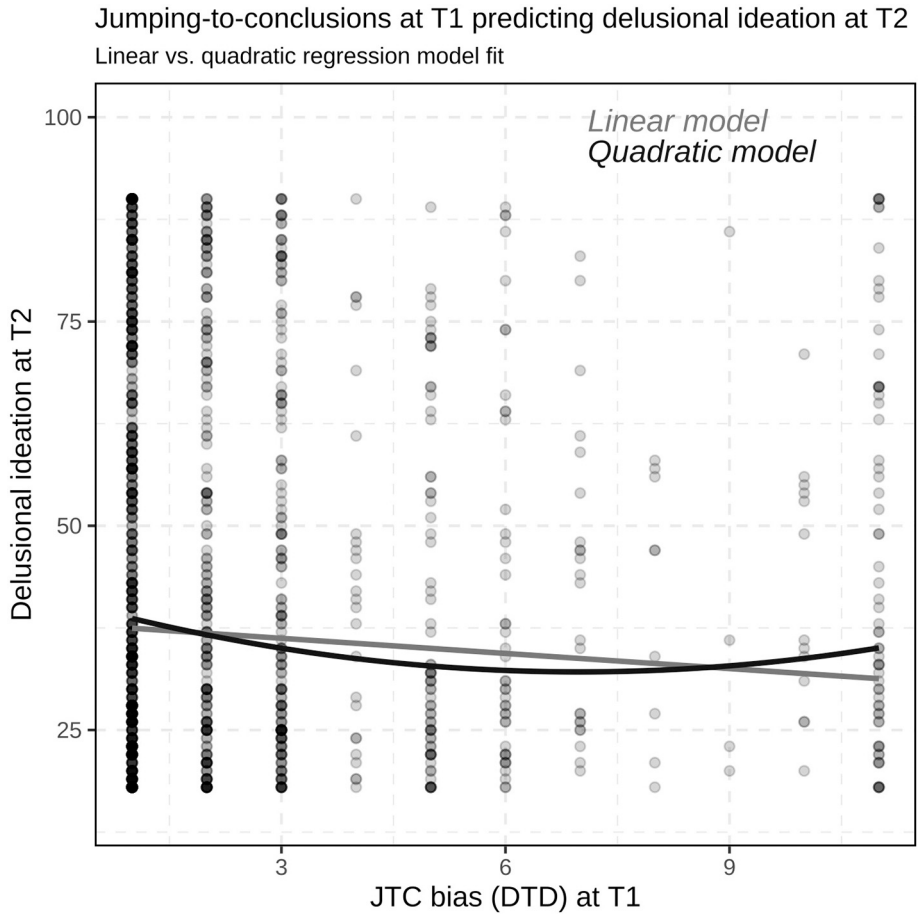

Fig. 1. Linear and quadratic regression models: JTC bias at T1 predicting delusional ideation at T2. For reasons of comprehensibility, the figure represents the model estimates of intercepts and JTC bias regression coefficients.

et al., 2014). For example, findings of the recent large-scaled SlowMo trial implied that belief inflexibility bias components may mediate changes in delusions (Garety et al., 2021). This empirical discrepancy fosters the assumption that belief inflexibility biases such as BADE rather represent (1) short-term maintenance factors for delusional ideation in the general population (Moritz et al., 2017b) and/or (2) maintenance or formation risk factors for delusional experiences in more advanced stages of delusions (So et al., 2012).

Crucially, the temporal distance of several months between reasoning biases and delusional ideation may have also been too long to detect more-than-weak associations. As theories suggest, reasoning aberrations may be the last to come into play after other, more trait-like risk factors have "paved the way" for increases in manifested delusional ideation, and an immediate interpretation of ambiguous experiences is needed (Garety and Freeman, 1999). Research designs such as experience sampling methodology approaches (Csikszentmihalyi and Larson, 1987) may find stronger longitudinal associations between LA bias or BADE, respectively, and delusional ideation in healthy non-clinical or at-risk individuals (Reininghaus et al., 2019a). Such findings would foster the notion of these biases as maintenance rather than formation risk factors for these beliefs, making these biases potential treatment starting points for low-threshold interventions to diminish delusional ideation.

The discrepancy between our results and longitudinal research in clinical samples (So et al., 2012) implies that in the case of reasoning biases, the psychosis continuum might not necessarily manifest on an etiological dimension. From a theoretical perspective, it is possible that even if a phenomenological or temporal delusion continuum exists (van Os and Reininghaus, 2016), the JTC bias may be a risk factor for delusional ideation but not more severe clinical delusions. In other words, reasoning biases may not necessarily be part of a "core vulnerability" (van Os and Reininghaus, 2016) across the whole delusion continuum, but rather relevant in some stages. Our finding of a u-shaped association between a JTC bias and delusional ideation supports the idea of a non-linear relationship between reasoning biases and delusion-like experiences over a delusional continuum and aligns with recent studies (Kuhn et al., 2021; McLean et al., 2020b, 2020a; So and Kwok, 2015).

Our findings need to be considered in the light of some limitations: First, our web-based non-probability recruitment approach may have favored a selection bias; however, most people nowadays have frequent access to the internet (DeStatis, 2020; Bundesamt für Statistik, 2020). Second, delusional ideation was slightly higher in our sample than in comparable samples (e.g., Lincoln et al., 2009; Sellers et al., 2018). Third, many participants of this study demonstrated an extreme JTC bias which may have arisen from a lack of motivation or miscomprehension of the task. However, some studies have reported similar levels of draws-to-decision in comparable samples (e.g., Moritz et al., 2020; Reininghaus et al., 2019b). Replications with different JTC paradigms are strongly encouraged. Moreover, we can only speculate about the significant increase in delusional ideation over time; a link to the then-prominent topic of the SARS-CoV-2 pandemic is conceivable (Suthaharan et al., 2021), yet it would be premature to conclude that this might have affected the investigated associations mechanistically. Lastly, while our sample was recruited from the general population (i.e., not in a clinical setting), we may have included some participants with clinical delusions. However, as prevalence estimates of severe psychotic disorders are low (e.g., Moreno-Küstner et al., 2018), we expect that exclusion of these participants would not have changed results substantially.

These limitations notwithstanding, our study has several strengths. First, our analyses relied on a large, quota-based general population sample. Second, to our knowledge, this is the first study scrutinizing associations between reasoning biases and delusional ideation in this population within a longitudinal research design, which is a necessity when investigating causal relationships. Third, the pool of participants from which we have recruited is subject to regular motivation checks, hence increasing the validity of our results. Further, we approached our research questions using established experimental paradigms and a validated questionnaire. Lastly, testing for non-linear relationships in this field has the potential to develop more differentiated theoretical accounts of delusions as well as to reconcile seemingly contradictory findings for the association between JTC bias and delusions in the literature.

In sum, this study provides large-scaled longitudinal evidence that aberrant data gathering is linked to increased delusional ideation in the general population. By showing that in individuals with high delusional ideation, either a pronounced *or* a nominal JTC bias can be observed, we offer a (reconciliating) explanation for a seemingly contradictive evidence base regarding JTC bias in delusions. By demonstrating that the JTC bias but no other prominent biases such as BADE or LA bias were longitudinally associated with delusional ideation, this study indicates that cognitive risk factors are not necessarily similar for slight delusional ideation and severe delusions. As an outlook, it may be of interest to examine whether targeting JTC bias in non-clinical help-seeking individuals can help to diminish negative effects of delusional ideation or even preemptively reduce the risk of transition towards more severe, distressing delusions. Additionally, future short-term studies may shed further light on the role of reasoning biases as risk factors for delusional ideation in the general population.

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Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.schres.2023.03.009.

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