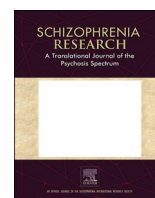


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Exploring the relationship between attributional style measured in virtual reality and bullying among children at familial high risk of schizophrenia or bipolar disorder compared with controls

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ABSTRACT

Background: Children of parents with severe mental illness report bullying more often compared with controls. We hypothesized that deviations in attributional styles may explain the increased prevalence of bullying experiences. We aimed to assess real-time responses to standardized ambiguous social situations, bullying experiences by children, their primary caregivers, and teachers, and to investigate potential associations between attributional styles and bullying.

Method: The study included 465 children aged 11–12, born to parents with schizophrenia, N = 179, bipolar disorder, N = 105, or population-based controls, N = 181. Attributional style was evaluated using virtual reality environments depicting ambiguous social everyday situations. We created a tailored assessment since no suitable assessments were found. Bullying was assessed through self-reports and reports from primary caregivers and teachers.

Results: We observed no group differences in the attributional style of the children. Reports from children, primary caregivers, and teachers revealed that compared with controls, children born to parents with schizophrenia were more likely to perceive bullying victimization, with high consistency among reports. No associations were found between bullying reports and attributional style.

Conclusions: Children of parents with schizophrenia consistently experienced more bullying, as reported by the children themselves, primary caregivers, and teachers. No differences in attributional style were found, indicating that attributional style did not explain the increased prevalence of bullying reports. While it cannot be ruled out that our virtual environments were insufficient to trigger a sense of social exclusion, the results suggest that the observed differences in reported bullying are genuine and not a result of the child's attributional style.

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1. Introduction

Schizophrenia and bipolar disorder are severe neurodevelopmental disorders with a high heritability (Lichtenstein et al., 2009; Dean et al., 2010). As such, throughout their lifespan children born to parents with schizophrenia or bipolar disorder have greatly increased risk of developing the concordant psychiatric disorder, as well as other psychiatric disorders (Thorup et al., 2018). Subtle signs of neurodevelopmental derailment, such as impaired social cognitive functioning, often show years before the onset of manifest psychiatric illness (Erlenmeyer-Kimling et al., 2000). Social cognition is an essential aspect of social development and adaptive functioning, encompassing the ability to perceive, interpret, and utilize social information is often impaired in individuals with schizophrenia (Penn et al., 2008). Similarly, children born to parents with schizophrenia or bipolar disorder may experience a spectrum of difficulties in social cognition (Keshavan et al., 2014; Bora and Ozerdem, 2017).

Social cognition is connected to attributional style. Attributional style refers to the characteristic way in which individuals explain or attribute the causes of events, situations, or behaviors, either to internal factors (personal traits or abilities) or external factors (situational or environmental factors) (Raps et al., 1982). As such, attributional style can impact various domains of social cognition, such as social perception, social judgements, and interpersonal relationships (Elliott and Dweck, 1988). Individuals with a negative attributional style may be more likely to interpret ambiguous social cues as negative, leading to more negative social interactions and experiences. Conversely, individuals with a positive attributional style may be more likely to perceive and interpret social cues in a positive light, leading to more positive social interactions and experiences (Abramson and Alloy, 1981; Weiner, 1985; Watkins and Teasdale, 2004).

Since poor social functioning is a common challenge for individuals with mental health conditions, and hostile attributions may exacerbate these difficulties, attributional style of individuals with schizophrenia is a critical aspect of social cognition (Penn et al., 2008). People with bipolar disorder and schizophrenia often exhibit hostile attributions. Hostile attributions refer to the tendency to interpret ambiguous social situations in which others have hostile intentions. These attributions may lead to misinterpretations of others' actions and intentions, leading to conflicts and strained relationships (Laheara et al., 2015). In accordance, it has been suggested that people with schizophrenia who attribute negative events to internal and stable factors, and global causes, such as believing that all aspects of their life are negatively affected, are more prone to developing depressive symptoms (Addington et al., 1999). Furthermore, the attributional style of children of parents with schizophrenia or bipolar disorder has been found to differ significantly from children without a parental history of mental illness. One study found that children of parents with either schizophrenia or bipolar disorder exhibited a more negative attributional style than the control group (Ochoa et al., 2012).

Attributional style has also been found to be related to bullying victimization. Being bullied can over time cause a negative distortion in social cognition, which may incline victims to negative interpretations of social interactions (Lansu et al., 2017). Accordingly, children who have experienced bullying are more likely to attribute negative events to internal and stable factors, such as their own personal flaws or weaknesses. This negative attributional style has been linked to an increased risk of developing feelings of helplessness and depression (Hodges et al., 1997; Schneider et al., 2012). In alignment, previous studies show, that the consequences of being bullied as a child carry into adulthood resulting in poorer perceived quality of life and increased social isolation, even in middle-age (Takizawa et al., 2014) and adolescent victims of bullying report more depressive symptoms in adulthood (Winding et al., 2020). Additionally, bullying and suffering of social defeat increases the risk of having psychotic-like experiences and of developing psychopathology (Lataster et al., 2006; Kelleher et al., 2008; Arseneault

et al., 2011; De Loore et al., 2011). Accordingly, bullying has been linked to the development of paranoid ideation, which is a type of delusion involving a strong, persistent belief that others are trying to harm or persecute you (Lataster et al., 2012). According to the aberrant salience hypothesis is caused by a cognitive bias that leads to attribute excessive importance or significance to irrelevant or meaningless stimuli or experiences (Kapur, 2003; Roiser et al., 2009; Li et al., 2020). Children at familial high risk of schizophrenia may be particularly vulnerable to the negative consequences of bullying as they face the risk of not only enduring personal and social ramifications of bullying but, also are grapple with the social cognitive impairments intrinsic to their genetic predisposition. This includes the adverse impact of perceiving hostility in social situations even when none is present.

Findings from our own longitudinal cohort study, The Danish High Risk and Resilience Study including 202 children born to parents diagnosed with schizophrenia, 120 children born to parents diagnosed with bipolar disorder, and 200 children born to parents without any of these diagnoses (Thorup et al., 2018), revealed that compared with controls, children at familial high risk of schizophrenia, and to a lesser degree children at familial high risk of bipolar disorder, already at aged seven reported more experiences of being bullied and a poorer perceived quality of life in general (Ellersgaard et al., 2020). Given the prolonged developmental course of schizophrenia, it is likely that aberrant salience attribution is a social cognitive deficit that manifests early, and thus may be a contributing factor to the development of psychotic symptoms later in life. One retrospective study found that a history of childhood bullying was significantly more frequent in the group of young adult participants at ultra-risk for psychosis when compared with healthy controls. Additionally, the cohort of this study was exposed to a virtual reality assessment measuring paranoid ideation. Paranoid ideation was significantly associated with childhood bullying, but risk status was not associated with paranoid ideation (Valmaggia et al., 2015) However, another ultra-high risk study, also using the assessment of virtual reality indicated that severe bullying in childhood increased the risk of paranoid ideation mediated by interpersonal sensitivity (McDonnell et al., 2018), and in a comprehensive systematic review of multiple studies that utilized virtual reality assessments, it was found that virtual reality can effectively be employed to investigate the psychological processes and mechanisms related to psychosis (Valmaggia et al., 2016). These studies suggest that virtual reality could be a useful tool for investigating the attributional style of individuals at high risk of developing severe mental illness.

Building upon findings from prior studies of both attributional style, bullying, and virtual reality, during our first follow-up of the Danish High Risk and Resilience Study, we aimed to explore potential interpretation differences between children at familial high risk of schizophrenia or bipolar disorder and controls when exposed to ambiguous social situations. By simulating two different social scenarios in a virtual reality environment, we aimed to quantify and compare levels of perceived hostility and bullying in a standardized way. The virtual scenarios were specifically designed for our study and for 11–12-year-old children. We hypothesized that compared with controls, children with a familial high risk of schizophrenia or bipolar disorder would be more likely to interpret higher levels of hostility and bullying in an ambiguous social situation in a simulated virtual environment, and would be more likely to report being bullied in daily life. We also hypothesized that higher occurrences of bullying would be associated with higher levels of perceived hostility in the simulated virtual social environment.

2. Methods

2.1. Study design and participants

The Danish High Risk and Resilience Study – VIA 11 was conducted in the period between March 1st 2017 and June 30th 2020. Our

participants were 11–12-year-old children. The study is the first follow-up study of our baseline study, The Danish High Risk and Resilience Study – VIA 7. When included and assessed at baseline, all participants were children aged seven. Our participants were identified combining information from the Danish Psychiatric Central Research Register and the Danish Civil Registration System. The Danish Psychiatric Central Research Register holds information on psychiatric diagnosis made and registered on basis of contacts to the Danish mental health services system including both in- and outpatients. All people living in Denmark are registered in The Danish Civil Registration System, which holds information on age, sex, address, children, and identity of parents. Linking of the two data bases enabled identification of children aged seven born to parents with schizophrenia spectrum psychosis defined as ICD-10 codes F20, F22 and F25 or ICC-8 codes 295, 297, 298.29, 298.39, 298.89, or 298.99 and children born to parents with bipolar disorder defined as ICD-10 codes F30, F31 or ICD-8 codes 296.19 and 296.39 or parents without any of these disorders. Following the ICD-10 diagnostic hierarchy system, children of parents diagnosed with both schizophrenia and bipolar disorder were allocated to the high-risk group of children born to parents with schizophrenia spectrum psychosis. Children with at least one parent diagnosed with schizophrenia spectrum psychosis were matched to control children according to age, sex, and municipality. The index parent was defined as the parent with a diagnosis of schizophrenia or bipolar disorder in the Danish registries. The parent in the control group with the same sex was defined as the index control parent. Parents of the control children could be registered with any other diagnosis but schizophrenia spectrum psychosis diagnoses or bipolar disorder. Using the semi-structured diagnostic interview Schedules for Clinical Assessment in Neuropsychiatry, version 2.0. as part of our baseline study (The Danish High Risk and Resilience Study - VIA 7), we found that 46 index control parents during some time of their adult life fulfilled the criteria for a diagnosis other than schizophrenia spectrum disorder or bipolar disorder, meaning psychoactive substance use ($N = 3$), depressive episode and recurrent depressive disorder ($N = 31$), and phobic and other anxiety disorders including obsessive-compulsive disorder ($=12$). Children of parents with bipolar disorder were an unmatched group. This choice was made due to limited resources, but the sample were comparable to the other two groups in terms of sex and age. The study design is described in detail elsewhere (Thorup et al., 2018; Thorup et al., 2015).

Written consent to participation were obtained from the children's custody holders. The Danish Data Protection Agency and The Danish National Committee on Health Research Ethics approved the study protocol (Protocol number H16043682).

The overall aims of the Danish High Risk and Resilience Studies are to explore and describe the developmental pathways of children with a familial high risk of either schizophrenia spectrum disorders (FHR-SZ) or bipolar disorder (FHR-BP), and to identify both risk and resilience factors for early interventions in future treatment. As part of a long-term plan for repeated waves of assessment, age 11 was chosen as the first follow-up before the children entered adolescence. As such, for this study we were aiming for the inclusion-age of 11. The Covid-19 pandemic delayed our study, why some children reached the age of 12 before inclusion.

2.2. Assessors

The assessments were conducted by a team of experienced professionals, including psychologists, medical doctors, and research nurses, who were certified in using all instruments of the full assessment battery. The assessors were trained and certified to ensure the accuracy and consistency of the assessments. To avoid potential biases, the assessors were blinded to the diagnostic status of the children's parent(s). The assessments were performed in age-appropriate facilities, either at the hospital clinic or, on occasion, in the participants' homes. This part of the study took place in age-appropriate facilities at the hospital.

3. Measure

3.1. Sample characteristics

We used The Children's Global Assessment Scale (Shaffer et al., 1983) (CGAS) to assess the child's global level of daily function. CGAS is single score on a scale from 1 to 100 that represents a child's current daily life functioning. Socioeconomic information was obtained through anamnesic interviews with the primary caregivers, and for this study current employment engagement was used as the socioeconomic status marker of the primary caregiver. Information on employment engagement was dichotomized into "yes" or "no."

3.2. Attributional style

For assessment of attributional styles, we simulated two ambiguous social situations in a virtual reality environment. Virtual Reality stimulation refers to a computer-generated environment that simulates a realistic 3D experience, which users can interact with using specialized electronic devices, such as head-mounted displays, gloves, or controllers. This technology creates an immersive environment that simulates real-world scenarios, providing users with a sense of presence and interaction that can be used for various purposes, such as gaming, training, education, or therapy. Since no prior studies had employed this method, no existing materials were accessible. We collaborated with Khora (<https://khora.com>) to develop the virtual reality movies used for assessment. Through focus group interviews with 11–12-year-old children, we identified two realistic and relatable settings for the ambiguous social situations tailored to our participant children. These interviews, facilitated by the first author (Anne Søndergaard), were conducted using a combination of open and semi-structured dialogues. Drawing from these interviews, Khora created two brief movies featuring avatar protagonists encountering social ambiguity. The first movie is set in a classroom, where the ambiguous situation involves the protagonist not being offered a treat by a peer while all others receive treats. In the second movie, set in a schoolyard, the ambiguity lies in whether a group of peers deliberately ignore the protagonist as they showcase their new phone (Fig. 1, Photos illustrating the virtual environment used to assess attributional style in children aged 11–12). Immediately after each movie, the children were asked to complete a short version of the State Social Paranoia Scale Questionnaire (Freeman et al., 2007) (SSPS), reduced from the original 24 items to 8. The SSPS was reduced from 24 to 8 questions by Freeman and colleagues in 2013. The shortened version of the questionnaire was developed to improve the feasibility of using the SSPS in research and clinical settings, as the longer version was found to be too time-consuming and burdensome.

At the time of implementing the shortened version in our study cohort, no previous research had applied this approach to a younger population. The modified version of SSPS contains five questions measuring paranoid ideation and three questions measuring positive appraisal. Each question response corresponds to a score between one and five allowing for a maximum score of 25. Higher scores reflect more paranoid ideation and lower scores vice versa. The same applies for positive appraisal. At $N = 100$ showings we conducted a preliminary analysis and found that nearly all children reported close to the minimum SSPS score of paranoid ideations on the classroom movie. Accordingly, the verbal content of the classroom movie was adjusted to convey a more pronounced sense of ambiguity. We also added an extra question after each movie, asking whether the child had "Perceived being bullied and/or excluded." In our final analyses, we only included results from the adjusted version of the classroom movie with the extra question added.

3.3. Bullying

Self-reported bullying was assessed using the Strengths and



The first movie



The second movie

Fig. 1. Photos illustrating the virtual environment used to assess attributional style in children aged 11–12.

Difficulties Questionnaire (SDQ-CE) item 19: “Other children or young people pick on me or bully me” and information on bullying from the primary caregiver was obtained by the Strength and Difficulties Questionnaire for parents or teachers (SDQ-PE) (Obel et al., 2003), item 19 “Picked on or bullied by other children”. Information from school-teachers was obtained from the items 34 and 38 of the Teachers Report Form (TRF) (Achenbach and Rescorla, 2001), “Feels that others are out to get him/her” and “Gets teased a lot”, respectively. Data on bullying

Table 1

Characteristics of 11–12-year-old children at Familial High Risk of Schizophrenia (FHR-SZ) or Familial High Risk of Bipolar Disorder (FHR-BP) and controls and their primary caregiver.

	FHR-SZ	FHR-BP	Controls	Pairwise comparisons			
				P-Value	FHR-SZ vs. controls p-Value (effect size Cohen's d)	FHR-BP vs. controls p-Value (effect size Cohens d)	FHR-SZ vs. FHR-BP p-Value (effect size Cohen's d)
Age of inclusion, N, mean (SD)	179 11.9 (0.26)	105 11.9 (0.23)	181 11.9 (0.22)	0.573 ^a	–	–	–
Female N (%)	85 (47.5 %)	46 (43.8 %)	83 (45.9 %)	0.834 ^b	–	–	–
CGAS score ^c N mean (SD)	173 64.6 (15.6)	104 68.1 (15)	175 75.2 (14)	<0.001** ^a	<0.001** ^d (0.7)	<0.001** ^d (0.5)	0.177 ^d (0.2)
Employment, primary Caregiver ^e N, No. =yes (%)	176 132 (75 %)	105 79 (75.2 %)	180 175 (97.2 %)	<0.001** ^b	<0.001** ^b	<0.001** ^b	0.964 ^b

SD = Standard deviation P-value<0.001**

^a One-way ANOVA.

^b Chi-square test.

^c CGAS: Children's Global Assessment Scale. CGAS is a single score on a scale from 1 to 100 that represent a child's present daily life functioning.

^d One-way ANOVA with post hoc Bonferroni multiple comparison.

^e Primary caregiver is defined as the parent or foster parent that knows the child best and spends most time with the child.

were dichotomized into yes or no. The Danish High Risk and Resilience Study – VIA 11 consists of a large assessment-battery including the above-mentioned questionnaires. To ensure not asking our participants the same kind of question more than once (e.g., about bullying) data regarding bullying employed in this study originate from those forms.

4. Statistical analyses

All statistical analyses were performed using IBM SPSS Version 22.0, and a significance level of $p < 0.05$ was set for all analyses. Between-group differences in age of inclusion, scores of CGAS (Table 1), and SSPS (Table 2) were analyzed using one-way ANOVA. Between-group differences of participants sex and employment status (Table 1) were analyzed with Pearson's Chi-square tests, as well as the added question about perceived bullying/exclusion (Table 2). Logistic regression analysis was used to compare group scores on the instruments of SDQ-CE,

Table 2

Attributional style in 11–12-year-old children at Familial High Risk of Schizophrenia (FHR-SZ) or Familial High Risk of Bipolar Disorder (FHR-BP) and controls in virtual environments of Schoolyard and Classroom.

	FHR-SZ Mean (SD)	FHR-BP Mean (SD)	Controls Mean (SD)	P- value
Schoolyard, positive appraisal ^a N = 438	9.49 (3.27)	9.83 (3.23)	10.15 (3.24)	0.171 ^b
Schoolyard, paranoid ideation ^a N = 438	6.09 (1.98)	6.21 (2.19)	6.20 (2.29)	0.859 ^b
Classroom, positive appraisal ^a N = 283	5.77 (2.89)	6.06 (3.19)	6.02 (2.83)	0.777 ^b
Classroom, paranoid ideation ^a N = 282	7.94 (3.07)	8.14 (3.20)	7.83 (3.47)	0.816 ^b

	FHR-SZ N (%)	FHR-BP N (%)	Controls N (%)	P- value
Schoolyard, felt bullied/ excluded = yes	16 (13.8 %)	15 (18.1 %)	18 (14.1 %)	0.285 ^c
Classroom, felt bullied/ excluded = yes	34 (29.1 %)	22 (26.5 %)	44 (34.4 %)	0.719 ^c

SD = Standard Deviation.

^a Measured with the State Social Paranoia Scale Questionnaire.

^b One-way ANOVA.

^c Chi-square test.

SDQ-PE, and TRF (Table 3). For correlation analyses of bullying reports, p-values were estimated based on binary logistic regression models (Table 4). We calculated associations between the independent dichotomous variables of perceived bullying/exclusion and the dependent dichotomous variables of SDQ-CE, SDQ-PE, or TRF using Pearson’s Chi-square test (data not shown). Association analyses between the independent continuous variables of SSPS scores and the dependent dichotomous variables of SDQ-CE, SDQ-PE or TRF were conducted using logistic regression analyses (data not shown).

5. Results

5.1. Sample characteristics

The complete study cohort consisted of 465 children, with the following group distribution: FHR-SZ (N = 179), FHR-BP (N = 105), and controls (N = 181). The mean age of all groups was 11.9 years. Based on CGAS scores, children at FHR-SZ (64.6, SD 15.6) or FHR-BP (68.1, SD 15) had significantly lower global functioning compared with controls (75.2, SD 14, p < 0.001). A significantly smaller proportion of primary caregivers to children at FHR-SZ or FHR-BP were employed when compared with primary caregivers to controls, 75 %, 75.2 % and 97.2 % respectively, p < 0.001 (Table 1).

5.2. Attributional style

A total of 438 children participated in the virtual reality movie assessment of attributional style. Our analysis revealed no significant interpretation differences between the groups, including scores of paranoid ideations, positive appraisal in SSPS, or in questions about feeling bullied or excluded (Table 2). Exposure to the virtual reality movies did not cause adverse events of any kind.

5.3. Bullying

A total of 441 children completed SDQ-CE. Responses to SDQ-CE item 19 revealed that a significantly larger percentage of children at FHR-SZ have had experiences of being bullied or picked on when compared with controls, 18.5 % and 9.8 % respectively (p = 0.024, OR 2.33, CI95% 1.12–4.87). Similarly, primary caregivers to children at FHR-SZ reported a significantly higher percentage of bullying or being picked on compared to controls, 19.2 % and 9.1 % respectively (p = 0.008, OR 2.37, CI95% 1.24–4.50). Teachers’ responses to TRF items 34 and 38 revealed that significantly more children at FHR-SZ perceived hostility from their peers compared to controls, 25.3 % and 14.6 % respectively (p = 0.018, OR 2.03, CI95% 1.13–3.65) for item 34, and 8.4 % and 2.6 % respectively (p = 0.040, OR 3.37, CI95% 1.06–10.69) for item 38. No significant differences were found between children in the FHR-BP group and controls (Table 3).

Table 3

Bullying in 11–12-year-old children at Familial High Risk of Schizophrenia (FHR-SZ) or Familial High Risk of Bipolar Disorder (FHR-BP) and controls. Self-report by The Strength and Difficulties Questionnaire-CE (SDQ-CE). Report of primary caregiver by The Strength and Difficulties Questionnaire-PE (SDQ-PE). Report of teacher by Teachers Rating Form (TRF).

	FHR-SZ	FHR-BP	Controls	FHR-SZ vs. controls	FHR-BP vs. controls	FHR-SZ vs. FHR-BP
N (%)	N (%)	N (%)	N (%)	OR (95 % CI)	OR (95 % CI)	OR (95 % CI)
Self-report, SDQ-CE: <i>Other children or young people pick on me or bully=</i> yes	31 (18.5 %)	13 (13 %)	17 (9.1 %)	2.1 (1.1–4.0)*	1.6 (0.7–3.9)	1.5 (0.8–3.1)
Report of primary caregiver, SDQ-PE: <i>Picked on or bullied by other children=</i> yes	32 (19.2 %)	14 (13.7 %)	16 (9.1 %)	2.4 (1.2–4.5)*	1.6 (0.7–3.4)	1.5 (0.8–3.0)
Report of teacher TRF: <i>Feels others are out to get him/her=</i> yes	37 (25.3 %)	19 (21.3 %)	22 (14.6 %)	2.0 (1.1–3.6)*	1.6 (0.8–3.1)	1.3 (0.7–2.4)
Report of teacher, TRF: <i>Gets teased a lot=</i> yes	12 (8.4 %)	5 (5.6 %)	4 (2.6 %)	3.4 (1.1–10.7)*	2.2 (0.6–8.4)	1.5 (0.5–4.5)

p-value less than 0.05 *. OR = odds ratio. 95 % CI = confidence interval.

Table 4

Binary logistic regression analyses of correlation between reports of bullying in 11–12-year-old children at Familial High Risk of Schizophrenia (FHR-SZ) or Familial High Risk of Bipolar Disorder (FHR-BP) and controls. Self-report by The Strength and Difficulties Questionnaire-CE (SDQ-CE). Report of primary caregiver by The Strength and Difficulties Questionnaire-PE (SDQ-PE). Report of teacher by Teachers Rating Form (TRF).

	Report of primary caregiver, SDQ-PE: <i>Picked on or bullied by other children=</i> yes	Report of teacher, TRF: <i>Feels others are out to get him/her=</i> yes	Report of teacher, TRF: <i>Gets teased a lot=</i> yes
Self-report, SDQ-CE: <i>Other children or young people pick on me or bully=</i> yes	<0.001**	<0.001**	<0.001**
Report of primary caregiver, SDQ-PE: <i>Picked on or bullied by other children=</i> yes	–	<0.001**	<0.001**
Report of teacher, TRF: <i>Feels others are out to get him/her=</i> yes	–	–	<0.001**

P-value 0.001 **.

5.4. Associations between bullying and attributional style

Our analyses revealed no significant associations between higher scores in SSPS/question about feeling bullied/excluded and indicators of bullying victimization. However, teacher assessments of the child, specifically the item ‘Gets teased a lot,’ showed a trend toward an association with higher scores in paranoid ideation responses for the classroom movie (without adjusting for multiple comparison, p = 0.049).

5.5. Correlation between reports of bullying

Our findings indicated highly significant consistency across children’s, primary caregivers’, and teachers’ reports of bullying (p < 0.001) (Table 4).

6. Discussion

In this nationwide longitudinal cohort study, we found that children at familial high risk of schizophrenia, their primary caregivers, and teachers reported significantly more bullying victimization compared with controls and consistency across the different informants was remarkably high. However, when the children were exposed to an ambiguous virtual social environment, we did not find any differences in attributional styles between the three groups of children regarding

neither paranoid ideation nor positive appraisal. This suggests that the increased bullying experienced by children at familial high risk of schizophrenia is a real-world difference, independent of attributional style. We found no association between bullying and attributional style in either the children or primary caregiver's responses. However, teacher's reports of "Gets teased a lot" tended to associate with the children's attributional style in one movie, but this result was not adjusted for multiple comparisons.

Contrary to the bullying assessments utilized in this study, there were no pre-existing options suitable for evaluating our cohort using an ambiguous virtual environment. Consequently, we devised a virtual assessment aimed at representing everyday ambiguous situations, striving to strike a balance between non-threatening cues and those that were not overly weak or subtle. Data collection for this study commenced in 2017, while the virtual reality movies were developed in 2016. In the intervening years, advancements in virtual reality technology and its applications have expanded to encompass use within the healthcare system for treating psychiatric disorders (Cieslik et al., 2020; Pot-Kolder et al., 2018). This development has accelerated according to more sophisticated designs of virtual reality creations and equipment. Our design reflects that virtual reality was in its early stages in 2016 and the two movies were kept in an overall manageable setting and were both easily understood. That may have influenced our results, meaning that our virtual environment assessment may not have represented true ambiguous situations and as such, regardless of attributional styles all children would interpret the virtual situations almost identically. As mentioned in the Methods section, based on 100 SSPS-scores preliminary analyses and an updated version of one of the movies was implemented, but without any significant changes of the scores.

However, although children born to parents with schizophrenia or bipolar disorder are known to diverge from controls in multiple domains, attributional style may not be one of them or at least not to a legible level already at aged 11. That also explains the lack of association between reports of being bullied and the child's interpretation of the virtual environment, suggesting that experiences of being bullied are based on similar situational attributions by the children. Yet, we did find a trend suggesting that the teachers report of 'Gets teased a lot' could indicate which children would be more likely to interpret an ambiguous situation in a more paranoid way. These findings support our hypothesis, but we did not find any similar studies supporting this. However, it has been shown that paranoid ideation in adults can be assessed through a virtual reality exposure (Riches et al., 2019). Thus, we cannot conclude whether a virtual situation is suitable or not for measuring various attributional styles between children at familial high risk of schizophrenia or bipolar disorder and controls if such differences do exist. On the contrary, the teachers' reports also suggest that children at familial high risk of schizophrenia are, in fact, less susceptible to bullying. This is evident from the teacher-reported categories 'Feels others are out to get him/her' and 'Gets teased a lot' (Table 3), where the congruence of responses is 33.2 % in the group of children at familial high risk of schizophrenia (25.3 % versus 8.4 %, congruence = 33.2 %) as opposed to only 17.8 % in the control group (14.6 % versus 2.6 %, congruence = 17.8 %). For children at familial high risk of bipolar disorder the numbers are 21.3 % versus 5.6 %, meaning that the congruence is 26.3 %. These findings indicate that children with a familial high risk of schizophrenia or bipolar disorder may not be more - but less - likely to interpret hostility and bullying in an ambiguous social situation when compared with controls and do as such contradict our hypothesis.

Since experiences of bullying according to our study is not caused by attributional bias but on the contrary - according to both self-reports, reports by primary caregivers and teachers - is highly related to the children's risk status, it seems evident that children at familial high risk of schizophrenia are truly suffering from more bullying victimization compared to controls. Knowing that childhood bullying is an independent mental health risk factor (Kallmen and Hallgren, 2021), it is alarming that children at familial high risk of schizophrenia, whom are

already at increased risk of suffering from various impairments and psychiatric illnesses in both childhood and adulthood (Rasic et al., 2014; Gregersen et al., 2021) also report more bullying. It is even more serious considering that the children, now aged 11–12 years were also reporting more bullying experiences at age 7. Such negative life experiences may add negatively to the predisposed genetic disadvantage which they already carry. One may speculate, that our findings of higher reports of bullying in children at familial high risk of schizophrenia could be explained by the children's difficulties in social interaction (Christiani et al., 2019) and it may be that the parents in the familial high risk families were less able to provide a sufficient home environment (Gantriis et al., 2019) as a base for interactions with classmates.

7. Strengths and limitations

This nationwide study is one of the largest familial high-risk studies. It is also the first to our knowledge, to explore the association between bullying and attributional style through exposure to ambiguous social situations in virtual reality. One of the strengths of the study is its use of the Danish National Register, which ensures a high level of representativeness and a narrow age range. Additionally, the large sample size of both participants at FHR-SZ and FHR-BP and the matching of controls, along with the assessors' blinding of the groups, is a notable strength. However, the study aimed to evaluate attributional style through virtual reality scenarios. Nonetheless, due to the lack of validation for this assessment, the appropriateness of our test cannot be fully ascertained, and as such the study is limited by the fact that our virtual reality scenarios were only pilot tested in a small group of children who were not at high risk of severe mental illness and were not validated prior to the study. Additionally, we did not measure immersion, which is a limitation to the study. Measures of immersion could have indicated if the environment felt real to the children. Ideal, immersion assessment should have been applied on our pilot cohort. Ensuring not to frighten the children or in other ways make them uncomfortable we kept the movies in an overall manageable easily understood setting. This approach might have resulted in creations of virtual environment assessment which did not represent true ambiguous situations which then again may have influenced our results. Also, the shortened version of the SSPS may contain lower sensitivity compared to the original version and may not capture the full range of paranoid experiences. Using well validated questionnaires is a strength but including only selected items in this study could be a limitation. To minimize participant burden and prevent redundancy in questioning, we employed a data extraction approach in which questions related to bullying were taken from pre-existing questionnaires within our extensive assessment battery. This decision was made to streamline the assessment process and reduce potential sources of measurement error.

8. Conclusions

Based on self-reports, assessments from primary caregivers, and teachers, we found that children at FHR-SZ exhibited a notably higher frequency of exposure to instances of bullying when compared to controls. This trend was supported by a robust and significant correlation between the accounts provided by the children themselves, their primary caregivers, and their teachers. Moreover, according to responses of all groups in relation to their encounters with ambiguous social situations, no differences were detected. Furthermore, there were no significant associations when examining the relationship between experiences of bullying and responses to ambiguous social situations. In light of these findings, we argue that 11–12-year-old children at FHR-SZ endure a higher incidence of bullying in comparison to controls.

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Anne Søndergaard: Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing, Conceptualization. **Maja Gregersen:** Writing – original draft, Writing – review & editing, Investigation, Conceptualization. **Martin Wilms:** Data curation, Writing – original draft, Writing – review & editing, Investigation. **Julie Marie Brandt:** Writing – review & editing, Investigation, Writing – original draft. **Carsten Hjorthøj:** Formal analysis, Writing – review & editing. **Jessica Ohland:** Software, Validation, Writing – review & editing, Data curation, Writing – original draft. **Sinnika Birkehøj Rohd:** Investigation, Writing – review & editing, Writing – original draft. **Nicoline Hemager:** Conceptualization, Writing – original draft, Writing – review & editing. **Anna Krogh Andreassen:** Investigation, Writing – original draft, Writing – review & editing. **Christina Bruun Knudsen:** Investigation, Writing – original draft, Writing – review & editing. **Lotte Veddem:** Investigation, Writing – original draft, Writing – review & editing. **Mette Falkenberg Krantz:** Investigation, Writing – review & editing. **Aja Greve:** Writing – original draft, Writing – review & editing. **Vibeke Bliksted:** Conceptualization, Writing – original draft, Writing – review & editing. **Ole Mors:** Conceptualization, Project administration, Writing – review & editing. **Lucia Valmaggia:** Conceptualization, Supervision, Writing – original draft, Writing – review & editing. **Anne E. Thorup:** Methodology, Project administration, Writing – review & editing. **Merete Nordentoft:** Conceptualization, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

All authors declare no conflict of interest.

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