Schizophrenia Research 210 (2019) 197–202

Contents lists available at ScienceDirect

Schizophrenia Research

journal homepage: www.elsevier.com/locate/schres

# Emotion recognition latency, but not accuracy, relates to real life functioning in individuals at ultra-high risk for psychosis

Louise Birkedal Glenthøj [a,b,*], Nikolai Albert [a], Birgitte Fagerlund [b,c], Tina Dam Kristensen [a,b], Christina Wenneberg [a,b], Carsten Hjorthøj [a], Merete Nordentoft [a,b], Jens Richardt Møllegaard Jepsen [a,b,c,d]

[a] Mental Health Centre Copenhagen, Copenhagen University Hospital, DK-2900 Hellerup, Denmark
[b] Centre for Clinical Intervention and Neuropsychiatric Schizophrenia Research, CINS, DK-2600 Glostrup, Denmark
[c] Centre for Neuropsychiatric Schizophrenia Research (CNSR), Mental Health Centre Glostrup, Copenhagen University Hospital, DK-2600 Glostrup, Denmark
[d] Child and Adolescent Mental Health Centre, Mental Health Services, Capital Region of Denmark, University of Copenhagen, Denmark

ARTICLE INFO

*Article history:*
Received 20 August 2018
Received in revised form 17 November 2018
Accepted 20 December 2018
Available online 28 December 2018

*Keywords:*
Ultra-high risk
Clinical high risk psychosis
Social cognition
Emotion recognition
Real-life functioning

ABSTRACT

*Background:* Emotion recognition deficits are essential features of psychotic disorders and the ultra-high risk state of psychosis (UHR), that are known to relate to functional outcome. The potential associations between aspects of emotion recognition deficits and functioning are, however, understudied in UHR individuals.
*Method:* Emotion recognition accuracy and latency were assessed in 132 UHR individuals and 60 healthy controls using the CANTAB emotion recognition task along with multiple measures of real life functioning. Multiple regression analyses assessed the potential relations between emotion recognition accuracy, latency, and measures of functioning.
*Results:* A consistent finding was that emotion recognition latency, but not accuracy, was associated with the four observer-rated measures of functioning ($\beta$ in the range −1.57 to −16.20), which remained significant on one measure after controlling for neurocognitive processing speed. Neither emotion recognition accuracy, nor latency related to real life functioning in healthy controls.
*Discussion:* The results suggest that processing speed of social cognitive information is an important correlate to real-life functioning in UHR individuals which may be a relevant target in social cognitive remediation programs for patients at risk for psychosis.



## 1. Introduction

Emotion recognition deficits constitute a hallmark of social cognitive deficits in individuals at ultra-high risk (UHR) for psychosis (Lee et al., 2015; van Donkersgoed et al., 2015) and patients with established psychosis (Comparelli et al., 2013). Additionally, emotion recognition deficits have been suggested to be a psychosis endophenotype (Allott et al., 2015). Emotion recognition accuracy has been found to correlate cross-sectionally to functioning in UHR individuals; that is both overall functioning (Amminger et al., 2013; Barbato et al., 2013; Cotter et al., 2015), role functioning (Glenthøj et al., 2016), and quality of life (Glenthøj et al., 2016). Furthermore, emotion recognition may be a predictor of psychosis development in the UHR population (Corcoran et al., 2015), although evidence is mixed (Piskulic et al., 2016). Impairments in emotion recognition accuracy are well established in the UHR population (Amminger et al., 2012; Comparelli et al., 2013; Glenthøj et al., 2016), but evidence is sparse on potential deficits in emotion recognition processing speed in the UHR state. Slower facial affect recognition has been found in individuals at familial high-risk for psychosis (Calkins et al., 2010; Eack et al., 2010), but evidence is mixed (Li et al., 2010). To our knowledge, only two studies (Glenthøj et al., 2017; Seiferth et al., 2008) have examined facial emotion recognition response latencies within the UHR/clinical high-risk population. Using data from 77 and 12 UHR individuals, respectively, these studies did not reveal significant deficits in emotion recognition response latencies. This is though initial findings, hence potential deficits in emotion recognition latency in the UHR population need further scrutiny.

It is well known, that UHR individuals suffer significant and persistent impairments in functioning (Addington et al., 2011; Cotter et al., 2014). Links between emotion recognition accuracy and functioning have been established, but to our knowledge, no prior study has examined the possible contribution of both emotion recognition accuracy and emotion recognition processing speed to functioning in UHR individuals. Examining whether social cognitive processing speed may be a potentially important and unique factor relating to the functional outcome of UHR individuals is essential, as it may guide intervention approaches that aim at improving the real life functional outcome of UHR individuals.

* Corresponding author at: Mental Health Centre Copenhagen, Research Unit, Kildegaardsvej 28, 15, 4, DK-2900 Hellerup, Denmark.
*E-mail address:* louise.birkedal.glenthoej@regionh.dk (L.B. Glenthøj).

https://doi.org/10.1016/j.schres.2018.12.038
0920-9964/

The current study aimed at examining the relative contribution of facial emotion recognition accuracy and facial emotion recognition processing speed to multiple aspects of functioning in UHR individuals (i.e. overall, social- and role functioning, and quality of life). A priori, we hypothesized that both emotion recognition accuracy and latency would significantly relate to functioning measures in UHR individuals.

## 2. Methods

Participants were recruited as part of a randomized clinical trial examining the effect of cognitive remediation in UHR individuals (Glenthøj et al., 2015). The study was carried out at the Mental Health Centre Copenhagen, Denmark. Patients were recruited from the psychiatric in- and outpatient facilities in the catchment area of Copenhagen, between April 2014 and December 2017. This report includes baseline data on emotion recognition and functioning. The study protocol was approved by the Committee on Health Research Ethics of the Capital Region Denmark (study: H-6-2013-015). All participants provided informed consent prior to inclusion in the study.

### 2.1. Participants

The sample consisted of 146 help-seeking individuals aged 18–40 years who fulfilled one or more of the UHR criteria as assessed by the Comprehensive Assessment of At-Risk Mental State (CAARMS) (Yung et al., 2005): attenuated psychotic symptom group; brief limited intermittent psychotic symptoms group; and/or trait and vulnerability group along with a significant drop in functioning or sustained low functioning for the past year. The 146 UHR individuals represent the total sample from the RCT study with available data on cognition and psychopathology. Due to a hardware failure, we have missing data on 14 UHR individuals, i.e. out of the 146 UHR individuals, 132 completed the emotion recognition task.

Exclusion criteria were 1. Past history of a psychotic episode of ≥ one week duration. 2. Psychiatric symptoms explained by a physical illness with psychotropic effect (e.g. delirium) or acute intoxication (e.g. cannabis use). 3. A diagnosis of a serious developmental disorder (e.g., Asperger's syndrome or mental retardation (i.e. IQ <70)). 4. Currently receiving methylphenidate.

A total of 63 healthy controls were included and matched at group level to the UHR individuals on sex, age (+/−2 years), and ethnicity. The healthy controls did not meet criteria for any DSM-IV disorder and did not have a first degree relative with a psychotic disorder. Sixty of the healthy controls completed the emotion recognition task.

### 2.2. Assessments

The clinical assessments were conducted by experienced psychologists or medical doctors trained in conducting the CAARMS interview by the creator of the instrument, professor Alison Yung. Additionally, a large proportion of the CAARMS ratings were based on consensus ratings by two clinicians to secure similar ratings among the raters.

#### 2.2.1. Emotion recognition

Emotion recognition was assessed using the Emotion Recognition Task from the Cambridge Neuropsychological Test Automated Battery (CANTAB ERT) (Sahakian and Owen, 1992). This is a computerized test comprising the recognition of six, basic facial emotional expressions: happiness, sadness, anger, disgust, fear, and surprise. Following a quick presentation (200 ms) of a facial expression, the participant must make a selection between the six emotional expressions presented on the screen by pressing the touch screen. The faces are presented in two blocks (90 stimuli each). The task outcome is total percent correctly identified, along with a mean response latency (ms) for all emotions correctly identified.

#### 2.2.2. Functioning

Broad, interview-based ratings served as measures of overall functioning consisting of the Social and Occupational Functioning Assessment Scale (SOFAS) (Hilsenroth et al., 2000), Global functioning: Social and Role Scales (Cornblatt et al., 2007), and the Personal and Social Performance Scale (PSP) (Morosini et al., 2000). These measures assess functioning in areas such as occupational functioning, social functioning, and self-care. A self-report measure of quality of life was obtained using the Assessment of Quality of Life (AQoL-8D) (Richardson et al., 2014).

#### 2.2.3. Neurocognitive processing speed and estimated IQ

Neurocognitive processing speed was indexed using the symbol-coding subtest from the Brief Assessment of Cognition in Schizophrenia (BACS) battery (Keefe et al., 2008).

Current IQ was estimated using four subtests from the Third version of the Danish Weschler Adult Intelligence Scale (WAIS-III); Vocabulary and Similarities providing indices of verbal IQ and Block Design and Matrix reasoning providing indices of performance IQ (Wechsler, 1997). The four subtests are strongly correlated with Full Scale IQ (Axelrod, 2002).

#### 2.2.4. Cannabis use

The ASSIST (World Health Organisation ASSIST Working Group, 2002) was used to assess current cannabis use. Patients with a score of 4, 5, or 6, corresponding to a monthly, weekly or daily use of cannabis within the last year were included in the analyses.

### 2.3. Statistical analysis

Analyses were performed using SPSS version 22.0. Raw data was checked for normality and outliers. ERT response latencies were transformed with log 10. A univariate general linear model was used to compare performance on the emotion recognition tasks (ERT accuracy and latency) and functioning measures in UHR individuals with healthy controls. We used age and sex as covariates.

Univariate regression analyses were calculated to investigate the relationship between ERT accuracy and ERT latency to the five functioning measures (SOFAS, PSP, GF: social, GF: role, and AQoL) in UHR and healthy controls. To exploratively investigate whether effects of ERT latency were influenced by general or neurocognitive processing speed; we conducted secondary multiple regression analyses including ERT latency and BACS symbol-coding as predictors.

## 3. Results

The UHR sample consisted of 54.8% females. The UHR group had a mean age of 24.3 years (SD 4.2), and an average of 14.5 years of education (SD 2.8). The majority of the UHR individuals (75.3%) fulfilled the CAARMS criteria of attenuated psychotic symptoms, followed by 18.5% fulfilling the criteria of APS plus trait/state, and 4.1% fulfilling the trait/state criteria, 1.4% APS + BLIPS criteria, and lastly 0.7% fulfilling the trait + BLIPS criteria. The UHR individuals displayed significant deficits on all the functioning measures ($p < .001$) and on the emotion recognition latency task ($p = .04$), and emotion recognition accuracy task ($p = .004$) (Table 1).

Sensitivity analyses were conducted to control for cannabis use as a potential explanation for the slower response latencies observed in UHR individuals. Controlling for a monthly, weekly, or daily cannabis use in UHR individuals did not change the significant between-group differences on ERT latency total.

**Table 1**
Group comparison on sociodemographic variables between 146 UHR patients and 63 healthy controls.

| Variable | UHR N = 146 | Healthy controls N = 63 | p Value |
|---|---|---|---|
| N (%) | | | |
| Female | 80 (54.8) | 37 (58.7) | 0.44 |
| CAARMS status | | | |
| - APS | 110 (75.3) | – | – |
| - BLIPS | 0 (0) | – | – |
| - Trait/state | 6 (4.1) | – | – |
| - APS + trait/state | 27 (18.5) | – | – |
| - APS + BLIPS | 2 (1.4) | – | – |
| - Trait − BLIPS | 1 (0.7) | – | – |
| Cannabis use total | 23 (15.8%) | | |
| - Daily | 6 (4.1%) | | |
| - Weekly | 7 (4.8%) | | |
| - Monthly | 10 (6.9%) | | |
| Mean (SD) | | | |
| Age | 24.3 (4.2) | 24.3 (3.6) | – |
| Years of education | 14.5 (2.8) | 16.1 (2.5) | 0.006 |
| Estimated IQ | 105.0 (12.9) | 111.6 (13.3) | <0.001 |
| PSP | 57.0 (9.8) | 87.7 (5.6) | <0.001 |
| SOFAS | 55.0 10.5) | 88.3 (5.2) | <0.001 |
| GF:Social | 6.2 (1.1) | 8.8 (0.5) | <0.001 |
| GF:Role | 5.6 (1.2) | 8.7 (0.6) | <0.001 |
| AQoL-8D | 0.44 (0.15) | 0.90 (0.08) | <0.001 |
| ERT total % accuracy | 69.4 (7.6) | 72.6 (5.9) | 0.004 |
| ERT % accuracy happiness | 82.1 (10.8) | 83.4 (10.9) | 0.45 |
| ERT % accuracy sadness | 79.9 (14.4) | 82.3 (9.0) | 0.21 |
| ERT % accuracy anger | 57.3 (8.8) | 61.3 (7.0) | 0.002 |
| ERT % accuracy disgust | 71.5 (15.5) | 76.7 (12.8) | 0.02 |
| ERT % accuracy fear | 48.8 (20.4) | 55.9 (19.2) | 0.02 |
| ERT % accuracy surprise | 77.2 (8.9) | 75.6 (10.9) | 0.31 |
| ERT total latency ms | 1684 (627) | 1501 (376) | 0.04 |
| ERT latency happiness | 1416 (866) | 1182 (473( | 0.02 |
| ERT latency sadness | 1696 (645) | 1491 (468) | 0.04 |
| ERT latency anger | 1869 (700) | 1716 (544) | 0.13 |
| ERT latency disgust | 1838 (1173) | 1513 (402) | 0.03 |
| ERT latency fear | 1796 (726) | 1720 (554) | 0.55 |
| ERT latency surprise | 1479 (627) | 1365 (393) | 0.35 |
| BACS symbol-number | 57.3 (11.4) | 68.2 (13.7) | <0.001 |

Note: The table display the raw scores.
CAARMS: Comprehensive assessment of at-risk mental states; SANS: APS: Attenuated Psychotic Symptom; BLIPS: Brief Limited Intermittent Psychotic Symptom; PSP: Personal and Social Performance Scale; SOFAS: Social and Occupational Functioning Assessment Scale; GF: Global Functioning; AQoL: Assessment of Quality of Life; ERT: Emotion Recognition Task; BACS: Brief assessment of cognition in schizophrenia.

### *3.1. The relationships between facial emotion recognition accuracy and processing speed to functioning measures in UHR individuals and healthy controls*

#### *3.1.1. UHR individuals*

The regression analyses (Table 2) showed emotion recognition latency total score to be significantly and negatively associated with the functioning measures PSP ($\beta = -16.20$, 95% CI = −28.53 to −3.87, p = .01), SOFAS ($\beta = -14.41$, 95% CI = −27.64 to −1.17, p = .03), GF-Social ($\beta = -1.57$, 95%CI = −2.92 to −0.22, p = .02), and trending association on GF-Role ($\beta = -1.30$, 95%CI = −2.81–0.20, p = .09), but not with the quality of life measures AQoL ($\beta = -0.12$, 95%CI = −0.31–0.07, p = .22). Emotion recognition accuracy was not significantly associated with any of these outcome measures. Additionally, we investigated how accuracy and latency on the six specific emotions related to the functioning measures. Emotion recognition latency on sadness, anger, and fear associated with the PSP; emotion recognition latency on sadness with the SOFAS; emotion recognition latency on happiness, disgust, and surprise with the GF-Social, and emotion recognition latency on sadness with the GF-Role. Finally, response latency on sadness associated with AQoL-8D. Emotion recognition accuracy on the six emotions did not relate to any of the functioning measures (Table 2).

**Table 2**
Relation between emotion recognition accuracy, latency, and functioning measures in UHR individuals.

| Outcome | Predictors | β [95% CI] | t | p | $R^2$ |
|---|---|---|---|---|---|
| PSP | | | | | 0.06 |
| | Accuracy total | 0.11 [−0.18–0.34] | 0.97 | 0.34 | |
| | Latency total | −16.20 [−28.53 to −3.87] | −2.60 | 0.01* | |
| | Accuracy happiness | 0.14 [−0.03–0.32] | 1.59 | 0.11 | |
| | Latency happiness | −8.16 [−18.61–2.28] | −1.55 | 0.12 | |
| | Accuracy sadness | −0.06 [−0.19–0.06] | −1.02 | 0.31 | |
| | Latency sadness | −17.17 [−28.70 to −5.64] | −2.95 | 0.004* | |
| | Accuracy anger | 0.16 [−0.03–0.35] | 1.64 | 0.10 | |
| | Accuracy anger | −13.02 [−24.77 to −1.27] | −2.19 | 0.03* | |
| | Accuracy disgust | −0.08 [−0.19–0.03] | −1.49 | 0.14 | |
| | Latency disgust | −8.01 [−18.17–2.16] | −1.56 | 0.12 | |
| | Accuracy fear | 0.06 [−0.02–0.14] | 1.41 | 0.16 | |
| | Latency fear | −12.89 [−24.60 to −1.17] | −2.18 | 0.03* | |
| | Accuracy surprise | −0.08 [−0.27–0.12] | −0.75 | 0.45 | |
| | Latency surprise | −10.98 [−22.12–0.15] | −1.95 | 0.053 | |
| SOFAS | | | | | 0.05 |
| | Accuracy total | 0.15 [−0.10–0.39] | 1.21 | 0.23 | |
| | Latency total | −14.41 [−27.64 to −1.17] | −2.15 | 0.03* | |
| | Accuracy happiness | 0.11 [−0.08–0.30] | 1.16 | 0.25 | |
| | Latency happiness | −8.56 [−19.80–2.69] | −1.51 | 0.14 | |
| | Accuracy sadness | 0.004 [−0.13 to −14] | 0.06 | 0.95 | |
| | Latency Sadness | −13.02 [−25.49 to −0.54] | −2.06 | 0.04* | |
| | Accuracy anger | 0.09 [−0.12–0.30] | 0.83 | 0.41 | |
| | Latency anger | −9.36 [−22.18–3.45] | −1.45 | 0.15 | |
| | Accuracy disgust | −0.08 [−0.20–0.04] | −1.35 | 0.18 | |
| | Latency disgust | −6.45 [−17.35–4.45] | 1.17 | 0.24 | |
| | Accuracy fear | 0.04 [−0.06–0.13] | 0.77 | 0.44 | |
| | Latency fear | −10.37 [−23.02–2.28] | −1.62 | 0.11 | |
| | Accuracy surprise | 0.18 [−0.03–0.39] | 1.70 | 0.09 | |
| | Latency surprise | −9.97 [−21.68–1.75] | −1.68 | 0.10 | |
| GF-Social | | | | | 0.04 |
| | Accuracy total | 0.005 [−0.20–0.30] | 0.39 | 0.70 | |
| | Latency total | −1.57 [−2.92 to −0.22] | −2.29 | 0.02* | |
| | Accuracy happiness | 0.01 [−0.008 to −0.03] | 1.13 | 0.26 | |
| | Latency happiness | −1.25 [−2.39–0.10] | −2.16 | 0.03* | |
| | Accuracy sadness | −0.004 [−0.02–0.01] | −0.61 | 0.55 | |
| | Latency sadness | −1.26 [−2.53–0.02] | −1.94 | 0.054 | |
| | Accuracy anger | 0.002 [−0.02–0.02] | 0.17 | 0.87 | |
| | Latency anger | −1.14 [−2.45–0.18] | −1.71 | 0.09 | |
| | Accuracy disgust | −0.006 [−0.02–0.006] | −0.94 | 0.35 | |
| | Latency disgust | −1.15 [−2.25 to −0.05] | −2.06 | 0.04* | |
| | Accuracy fear | −0.002 [−0.01–0.007] | −0.51 | 0.61 | |
| | Latency fear | −1.00 [−2.32–0.32] | −1.50 | 0.14 | |
| | Accuracy surprise | −0.005 [−0.03–0.02] | −0.42 | 0.67 | |
| | Latency surprise | −1.26 [−2.49 to −0.03] | −2.03 | 0.05* | |
| GF-Role | | | | | 0.03 |
| | Accuracy total | 0.01 [−0.02–0.04] | 0.68 | 0.50 | |
| | Latency total | −1.30 [−2.81–0.20] | −1.71 | 0.09 | |
| | Accuracy happiness | −0.005 [−0.03–0.02] | 0.06 | 0.96 | |
| | Latency happiness | −0.77 [−2.04–0.51] | −1.19 | 0.24 | |
| | Accuracy sadness | 0.002 [−0.01–0.02] | 0.25 | 0.81 | |
| | Latency sadness | −1.61 [−2.98 to −0.25] | −2.34 | 0.02* | |
| | Accuracy anger | 0.001 [−0.02–0.03] | 0.09 | 0.93 | |
| | Latency anger | −1.06 [−2.49–0.36] | −1.48 | 0.14 | |
| | Accuracy disgust | −0.01 [−0.03–0.00] | −1.91 | 0.06 | |
| | Latency disgust | −0.58 [−1.77–0.62] | −0.96 | 0.34 | |
| | Accuracy fear | 0.006 [−0.004–0.02] | 1.11 | 0.27 | |
| | Latency fear | −1.38 [−2.8–0.03] | −1.93 | 0.06 | |
| | Accuracy surprise | 0.007 [−0.02–0.03] | 0.63 | 0.53 | |
| | Latency surprise | −1.14 [−2.46–0.19] | −1.69 | 0.09 | |
| AQoL-8D | | | | | 0.01 |
| | ERT accuracy | – | – | – | |
| | ERT latency | −0.12 [−0.31–0.07] | −1.29 | 0.22 | |

**Table 2** (*continued*)

| Outcome | Predictors | β [95% CI] | t | p | $R^2$ |
|---|---|---|---|---|---|
| | Accuracy happiness | 0.001 [−0.002–0.003] | 0.20 | 0.62 | |
| | Latency happiness | −0.09 [−0.25–0.07] | −1.14 | 0.26 | |
| | Accuracy sadness | −0.001 [−0.003–0.001] | −0.61 | 0.55 | |
| | Latency sadness | −0.18 [−0.36 to −0.004] | −2.02 | 0.05* | |
| | Accuracy anger | 0.002 [−0.001–0.005] | 1.28 | 0.20 | |
| | Latency anger | −0.11 [−0.29–0.08] | −1.15 | 0.25 | |
| | Accuracy disgust | −0.001 [−0.002–0.001] | −0.75 | 0.46 | |
| | Latency disgust | −0.11 [−0.26–0.05] | −1.40 | 0.17 | |
| | Accuracy fear | – | – | – | |
| | Latency fear | −0.07 [−0.26–0.11] | −0.80 | 0.43 | |
| | Accuracy surprise | 0.001 [−0.003–0.004] | 0.36 | 0.72 | |
| | Latency surprise | −0.08 [−0.25–0.09] | −0.90 | 0.37 | |

* P ≤ 0.05.

In post-hoc analyses, we calculated the correlation estimate between the emotion recognition latency total score and the neurocognitive processing speed ($r = 0.23$, $p = .008$). We also included neurocognitive processing speed (BACS symbol-coding) in the regression analyses, to test whether emotion recognition latency could be reflecting a general or neurocognitive processing speed. In these post-hoc analyses ERT latency total continued to relate significantly to the functioning measure PSP. The significant associations with SOFAS and GF-social were, however, no longer significant and instead these functioning measures related significantly with the neurocognitive processing speed measure (Table 3). Additionally, estimated IQ and years of education was added as predictors in the post-hoc analyses to test whether that would change the finding of a significant association between ERT latency and the PSP. ERT latency did, though, continue to relate significantly with the PSP when controlling for the effect of IQ ($p = .04$) and years of education ($p = .03$).

### 3.1.2. Healthy controls

Regression analyses were conducted on ERT accuracy, latency and the five functioning measures in the healthy control sample. Neither emotion recognition latency nor accuracy related significantly to any of the functioning measures (Table 4). There was, though, a trending association between emotion recognition accuracy and the quality of life measure AQoL-8D ($\beta = 0.005$, 95%CI = 0.000–0.01, $p = .051$).

**Table 3**
The effect of emotion recognition latency and BACS processing speed on functioning in UHR individuals.

| Outcome | Predictors | β [95% CI] | t | p | $R^2$ |
|---|---|---|---|---|---|
| PSP | | | | | 0.08 |
| | ERT latency | −13.61 [−26.18 to −1.04] | −2.14 | 0.03* | |
| | BACS symbol-coding | 0.14 [−0.009–0.29] | 1.86 | 0.07 | |
| SOFAS | | | | | 0.07 |
| | ERT latency | −11.26 [−24.73–2.20] | −1.66 | 0.10 | |
| | BACS symbol-coding | 0.17 [0.01–0.34] | 2.12 | 0.04* | |
| GF-Social | | | | | 0.10 |
| | ERT latency | −1.02 [−2.38–0.34] | −1.49 | 0.14 | |
| | BACS symbol-coding | 0.03 [0.009–0.042] | 3.10 | 0.002** | |
| GF-Role | | | | | 0.03 |
| | ERT latency | −1.02 [−2.54–0.50] | −1.33 | 0.19 | |
| | BACS symbol-coding | 0.01 [−0.006–0.03] | 1.34 | 0.18 | |
| AQoL-8D | | | | | 0.20 |
| | ERT latency | −0.11 [−0.31–0.08] | −1.17 | 0.25 | |
| | BACS symbol-coding | 0.001 [−0.002–0.003] | 0.52 | 0.60 | |

* P ≤ 0.05.

## 4. Discussion

Previous studies in the UHR population have found deficits in emotion recognition accuracy and established links between emotion recognition accuracy and functioning (Amminger et al., 2013; Barbato et al., 2013; Cotter et al., 2015; Glenthøj et al., 2016). This is, however, the first study to investigate whether processing speed of correctly recognized facial emotions show associations to aspects of functioning in UHR individuals. Contrasting previous findings, albeit in a smaller sample (Glenthøj et al., 2017), we found significant deficits in emotion recognition processing speed between UHR individuals and healthy controls. Corroborating the existing literature (Amminger et al., 2012; Comparelli et al., 2013; Glenthøj et al., 2016), we also found significant deficits in emotion recognition accuracy. A priori, we hypothesized that both emotion recognition accuracy and latency would relate to real life functioning in UHR. Partially contradicting our hypothesis, we found that only emotion recognition processing speed was associated with the three observer-rated functioning measures PSP, SOFAS, GF-Social, and trending association with the role functioning measure (GF-Role). No association was found between emotion recognition accuracy or latency with the self-report quality of life measures (AQoL). The latter finding may be attributable to difficulties regarding self-evaluation of level of impairments (Harvey et al., 2007). When investigating the relationships between emotion recognition accuracy, latency on the six specific emotions and the functioning measures, we found that response latencies on sadness, anger, and fear associated with the PSP, response latencies on sadness with SOFAS and GF-Role, and response latencies on happiness, disgust, and surprise associated with GF-Social. Lastly, response latency on sadness associated with AQoL. This finding lend support to the notion that a specific deficit in processing of negative emotions may exist in patients with psychosis and psychosis-like states, as it has previously been reported in both adult and adolescent populations (Amminger et al., 2012; Giannitelli et al., 2015; Ruocco et al., 2014; Scholten et al., 2005).

Speculating, our finding of significant associations between ERT latency total and PSP, SOFAS, and GF-Social but not GF-Role, may reflect that speed of correct emotion recognition appear more important in social than role functioning. Our findings indicate that slower emotion recognition processing speed relate to lower functioning (β in the range −1.57 to −16.20). Due to the fast-paced nature of real-life social interactions, it can be assumed that performing adequately in daily social encounters and social communication demands not only accurate facial emotion recognition but also fast emotion recognition, which suggest more automatic/effortless processes (Murray et al., 2017). Similarly, slowing down the pace of an emotion recognition task to obtain higher emotion recognition accuracy has been observed in patients with autism spectrum disorders (Tardif et al., 2007). We did not reveal any significant associations between emotion recognition latency, nor accuracy and real-life functioning in healthy controls, suggesting that the observed relationship between slower response latencies and lower functioning may be part of the disease process in UHR individuals. Taken together, our findings suggest accuracy of facial emotion recognition to be less relevant to UHR individuals real-life functioning than the speed at which they correctly identify facial emotions. This points towards the necessity for emotion recognition tasks to encompass a processing speed measure to capture a more comprehensive understanding of emotion recognition deficits within the psychosis spectrum.

In our post-hoc analyses we examined whether the significant association between emotion recognition processing speed and functioning would merely reflect a general or neurocognitive processing speed (Lin et al., 2011; Meyer et al., 2014). In a bivariate perspective, emotion recognition speed and neurocognitive speed were significantly and weakly associated; thus, neurocognitive speed explained no more than about 5% of the variance in emotion recognition processing speed. The significant associations between emotion recognition processing speed and functioning were, however, only maintained on PSP when including

**Table 4**
Relation between emotion recognition accuracy, latency, and functioning measures in healthy controls.

| Outcome | Predictors | β [95% CI] | t | p | $R^2$ |
|---|---|---|---|---|---|
| PSP | | | | | 0.001 |
| | ERT accuracy | −0.02 [−0.28–0.24] | −0.13 | 0.90 | |
| | ERT latency | – | – | – | |
| SOFAS | | | | | 0.008 |
| | ERT accuracy | −0.08 −[−0.32–0.16] | −0.66 | 0.51 | |
| | ERT latency | – | – | – | |
| GF-Social | | | | | 0.002 |
| | ERT accuracy | 0.004 [−0.02–0.03] | 0.31 | 0.76 | |
| | ERT latency | – | – | – | |
| GF-Role | | | | | 0.019 |
| | ERT accuracy | 0.014 [−0.01–0.04] | 0.99 | 0.33 | |
| | ERT latency | – | – | – | |
| AQoL-8D | | | | | 0.06 |
| | ERT accuracy | −0.005 [−0.000–0.01] | −1.96 | 0.051 | |
| | ERT latency | – | – | – | |

our neurocognitive processing speed measure as another predictor in the multiple regression analyses. The neurocognitive processing speed, but not emotion recognition processing speed, did significantly relate to both functioning measures SOFAS and GF:Social. Speculating, it may be that our finding indicates that PSP is a more comprehensive measure of social functioning capturing more aspects of social functioning that may depend more on more social cognitive processes including emotion recognition processing speed than SOFAS and GF:Social. SOFAS and GF:Social have earlier been observed to be associated with neurocognitive processing speed in UHR individuals (Carrión et al., 2011). Additionally, the findings may reflect that social cognitive processing speed may have neurocognitive processing speed underpinnings that may drive the association between social cognitive processing speed and functioning. Studies on patients with schizophrenia, however, suggest social cognition to explain unique variance in functional outcome beyond neurocognition (Brekke et al., 2005; Pinkham et al., 2003). Also, meta-analytical findings from patients with psychosis suggest some social cognitive functions to be more strongly related to community functioning than neurocognitive functions (Fett et al., 2011). Overall, our findings indicate that different processing speed capacities have a differential effect on functioning in UHR individuals. While initial meta-analytical evidence has emerged on the effectiveness of facial affect recognition training on social functioning in patients with psychosis (Bordon et al., 2017), our findings indicate a need for integrating additional training of social cognitive processing speed in social cognitive remediation programs when aiming at enhancing real life functioning of the psychosis population. To our knowledge, no intervention studies have reported on the effect of enhancing emotion recognition processing speed in any psychiatric population. Hence, this points to future avenues to explore within the research field on social cognitive remediation programs.

### *4.1. Methodological considerations*

Strengths of this study are that it has a rather large sample size of UHR individuals, and that it includes diverse measures of functioning, hypothesized to capture different aspects of real life functioning. The use of multiple functioning measures may, though, involve the risk for multiplicity with the finding of a significant association between ERT latency and the functioning measure PSP being spurious. Another limitation of the study is, that the sample has been collected as part of a large randomized controlled trial, which might result in the sample being selected. Finally, as the study is based on cross-sectional data no causal inferences can be drawn.

**Conflict of interest**
All authors declare that there are no conflicts of interests.

**Role of funding source**
The study has been funded through The Danish Council for Independent Research (grant number DFF-4004-00314); TrygFonden (grant number ID 108119); the Mental Health Services in the Capital Region of Denmark; the research fund of the Capital Region of Denmark; the Lundbeck Foundation Center for Clinical Intervention and Neuropsychiatric Schizophrenia Research, CINS (grant number R155-2013-16337). The funding source had no role in any aspect of the study.

## CRediT authorship contribution statement

**Louise Birkedal Glenthøj:** Conceptualization, Data curation, Writing - original draft, Formal analysis, Writing - review & editing. **Nikolai Albert:** Formal analysis, Writing - review & editing. **Birgitte Fagerlund:** Conceptualization, Supervision, Writing - review & editing. **Tina Dam Kristensen:** Data curation, Writing - review & editing. **Christina Wenneberg:** Data curation, Writing - review & editing. **Carsten Hjorthøj:** Writing - review & editing. **Merete Nordentoft:** Conceptualization, Supervision, Writing - review & editing. **Jens Richardt Møllegaard Jepsen:** Supervision, Formal analysis, Writing - review & editing.

**Acknowledgements**
The study has been funded through The Danish Council for Independent Research (grant number DFF-4004-00314); TrygFonden (grant number ID 108119); the Mental Health Services in the Capital Region of Denmark; the research fund of the Capital Region of Denmark; the Lundbeck Foundation Center for Clinical Intervention and Neuropsychiatric Schizophrenia Research, CINS (grant number R155-2013-16337). The authors would like to thank Lise Mariegaard, Kristian Andersen, Frederik Zingenberg, and our psychologist students for their valued help with the project.

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