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Emotion recognition and adverse childhood experiences in individuals at clinical high risk of psychosis

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Emotion recognition and adverse childhood experiences in individuals at clinical high risk of psychosis

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Abstract

Objective:

To investigate the association between Facial Affect Recognition (FAR) and type of Adverse Childhood Experiences (ACE) in a sample of Clinical High Risk (CHR) individuals and a matched sample of Healthy Controls (HC).

Methods:

309 CHR individuals and **51** HC were recruited as part of an EU-funded multi-center study (EUGEI) **and included in this work.** During a 2-year follow-up period, 65 CHR participants made transition to psychosis (CHR-T) and 279 did not (CHR-NT). FAR ability was measured using a computerized version of the Degraded Facial Affect Recognition Task (DFAR). ACE were measured using the Childhood Experience of Care and Abuse Questionnaire, the Childhood Trauma Questionnaire and the Bullying Questionnaire. Generalized regression models were used to investigate the relationship between ACE and FAR. **Logistic regressions were used to investigate the relationship between FAR and psychotic transition.**

Results:

In CHR individuals, having experienced emotional abuse was associated with decreased total and neutral DFAR scores. CHR individuals who had experienced bullying performed better in the total DFAR and in the frightened condition. In HC and CHR, having experienced the death of a parent during childhood was associated with lower DFAR total score and lower neutral DFAR score, respectively. Analyses revealed a modest increase of transition risk with increasing mistakes from happy to angry faces.

Conclusions:

Adverse experiences in childhood seem to have a significant impact on emotional processing in adult life. This information could be helpful in a therapeutic setting where both difficulties in social interactions and adverse experiences are often addressed.

Key words: vulnerability to psychosis, psychosis risk, childhood adversities, facial affect recognition, emotional processing

Introduction

Social cognition alterations have received markedly increased attention in recent years due to their possible relationship with increased liability to psychosis[1]. Patients with psychosis have difficulties in the interpretation of facial emotional expressions, and as these difficulties are detectable in both remission and in the acute phase of the illness[2,3,4] and in unaffected first-degree relatives[5], they may represent a trait rather than a state effect. In an attempt to clarify this, attention has focused on social cognition skills, including facial emotion recognition, both in patients in the early stages of the illness as well as in those at Clinical High Risk of psychosis (CHR). Several studies have reported social cognition impairments in CHR individuals [1,6-8], including alterations in facial affect recognition (FAR), which has been proposed as a possible endophenotype related to the genetic risk of development of psychosis[9,10].

Prior studies in the CHR population have reported alterations in FAR ability [7,8,11-13], however findings are mixed [14-16] and the observed difficulties do not seem to be related to a specific type of emotion. For example, van Rijn et al[11] reported difficulties in the recognition of neutral facial expressions and misattribution of neutral faces as angry; Kohler et al[17] reported difficulties in the recognition of angry and fearful expressions, but not of neutral ones **while Amminger et al.[8] reported deficits in the recognition of fear and sadness.** The severity of the observed FAR difficulties has also varied across different studies. For example, Thompson et al[14] reported no impaired FAR in CHR subjects, while Leppänen et al[18] identified pronounced difficulties similar to those seen in patients with established psychosis. FAR performance has been also studied in relation to clinical outcome. Recent studies[13,7] examined whether emotion recognition was predictive of transition to psychosis. Contrary to their initial hypotheses, **Allot et al. [13] found that** total face and prosody emotion recognition performance did not predict transition to psychosis whereas better recognition of fearful and worse recognition of neutral faces were predictive. **Addington et al[7], investigated face and prosody emotion recognition in a large sample (CHR = 172). This study found no differences in FAR across groups and no relationship with subsequent transition to psychosis.**

The variability of results across studies could in part be explained by the employment of

different tasks[19,20]. **Tasks, in fact, varied in terms of type of emotions examined, response time, format and quality of the stimulus (e.g. degraded vs non-degraded). In addition, with the exception of few large studies[7,8,21], most of the previous ones have used** relatively small samples which may have limited their statistical power[20]. Differences in experienced adverse events between samples may also contribute to heterogeneity of findings. A further factor is the heterogeneity of the CHR population: inclusion criteria vary across studies[22,23] **(including the inclusion of low social and occupational functioning as criterion[22]**; only a small proportion of CHR individuals will develop psychosis[24]; at the time of the assessment they might be in different disease stages[25]; and, even when they do develop psychosis, they might present different symptoms.

Adverse childhood experiences (ACE), which are commonly reported by CHR individuals, are known factors that can affect FAR ability. For example, Da Silva et al[18] reported that FAR was impaired in children with a history of traumatic experiences of abuse and neglect. Other studies showed that even types of abuse considered "less severe" [26], such as emotional neglect, can lead to alterations of the neural and attentional systems involved in the processing of facial expressions[26]. ACE are highly prevalent in individuals with psychosis[27,28] as well as in the CHR population[29,30] and have also been associated with increased risk of transition from CHR to psychosis[31,32]. A recent meta-analysis[33] highlighted that CHR individuals report more frequent and severe ACE than healthy controls. In a recent study, Kraan et al [34] reported that a history of emotional abuse in particular was associated with an increased risk of transition to psychosis. Independently, childhood adversities have also been associated with alterations in social cognition, including the processing and recognition of facial emotion expressions [26,35,36]. Based on the theory that children adjust their emotional perception through the learning of social experiences, childhood adversity has been suggested to change sensory thresholds, leading to less effective regulation, processing, and recognition of emotions[37]. **This could confer greater vulnerability to psychosis as, according to the sociodevelopmental-cognitive model of psychosis, developmental alterations associated with enhanced genetic vulnerability, early**

brain insults, and adverse childhood experiences might result dysregulation of the dopaminergic system which in turn can lead to symptoms of psychosis[38].

The mechanisms underlying the observed impairments in facial emotional processing in CHR individuals have yet to be clarified. In particular, it remains unclear to what extent the observed FAR impairments could be associated to ACE and if associations between ACE and FAR are different in CHR individuals compared to the general population.

In the present study, we investigated the relationship between adverse childhood experiences and FAR in a large sample of CHR individuals and a matched sample of healthy controls (HC) who were recruited as part of the European Union Gene-Environment Interactions (EU-GEI) Study [39], a multicenter, prospective, naturalistic study. We predicted that **(i)** FAR ability in CHR individuals (CHR-T and CHR-NT) with a positive history of ACE would be worse than in individuals without such a history, and that **(ii)** the impact of ACE on FAR ability will be more pronounced in CHR (CHR-T and CHR-NT) than in HC. **To provide a complete picture, we also analysed the direct associations between FAR and psychosis risk and predicted the following: (iii) FAR ability would be worse in CHR individuals than in HC, and (iv) worse FAR ability would be associated with the risk of subsequent transition to psychosis.**

Methods

Sample

344 CHR participants and 67 HC were recruited as part of EU-GEI study[39] from 11 centers (London, Amsterdam, Den Haag, Vienna, Basel, Cologne, Melbourne, Copenhagen, Paris, Barcelona, Sao Paolo) from July 2010 to August 2015 and were clinically followed up for at least 24 months. The design of the study and the inclusion and exclusion criteria for both CHR and HC have been described elsewhere[32]. The study received ethical approval at each included site.

Measures

Socio-Demographics and Clinical data

Detailed socio-demographic characteristics were assessed using the modified Medical Research Council socio-demographic Schedule[39,40]. The Comprehensive Assessment of At Risk Mental State (CAARMS) [22] was used to measure subclinical psychotic-like symptoms and to determine transition to psychosis. The Structured Clinical Interview for DSM Disorders (SCID)[41] was used to establish the presence of other psychiatric disorders and to exclude the presence of current psychotic disorders.

Facial Affect Recognition Task

A computerized version of the Degraded Facial Affect Recognition Task (DFAR)[19,42-44] was used to measure FAR ability. **The task, which has been described in previous works[19,42-44],** shows images of 4 different actors (2 males and 2 females) representing four emotions: angry, happy, fearful, and neutral. The task involves 64 trials consisting of 16 presentations on each of these emotion categories. Participants were asked to indicate the emotional expression of each image by a button press. To increase the task difficulty, images were passed through a filter resulting in a reduced visual resolution by 30%. Higher scores on the DFAR are indicative of a better ability to recognize facial expressions in that particular emotion. Results show the proportion of images correctly recognized as neutral, happy, fearful, and angry and the overall proportion of correct answers. In addition, the direction of the misattribution for each emotion was also computed (e.g. when a participant incorrectly attributes neutral to angry expressions).

Adverse Childhood Experiences Measures

The short version of the Childhood Experience of Care and Abuse questionnaire (CECA-Q) [45] and the brief version of Child Trauma Questionnaire (CTQ-B)[46] were used to measure the adverse childhood experiences up to the age of 17. The CECA-Q assesses traumatic experiences such as the death of a parent, separation from parents (including being in foster care), parental discordance, lack of adult support, poverty, cruelty, and violence**. These different measures of ACE were categorized as present or absent.**

The CTQ is a 25-item self-report questionnaire that assesses five domains: emotional abuse, emotional neglect, sexual abuse, physical abuse, and physical neglect. Each item uses a 5-point scale to identify the frequency or severity of the experience (from 1 - never to 5 - almost always). **Validated cut-off scores were used to compute the presence or absence of specific traumatic experiences[47]. The CTQ subscales were dichotomized as present or absent using the following cut-off scores: physical abuse ≥8, sexual abuse ≥6, emotional abuse ≥9, physical neglect ≥8 and emotional neglect ≥10. The different types of trauma were considered as "present" when scores were above the cut-off.** The Bullying Questionnaire[48] was used to measure the severity and frequency of bullying before the age of 17.

Statistical analyses

Analyses were performed using SPSS version 25[49]. Socio-demographic data was analyzed using means and standard deviations for continuous data and frequencies for categorical data. Analysis of the variance (ANOVAs) with Bonferroni correction for multiple comparisons were used to examine group differences in continuous variables**, including the** overall differences in the DFAR task. Chi-squares were used to assess differences in adverse experiences variables across groups. Two binary logistic regression models (the first including DFAR total and DFAR scores for each emotion; the second including all misattributions) were used to analyze the relationship between baseline FAR ability and transition to psychosis **in the CHR group.** Age, gender, IQ, ethnicity and recruitment site were entered as covariates. In order to investigate the relationship between FAR and ACE, firstly univariate analyses were performed considering FAR ability as a dependent variable and each ACE variable as independent variables. Secondly, **for each group (HC, CHR, CHR-T, CHR-NT)** five generalized linear models (i.e. total DFAR, neutral, happy, frightened and angry conditions) were performed entering as independent variables those ACE **variables (a complete list can be found in sTable 3)** with a statistical significance of $p<.15$ in the univariate analyses[50] or those which have been found as significantly related to FAR ability in the literature (i.e. physical and emotional abuse/neglect and sexual abuse [51]). In each analysis, age, gender, IQ, ethnicity and recruitment site were

entered as covariates. To analyze the relationship between DFAR performance and ACE, clinical and socio-demographic variables a gamma with log link linear distribution was assumed and **Bonferroni correction was applied to the p-values of the marginal means derived from each tested model.** When we analyzed the effect of emotional abuse, all the other types of abuse were entered as covariates.

Results

Socio-Demographics and Clinical data

411 individuals were assessed at baseline (CHR= 344; HC= 67). 16 HC and 35 CHR participants were excluded, as they did not complete the DFAR task (see **sTable 1 and sTable 2** for a comparison between included/excluded samples). The final sample comprised 309 CHR and 51 HC. At 24-month follow-up, 58 (18.8%) CHR individuals had made a transition to psychosis (CHR-T) while 251 had not (CHR-NT). Baseline socio-demographics are detailed in **Table 1**. **There were no significant differences across groups except for IQ and employment status, which were significantly higher in HC compared to CHR-NT and CHR-T.**

Facial emotion recognition and adverse childhood experiences

Below we report results for the CHR group (overall group and CHR-T and CHR-NT separately) and the HC group.

CHR group

The experience of emotional abuse in childhood was significantly associated with lower score in the DFAR total (β= -.05, SE= .03, p=.04) and in the neutral condition (β= -.07, SE= .03, p=.03) The experience of the death of a parent was significantly associated to worse neutral emotion recognition (β= -.12. SE= .05, p=.01). Lack of adult support was significantly associated to worse angry emotion recognition (β= -.09, SE= .04, p=.02). The frequency of bullying was

significantly associated to better recognition of frightened faces (β=.1, SE= .45, p=.02) and higher total DFAR score (β=.05, SE= .02, p=.01), (**Table 3a**).

HC group

In the HC group, having experienced the death of a parent during childhood was significantly associated with lower DFAR total score (β= -.18, SE= .08, p=.02). No other significant associations were found in this group (**Table 3a**).

CHR-T and CHR-NT groups

In the CHR-NT group, having been taken into care and having experienced lack of social support in childhood were significantly associated with lower total DFAR (β= -.09, SE= .04, p= .03; β= -.04, SE= .02, p= .03) and with worse recognition of angry faces (β= -.17, SE= .08, p= .04; β= -.1, SE= .04, p= .01). Having experienced the death of a parent in childhood was significantly associated with worse neutral emotion recognition (β= -.11, SE= .06, p= .04) and worse happy emotion recognition (β= -.06, SE= .03, p= .05). CHR-NT individuals who experienced more frequent bullying performed better in the recognition of frightened facial expressions than those who did not (β= .11, SE= .05, p= .02), (**Table 3b**). In the CHR-T group, emotional abuse was significantly associated with worse DFAR total score (β= -.37, SE= .13, p= .004) and worse recognition of neutral faces (β= -.27, SE= .1, p= .006). In both CHR-T and CHR-NT groups, those individuals who experienced more frequent bulling obtained higher DFAR total score (β= .3, SE= .12, p= .02; β= .05, SE= .02, p= .004) than those who did not. No other significant associations were found in the CHR-T group (**Table 3b**).

Facial Affect Recognition

There were no significant differences between groups (i.e. HC; CHR-T and CHR-NT) in the number of mistakes in the DFAR tasks (Table 2). There are some significant differences in the misattributions (sTable 4). CHR-T participants misattribute angry to happy faces significantly more than CHR-NT (F(2, 359)= 4.03, p= .02). CHR-T

participants misattribute happy to frightened faces significantly more than HC participants (F(2, 359)= 3.28 , p= .04)

Adverse Childhood Experiences

Descriptive data on adverse childhood experiences are detailed in sTable 3 and have been already reported and discussed by Kraan et al [32]. A short summary for each instrument used is provided below.

CECA-Q

There were significant differences in presence of parental discordance (HC < CHR-NT, $\chi 2$= 5.86, p=.015), lack of adult support (HC < CHR-NT, $\chi 2$=12.11, p=.001; HC < CHR-T, $\chi 2$= 15.31, p<.001); frequency of episodes of cruelty before age 11 (HC < CHR-NT, $\chi 2$= 8.81, p=.003; HC < CHR-T, $\chi 2$= 7.83, p=.005) and between age 12-16 (HC < CHR-NT, $\chi 2$= 10.53, p=.001); and the frequency of episodes of violence before age 11 (HC < CHR-NT, $\chi 2$= 12.33, p=.002), (sTable 3).

CTQ

There were significant differences in sexual abuse (HC < CHR-NT, $\chi 2$= 9.84, p=.002; HC < CHR-T, $\chi 2$= 6, p=.014), physical neglect (HC < CHR – T, $\chi 2$= 17.55, p<.0001; HC < CHR-T, $\chi 2$= 8.07, p=.005), emotional abuse (HC < CHR-NT, $\chi 2$= 27.62, p<.0001; HC < CHR-T, $\chi 2$= 19.25, p<.0001) and emotional neglect (HC < CHR-NT, $\chi 2$= 39.29, p<.0001; HC < CHR-T, $\chi 2$= 20.29, p<.0001), (sTable 3).

Bullying

Bullying experiences were more severe in the CHR-NT group than in the HC group ($\chi 2$= 9.86, p=.002), (sTable 3).

Facial emotion recognition, adverse childhood experiences and transition to psychosis

Logistic regression analyses performed on the CHR sample only revealed a significant increase of transition risk with increasing number of misattributions of happy to angry faces (β= 0.1, SE=0.03; p=0.006). No other significant associations between transition to psychosis and FAR ability were found.

Discussion

To our knowledge, this is the largest study to date that has examined the relationship between FAR ability and ACE in CHR individuals. We found that emotional abuse **and** lack of adult social support in childhood were significantly associated with poor FAR ability in CHR participants. The experience of the death of a parent in childhood was significantly associated with poor FAR in both CHR and HC. In addition, the number of happy to angry misattributions was related to the incidence of later transition to psychosis.

Our **first** and **second** hypotheses were partially confirmed. Several associations between FAR ability and ACE were found. These were statistically significant in the CHR group but not in HC. This might suggest the possible presence of resilience mechanisms in HC or a possible interaction between adverse childhood experiences and other factors, such as genetic vulnerability[52], in CHR individuals leading to compromised FAR ability. **The latter would further support the integrated sociodevelopmental-cognitive model[38]**. However, the HC group was smaller than the CHR one and we cannot exclude that other associations would have been evident in the HC group if the sample had been as large as the CHR one. Yet, having experienced the death of a parent during childhood was associated with poor FAR ability in both the clinical and non-clinical groups. Early bereavement is considered as one of the most severe life events [53] and has been associated with several adverse outcomes, including a higher risk of developing mental and physical illness[54-57]. Interestingly, Fernández-Alcántara et al[58] did not find a significant association between the experience of the death of a parent and emotion recognition; however participants included in that study experienced parental loss after age 18. The fact that we did find a significant association suggests that age of parental loss may be a

key variable influencing social cognitive processes. If parental loss happens during the early developmental period, before the age of 17, it may have a significant impact on the ability to recognize emotions in others. To confirm this result, future studies should investigate this association looking at different age spans.

Other forms of adverse childhood experiences were associated with poorer performance on the FAR task in the CHR group. Thus, in the CHR group alone, emotional abuse was associated to a worse global FAR ability. Both emotional abuse and having experienced the death of a parent were associated with worse recognition of neutral faces. Lack of adult social support was associated with worse recognition of angry faces. Generalized difficulties in FAR have been widely reported in children with trauma antecedents[59] and these difficulties seem to remain stable in adulthood[43,60]. This is in line with other studies which have reported that living in a neglected environment has an impact on the accurate recognition of others' emotions[37,61,62].

When considering the CHR-NT and CHR-T groups separately, the larger CHR-NT group seems to be driving the significant results seen in the CHR group as a whole. Interestingly, in the CHR-T group but not in the CHR-NT nor in the HC one, emotional abuse was associated with worse total and neutral emotion recognition. This strengthens our previous findings[32] and confirms that emotional abuse seems to be an important risk factor for the sub-group who go on to develop psychosis. Except for bullying, associations between ACE and FAR ability that are statistically significant in the CHR-NT group are not significant in the CHR-T group. There are at least two possible explanations for these negative findings. Firstly, it is possible that these ACE are actually not related to the development of psychosis. Secondly, the CHR-T group is relatively smaller compared to the CHR-NT group hence the lack of significant results might be due to lack of statistical power. **Post-hoc power analyses performed to test this hypothesis confirmed low statistical power (19-38%) in these categories (sTable 5).**

The frequency of bullying in the CHR group was associated with an overall better DFAR total score (in both CHR-NT and CHR-T) and better recognition of frightened expressions (CHR-NT). **Previous studies investigating ACE, highlighted how bullying, compared to other ACE, seems to have a distinct association both with psychosis[63] and with FAR[64].** Bullying

usually happens in a school environment and therefore in middle and late childhood[65]. **On a speculative level**, the fact that this usually happens later in life might have resulted in a milder impact on the FAR skills that develop early in life as a result of the child relationship with the main caregivers[66]. The significant relationship between bullying and increased ability to recognize frightened faces might be interpreted as the result of increased interpersonal sensitivity associated with the bullying **experience**[67] or as a protective mechanism.

Contrary to our **third** hypothesis, FAR ability was not significantly different in CHR individuals and HC. This was true for both overall accuracy and for each individual emotion. Although previous studies have reported differences in the ability to recognize facial emotions between CHR and HC [6,8,68], others found no differences between CHR and HC[14,16,69], or between CHR-T and CHR-NT[7]. These inconsistent findings could, at least in part, be attributed to the use of different tasks to measure the FAR ability**. For example, other large studies investigating FAR in the CHR population (e.g. Addington et al.[21] and Amminger et al.[8]) did not use a degraded-face task. In these studies, to increase task difficulty, response time was limited. In the present study, while there was no time limit and participants were instructed to be as accurate as possible, the stimulus was degraded. Although both type of studies manipulated the paradigm to increase task difficulty, one by manipulating time and the other one by manipulating the quality of the stimulus, the fact that this was done in different ways could have had an impact on the observed results. Inconsistencies could be also due to** lack of adjustment for confounding variables (such as IQ[68]), or the use of small samples.

Our **fourth** hypothesis was **also only** partially confirmed. Although no significant differences were found in the **accuracy** rate between groups, the number of errors from happy to angry were associated with subsequent transition to psychosis. This suggests that individuals who go on to develop psychosis are more likely to interpret happy degraded faces as angry. While this finding warrants replication in another CHR study, it would be in line with data from studies

which have used other methods, such as virtual reality or imaging, to study mechanisms underlying paranoid ideation[70] and psychosis risk[69], and with the notion that psychosis involves the attribution of salience to non-salient stimuli[71].

Strengths and limitations

This study has several strengths. Firstly, this is the first study investigating the relationship between FAR and adverse childhood experiences in CHR individuals, and sample size was large. Secondly, the fact that the sample was recruited in 11 different centers in and outside Europe also suggests that results are likely to be generalizable. Finally, the emotion recognition task used has **been previously used in a number of studies investigating emotion recognition in psychiatric and non-psychiatric populations**[19,42-44] and the data analysis minimised the potential confounding effects of to age, sex, IQ, and ethnicity.

This study has a number of limitations. Firstly, the size of the HC group did not match that of the CHR sample, which may have reduced our power to detect statistically significant associations within the HC group. Secondly, ACE were assessed retrospectively, hence the recall might have been subjected to bias[72]. **Thirdly**, as adverse childhood experiences might lead to other changes, for example in stress-induced hormones and neurotransmitters[73], these in turn might have conferred greater likelihood of social cognition/emotion recognition difficulties. These possible associations remain to be tested in future studies. **Fouthly, we could not establish causality between ACE and FAR ability. It is indeed possible that, for some, but not all ACE (e.g. loss of a parent), impaired FAR could preceed and be related to ACE[74]. Fiftly, our results, especially the emotion-specific associations, could be specific to our sample and the type of ACE experinced by our partecipants. Finally, study samples with and without DFAR information were significantly different in terms of age, ethnicity, group status and IQ (Table s1). This could have had an impact on the results.**

Future studies

To further clarify the underlying mechanisms, future studies should investigate the relationship and possible mediating effect of other variables, such as genetic information. This might help understanding some of the inconsistencies found in studies investigating FAR. Genetic information has been collected and will be analysed as part of the EUGEI study.

Conclusions

Adverse childhood experiences are associated with emotional processing in adult life, particularly in individuals at CHR of psychosis. These findings could inform the delivery of therapeutic interventions aimed at the social cognition sequelae of early adversity.

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Table 1. Socio-demographic and clinical characteristics

		HC (N=51)	CHR-NT (N=251)	CHR -T (N=58)	
Mean age in years (SD)		23.37 (3.98)	22.63 (4.89)	22.67 (4.86)	F(2,357)= .53, p=.59
Gender male, N (%)		27 (53%)	131 (52%)	33 (57%)	χ^2= .42, p=.81
Mean IQ (SD)		110.44 (17.84)[a,b]	98.87 (17.5)	96.96 (14.48)	F(2,335)= 10.64, p<.0001
Ethnicity					
White, N (%)		33 (65%)	187 (75%)	39 (67%)	χ^2= 14.26, p=.16
Ever employed, N (%)		48 (94%)[a,b]	190 (79%)	38 (70%)	χ^2= 9.59, p=.008
CHR inclusion group, N (%)	Genetic Vulnerability		37 (17%)	12 (22%)	χ^2=.91, p=.43
	APS		200 (87%)	57 (91%)	χ^2=.78, p=.5
	BLIPS		17 (8%)	5 (9%)	χ^2=.12, p=.45

APS: attenuated psychotic symptoms; BLIPS: brief limited intermittent psychotic symptoms; CHR-NT: clinical high risk non transition; CHR-T: clinical high risk transition; HC: healthy controls.

[a] statistically significant differences between HC and CHR-NT, after Bonferroni correction for multiple comparisons

[b] statistically significant differences between HC and CHR-T, after Bonferroni correction for multiple comparisons

Table 2. DFAR task results across groups

DFAR task % of correct answers Mean (SD)	HC	CHR-NT	CHR-T	F (df), p
Total	75.7 (9.43)	76.52 (10.01)	73.76 (15.54)	F(2, 359)= 1.49, p=.23
Neutral	82.47 (15.31)	80.73 (16.04)	78.45 (16.89)	F(2, 359)= .87, p=.42
Happy	90.56 (9.47)	90.96 (11.52)	88.25 (19.2)	F(2, 359)= 1.05, p= .35
Frightened	60.54 (19.18)	61.01 (18.65)	60.56 (19.67)	F(2, 359)= .02, p=.98
Angry	69.24 (21.21)	73.38 (19.63)	67.78 (24.61)	F(2, 359)= 2.21, p=.11

HC: healthy controls; CHR-NT: clinical high risk non transition; CHR-T: clinical high-risk transition

Table 3. Relationship between adverse childhood experience variables and the DFAR task (adjusted results).

A

	CHR					HC				
DFAR total	**β**	**SE**	**p⁺**	**Exp(ß)**	**95%CI**	**β**	**SE**	**p⁺**	**Exp(ß)**	**95%CI**
Bullied frequency, p*=.02	.05	.02	**.01**	1.05	[1.01, 1.1]	.05	.03	.16	1.05	[.98, 1.12]
Death of a parent, p*=.067	-.07	.04	.08	.93	[.87,1.01]	-.18	.08	**.02**	.83	[.71, .97]
Taken into care, p*=0.015	-.06	.50	.21	.94	[.85,1.03]	.13	.13	.29	1.14	[.89, 1.47]
Lack of adult social support, *p=.015	-.03	.02	.15	.97	[.92, 1.01]	-.05	.06	.37	.95	[.85, 1.06]
Emotional abuse***, p*=.048	-.05	.03	**.04**	.95	[.9, .99]	-.07	.05	.16	.93	[.83, 1.03]
Neutral										
Death of a parent, p*= .015	-.12	.05	**.01**	.88	[.81, .98]	-.15	.14	.28	.86	[.66, 1.14]
Emotional abuse***, p*=0.1	-.07	.03	**.03**	.93	[.87, .99]	-.03	.08	.75	.97	[.83, 1.15]
Happy										
Bullied severely, p= .08	.04	.02	.11	1.04	[.98, 1.09]	.02	.03	.5	1.02	[.95, 1.1]
Death of a parent, p*= .057	-.08	.04	.06	.92	[.85, 1.01]	.14	.08	.09	1.15	[.98, 1.35]
Frightened										
Bullied frequently, p*=.029	.1	.45	**.02**	1.1	[1.02, 1.22]	.02	.09	.79	1.02	[.81, 1.1]
Angry										
Taken into care, p*=.033	-.12	.09	.18	.88	[0.73, 1.06]	-.27	.27	.33	.76	[.45, 1.31]
Lack of adult social support, p*=.001	-.09	.04	**.02**	.91	[.85, .99]	-.08	.13	.56	.92	[.71, 1.2]

B

	CHR-NT					CHR-T				
DFAR total	β	**SE**	**p⁺**	**Exp(ß)**	**95%CI**	**β**	**SE**	**p⁺**	**Exp(ß)**	**95%CI**
Bullied frequency, p*=.02	.05	.02	**.004**	1.05	[1.02, 1.09]	.3	.12	**.02**	1.35	[1.05, 1.72,]
Death of a parent, p*=.067	-.06	.03	.1	.94	[.88, 1.01]	-.08	.14	.59	.92	[.7, 1.22]
Taken into care, p*=0.015	-.09	.04	**.03**	.91	[.85, .99]	.4	.34	.25	1.49	[.76, 2.94]
Lack of adult social support, *p=.015	-.04	.02	**.03**	.96	[.92, .99]	.15	.13	.24	1.16	[.91, 1.49]
Emotional abuse***, p*=.048	-.01	.02	.45	.99	[.94, 1.03]	-.37	.13	**.004**	.69	[.53, .89]
Neutral										
Death of a parent, p*= .015	-.11	.06	**.04**	.89	[.8, .99]	-.07	.1	.48	.93	[.76, 1.14]
Emotional abuse***, p*=0.1	-.04	.04	.24	.96	[.89, 1.03]	-.27	.1	**.006**	.76	[.62, .92]
Happy										
Bullied severely, p= .08	.02	.02	.11	1.02	[.99, 1.06]	.13	.14	.36	1.14	[.86, 1.49]
Death of a parent, p*= .057	-.06	.03	.05	.94	[.88, 1]	-.1	.2	.61	.9	[.61, 1.33]
Frightened										
Bullied frequently, p*=.029	.11	.05	**.02**	1.12	[1.1, 1.22]	.27	.17	.1	1.3	[.95, 1.82]
Angry										
Taken into care, p*=.033	-.17	.08	**.04**	.84	[.71, .99]	.56	.46	.22	1.75	[.71, 4.35]
Lack of adult social support, p*=.001	-.10	.04	**.01**	.9	[.84, .98]	.14	.14	.30	1.15	[.88, 1.51]

*p value in univariate analyses

⁺p values after adjusting for gender, age, ethnicity, recruitment site, and IQ

HC: healthy controls; CHR-NT: clinical high risk non transition; CHR-T: clinical high-risk transition; CI: confidence interval; SE: standard error

B, standard error, expected B and p values are reported for all variables entered in the models. Interpretation of the exp(β): e.g. in the CHR group who experienced bullying, the exp(β) for the DFAR total is 1.05. This means that the DFAR total of the group who experienced bullying is 1.05 times higher than the one who did not experience bullying. In other words, there is a 5% increase in *accuracy* on the DFAR total in the group who did experience bullying.

APPENDIX

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Supplementary online content

Title: ***Emotion recognition and adverse childhood experiences in individuals at clinical high risk of psychosis***

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sTable 1. Socio-demographic characteristics of the samples with/without DFAR data

		DFAR missing N=51	DFAR N=360	
Status (N, %)	HC	16 (31%)	51 (14%)	$\chi2$= 9.72, p=.008
	CHR-NT	28 (55%)	251 **(70%)**	
	CHR-T	7 **(14%)**	58 (16%)	
Gender (N, %)	Male	29 (56%)	191 (53%)	$\chi2$= .13, p=.71
	Female	23 (44%)	169 (47%)	
Ethnicity (N, %)	White	29 (56%)	259 (72%)	$\chi2$= 17.95, p=.003
Ever employed (N, %)	Yes	37 (71%)	276 (77%)	$\chi2$= .19, p=.67
Age in years (mean, SD)		20.56 (4.49)	22.74 (4.76)	t=-3.11, p=.002
IQ (mean, SD)		106.95 (20.76)	100.27 (17.59)	t=2.17, p=.030

sTable 2. Adverse childhood experiences in the samples with/without DFAR data

N (%)	DFAR missing N=51	DFAR N=360	χ2 value, p value
Bullied frequency	22 (46%)	169 (50%)	χ2= .29, p=.59
Bullied severity	21 (45%)	122 (38%)	χ2= .77, p=.42
CECA Death of a parent	3 (7%)	25 (7%)	χ2= .007, p=.93
CECA Taken into care	2 (4%)	16 (5%)	χ2= .02, p=.89
CECA Parental discordance	26 (54%)	188 (56%)	χ2= .04, p=.83
CECA Lack of adult social support	18 (38%)	139 (41%)	χ2= .15, p=.7
CECA Poverty ever	17 (35%)	110 (33%)	χ2= .13, p=.72
CECA Cruelty 0-11 year	16 (33%)	79 (23%)	χ2= 2.28, p=.13
CECA Cruelty 12-16 year	16 (34%)	87 (26%)	χ2= 1.48, p=.22
CECA Violence 0-11 year	9 (19%)	82 (24%)	χ2= 6.86, p=.032
CECA Violence 12-16 year	12 (25%)	75 (22%)	χ2= 3.01, p=.22
CTQ Sexual abuse	15 (33%)	100 (30%)	χ2= .19, p=.66
CTQ Physical neglect	20 (43%)	147 (43%)	χ2= 0, p=.99
CTQ Physical abuse	16 (35%)	76 (22%)	χ2= 3.4, p=.06
CTQ Emotional neglect	32 (70%)	241 (71%)	χ2= .05, p=.83
CTQ Emotional abuse	26 (56%)	210 (62%)	χ2= .5, p=.48

sTable 3. Adverse childhood experiences in the included samples

N (%)	HC N= 51	CHR-NT N= 251	CHR-T N= 58	χ2 value, p value
Bullied frequently	20 (39%)	128 (54%)	21 (41%)	χ2= 5.66, p=.059
Bullied severity	9 (20%)[a]	97 (43%)	16 (33%)	χ2= 9.23, p=.01
CECA death of a parent	2 (4%)	16 (7%)	7 (13%)	χ2= 3.88, p=.14
CECA Taken into care	2 (4%)	13 (5%)	1 (2%)	χ2= 1.24, p=.54
CECA Parental discordance	21 (41%)[a]	140 (60%)	27 (53%)	χ2= 5.95, p=.051
CECA lack of adult social support	9 (18%)[a,b]	102 (43%)	28 (55%)	χ2= 16.1, p<.001
CECA poverty ever	12 (23%)	77 (33%)	21 (41%)	χ2= 3.62, p=.16
CECA cruelty 0-11 year	4 (8%)[a,b]	60 (25%)	15 (29%)	χ2= 8.42, p=.015
CECA cruelty 12-16 year	4 (8%)[b]	66 (28%)	17 (33%)	χ2= 10.65, p=.005
CECA violence 0-11 year	3 (6%)[a]	69 (29%)	10 (20%)	χ2= 13.21, p=.01
CECA violence 12-16 year	6 (12%)	59 (25%)	10 (20%)	χ2= 6.37, p=.17
CTQ sexual abuse	6 (12%)[a,b]	159 (32%)	18 (33%)	χ2= 8.66, p=.013
CTQ physical neglect	9 (18%)[a,b]	114 (48%)	24 (44%)	χ2= 15.66, p<.001
CTQ physical abuse	6 (12%)	57 (24%)	13 (24%)	χ2= 3.66, p=.16
CTQ emotional neglect	17 (34%)[a,b]	184 (78%)	40 (74%)	χ2= 39.64, p<.001
CTQ emotional abuse	14 (28%)[a,b]	158 (67%)	38 (70%)	χ2= 28.86, p<.001

[a] difference between HC and CHR-NT at p<0.05

[b] difference between HC and CHR-T p<0.05

[c] difference between CHR-NT and CHR-T at p<0.05

CHR-NT: clinical high risk non transition; CHR-T: clinical high risk non transition; HC: healthy controls;

sTable 4. Emotion misattributions in the included samples

Misattributions	HC (N=51)	CHR-NT (N=251)	CHR-T (N=58)	F (df), p
Neutral as Happy	9.19 (10.48)	9.41 (9.57)	11.1 (11.1)	F(2, 359)= .74 , p= .48
Neutral as Frightened	1.71 (3.97)	2.94 (7.29)	2.9 (6.33)	F(2, 359)= .71 , p= .49
Neutral as Angry	6.62 (8.7))	6.92 (9.49)	7.32 (10.28)	F(2, 359)= .08 , p= .92
Happy as Neutral	7.23 (7.94)	6.77 (8.8)	6.25 (8.03)	F(2, 359)= .18 , p= .83
Happy as Frightened	1.22 (4.68)	1.44 (4.65)	2.59 (7.94)	F(2, 359)= 1.23 , p= .29
Happy as Angry	0.98 (2.9)	0.82(3.08)[c]	2.37 (6.28)	F(2, 359)= 4.03, p= **.02**
Frightened as Neutral	30.15 (16.28)	31.37 (16.77)	29.63 (16.87)	F(2, 359)= .32 , p= .73
Frightened as Happy	0.49 (2.1)[b]	1.49 (3.74)	2.59 (7.03)	F(2, 359)= 3.28 , p= **.04**
Frightened as Angry	8.7 (10.76)	6.12 (8.9)	6.8 (9.9)	F(2, 359)= 1.63 , p= .20
Angry as Neutral	16.67 (16.33)	15.33 (14.86)	20.26 (19.32)	F(2, 359)= 2.28 , p= .10
Angry as Happy	2.57 (4.54)	3.41 (6.75)	2.9 (7.33)	F(2, 359)= .41 , p= .66
Angry as Frightened	11.03 (13.67)	7.42 (10.03)	8.51 (13.38)	F(2, 359)= 2.25 , p=.11

[a] statistically significant differences between HC and CHR-NT, after Bonferroni correction for multiple comparisons

[b] statistically significant differences between HC and CHR-T, after Bonferroni correction for multiple comparisons

[c] statistically significant differences between CHR-NT and CHR-T, after Bonferroni correction for multiple comparisons

sTable5. Post-doc power analyses

Variables significant in CHR-NT	Statistical Power
DFAR total – taken into care	20%
DFAR neutral – death of a parent	34%
DFAR frightened – bullied frequently	19%
DFAR angry – taken into care	38%

Post-doc power analyses to test the statistical power in the CHR-T group in relation to ACE variables which were significantly associated to FAR ability in the CHR-NT group.

Software: GRANMO: https://www.imim.cat/ofertadeserveis/software-public/granmo/