

AperTO - Archivio Istituzionale Open Access dell'Università di Torino

**Inter-relationships among psychopathology, cognition, and real-life functioning in early and late phase schizophrenia: A network analysis approach**

**This is a pre print version of the following article:**

*Original Citation:*

*Availability:*

This version is available <http://hdl.handle.net/2318/1902399> since 2023-05-05T22:32:28Z

*Published version:*

DOI:10.1016/j.schres.2023.04.011

*Terms of use:*

Open Access

Anyone can freely access the full text of works made available as "Open Access". Works made available under a Creative Commons license can be used according to the terms and conditions of said license. Use of all other works requires consent of the right holder (author or publisher) if not exempted from copyright protection by the applicable law.

(Article begins on next page)

1 **Inter-relationships among psychopathology, cognition, and real-life**  
2 **functioning in early and late phase schizophrenia: a network analysis**  
3 **approach**

4 **Running title:** Network analysis in early and late phase schizophrenia

5

6 Brasso C<sup>1,2\*</sup>, Bellino S<sup>1,2</sup>, Bozzatello P<sup>1,2</sup>, Del Favero E<sup>1,2</sup>, Montemagni C<sup>2</sup>, Rocca P<sup>1,2</sup>

7

8

9

10 <sup>1</sup>Dipartimento di Neuroscienze “Rita Levi Montalcini”, University of Turin, Italy.

11 <sup>2</sup>Struttura Complessa di Psichiatria Universitaria, Dipartimento di Neuroscienze e Salute Mentale, Azienda  
12 Ospedaliero-Universitaria “Città della Salute e della Scienza di Torino”, Turin, Italy.

13

14

15 **\* Correspondence:**

16 Claudio Brasso

17 Dipartimento di Neuroscienze “Rita Levi Montalcini”, Via Cherasco 15, Torino (TO), CAP 10126, Italy

18 [claudio.brasso@unito.it](mailto:claudio.brasso@unito.it)

19

20 **Keywords:** duration of illness, network comparison test, disorganization, metacognition,

21 neurocognition

22

23

24 **Abstract**

25 Many illness-related factors contribute to the reduction of the real-life functioning observed  
26 in people with schizophrenia (SZ). These include the psychopathological dimensions of the  
27 disorder such as positive, negative, disorganization, and depressive symptoms as well as  
28 impairment in neurocognition, social cognition, and metacognition. The associations between  
29 some of these variables change with the duration of illness (DOI), but this aspect was not  
30 explored with a network approach.

31 This study aimed at describing and comparing the inter-relationships between  
32 psychopathological, cognitive, and functioning variables in early ( $DOI \leq 5$  years) and late ( $DOI$   
33  $> 5$  years) phase SZ with network analyses and at assessing which variables were more strictly  
34 and directly associated with the real-life functioning.

35 A network representation of the relationships between variables and the calculation of  
36 centrality indices were performed within each group. The two groups were compared with a  
37 network comparison test.

38 Seventy-five patients with early and ninety-two with late phase SZ were included. No  
39 differences in the global network structure and strength were found between the two groups.  
40 In both groups, visual learning and disorganization exhibited high centrality indices and  
41 disorganization, negative symptoms, and metacognition were directly and strongly associated  
42 with real-life functioning.

43 In conclusion, regardless of the DOI, a rehabilitation aimed at improving visual learning and  
44 disorganization (i.e., the most central variables) might reduce the strength of the associations  
45 that compose the network and therefore indirectly facilitate functional recovery.  
46 Simultaneously, therapeutic interventions targeting disorganization and metacognition might  
47 directly improve real-life functioning.

48

## 49 1. Introduction

50 Schizophrenia (SZ) is a severe mental disorder and represents one of the leading causes of  
51 disability worldwide (Charlson et al., 2018). Many illness-related factors contribute to this  
52 disability in terms of reduction of real-life functioning. These include psychopathological  
53 dimensions of the disorder such as positive, negative, disorganization, and depressive  
54 symptoms as well as impairment in social and neuro-cognition (Galderisi et al., 2014; Galderisi  
55 et al., 2016; Melo Moura et al., 2022, Green et al., 2019). Also, metacognitive deficits, defined  
56 as the reduced ability to form an integrated sense of self and others, have been associated with  
57 a reduction in patients' functioning (Lysaker et al., 2018; Brune et al., 2011; Lysaker et al.,  
58 2020). Moreover, the associations between some of these variables change with the duration  
59 of illness (DOI) with a prevalence of positive symptoms in the earlier phases of the disorder  
60 and of disorganization and depressive symptoms in later ones (Fountoulakis et al., 2020).

61 Functional recovery, i.e., the achievement of good real-life psychosocial functioning, is one  
62 of the main goals of the treatment of SZ and is currently reached in about half of cases with  
63 higher rates, about 57%, in first-episode of psychosis (FEP) and lower, about 38%, in multiple  
64 episodes (Vita and Barlati, 2018; Huxley et al., 2021). This means that many patients treated  
65 for SZ maintain impaired psychosocial functioning, especially those with a longer DOI  
66 (Altamura et al., 2015). Therefore, understanding the interrelationships between illness-related  
67 variables and psychosocial functioning in individuals with long or short DOI might help in  
68 identifying targets of a functional recovery-oriented treatment in these two sub-groups of  
69 patients.

70 Network analysis is a quantitative method of studying relationships between variables  
71 without any *a priori* model (Borsboom et al., 2013). In recent years this methodological  
72 approach has found more space in psychiatry (Borsboom et al., 2017; Fried et al., 2017) and  
73 has also been applied to the study of SZ spectrum disorders. Some authors focused on specific

74 phases of the disorder like FEP (Chang et al., 2019; Griffiths et al, 2021 Isquierdo et al., 2021a,  
75 2021b, 2021c), suspected and recent onset psychosis (Jimeno et al., 2020; Heriman et al.,  
76 2021), and early and late phase SZ (Duran et al., 2021). Others works explored other aspects  
77 of SZ like depressive symptoms (Rooijen et al., 2018; Herniman et al., 2021), autistic  
78 symptoms (Isvoranu et al., 2021), metacognition (Hasson-Ohayon et al., 2018), attachment  
79 (Pena-Garijo et al., 2021), self-disorders and imagination (Rasmussen et al., 2022), remission  
80 (Rooijen et al., 2018), and recovery (Galderisi et al., 2018; Galderisi et al., 2020; Moura et al.,  
81 2021). Moreover, some studies exclusively described network characteristics (Chang et al.,  
82 2019; Galderisi et al., 2018; Hajduk et al., 2021; Hasson-Ohayon et al., 2018; Herniman et al.,  
83 2021; Izquierdo et al., 2021a) while others compared the network structure between two or  
84 more sub-samples divided by the DOI (Duran et al., 2021), the duration of untreated psychosis  
85 (Izquierdo et al., 2021b), the remission status (Rooijen et al., 2018), the recovery status  
86 (Galderisi et al., 2020; Moura et al., 2021), and the neighborhood socio-economic status  
87 (Izquierdo et al, 2021c).

88 Only Duran and colleagues (2021) compared early and late phase SZ patients with a network  
89 approach analyzing the differences in the interrelationships of the thirty signs and symptoms  
90 assessed by the Positive and Negative Syndrome Scale (PANSS, Kay et al., 1987). No  
91 significant difference emerged from this comparison (Duran et al., 2021). Considering the lack  
92 of studies on this topic, this paper would like to expand the research of Duran et al. (2021)  
93 investigating not only the psychopathological dimensions of the disorder but also cognitive and  
94 metacognitive alterations and their relationships with real-life functioning.

95 More specifically, this study aims at describing and comparing the inter-relationships  
96 between psychopathological, cognitive, and functioning variables in early and late phase SZ  
97 with a network approach. This kind of analysis can provide information about differences and  
98 similarities between the two groups of patients in terms of network structure and centrality

99 indices of the variables included in the analysis. In addition, this approach can show which  
100 variables are more strongly associated with real-life functioning in the two groups.

101 We hypothesize that patients with a longer DOI, as compared to the early-phase SZ group,  
102 will show stronger connections between symptoms, cognitive variables, and real-life  
103 functioning and that this may result in both a different structure and a stronger global strength  
104 of the network.

105

## 106 **2. Methods**

### 107 **2.1. Participants**

108 One hundred and sixty-seven people with a diagnosis of SZ according to DSM-5 criteria  
109 (American Psychiatric Association, 2013) were included in the study from January 2020 until  
110 March 2022. Patients were enrolled at the Struttura Complessa Psichiatria Universitaria,  
111 Dipartimento di Neuroscienze e Salute Mentale, Azienda Ospedaliero-Universitaria “Città  
112 della Salute e della Scienza di Torino”, Turin, Italy.

113 Inclusion criteria were age between 18 and 65 years and clinical stability as defined below.  
114 The diagnosis of SZ was confirmed by two expert clinicians (C.B., C.M.) using the Structured  
115 Clinical Interview for DSM-5, Research Version (SCID-5-RV; First et al., 2015). Clinical  
116 stability was defined as a period of at least 3 months without hospitalization and/or treatment  
117 modifications.

118 Exclusion criteria were psychiatric comorbidity with any mental disorder (DSM-5) and a  
119 history of severe head injury (coma  $\geq$  48 hours). The presence of psychiatric comorbidity was  
120 assessed by C.B. and C.M. using the SCID-5-RV.

121 Patients included in the study were evaluated using a semi-structured interview to assess  
122 age, gender, years of education, and age at illness onset. All patients received standard care  
123 provided in community mental health centers in Italy.

124 Written informed consent was obtained from all subjects. The study was carried out in  
125 accordance with the Declaration of Helsinki and was approved by the Local Research Ethics  
126 Committee (Protocol number: 0057625).

127

## 128 **2.2. Psychopathological, cognitive, and functioning assessment**

129 The severity of positive symptoms and disorganization was rated with the Positive and  
130 Negative Syndrome Scale (PANSS, Kay 1987) according to the solution proposed by  
131 Wallwork et al. (2012) (see supplementary materials for details). Negative symptoms were  
132 assessed with the Italian version of the Brief Negative Symptoms Scale (BNSS; Mucci et al.,  
133 2015). These symptoms were grouped into the factors “avolition”, consisting of anhedonia,  
134 asociality, and avolition, and “expressive deficit”, including blunted affect and alogia. (Strauss  
135 et al. 2012). The Calgary Depression Scale for Schizophrenia (CDSS, Addington et al., 1993)  
136 was employed to evaluate depressive symptoms. Compared to the depressed factor proposed  
137 by Wallwork et al. (2012) that evaluates depression with the PANSS items anxiety (G2),  
138 depression (G3), and motor retardation (G6), the CDSS proposes nine items, namely  
139 depression, hopelessness, self-depreciation, guilty ideas of reference, pathological guilt,  
140 morning depression, early wakening, suicide, and observed depression, specific for the  
141 assessment of depression in patients with SZ. Moreover, the choice to switch to the CDSS for  
142 the assessments of depressive symptoms is consistent with three previous large studies with a  
143 network approach (Galderisi et al., 2018; Galderisi et al., 2020; Moura et al., 2022).

144 Neurocognitive functions were assessed with the Measurement and Treatment Research to  
145 Improve Cognition in Schizophrenia (MATRICS) Consensus Cognitive Battery (MCCB)  
146 (Kern et al., 2008; Nuechterlein et al., 2008) (see supplementary materials for details).

147 Social cognition, in terms of emotion processing, was evaluated using the managing emotion  
148 section of the Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT), also included in  
149 the MCCB (Kern et al., 2008; Nuechterlein et al., 2008).

150 The results of the MCCB were expressed as T-scores standardized for age and gender.  
151 Higher scores indicate better performance.

152 Metacognitive abilities were assessed with the Metacognition Assessment Scale (MAS;  
153 Semerari et al., 2003). This is a clinician-rated scale that evaluates four metacognitive domains,  
154 namely self-reflectivity or awareness of oneself, understanding other's minds or awareness of  
155 specific others, decentration or awareness of one's larger community, and mastery or the use  
156 of metacognitive awareness to make sense of and respond to challenges (Lysaker 2020). For  
157 the purposes of this study, we employed the total score of the scale. Higher scores reflect higher  
158 metacognitive abilities.

159 Real-life functioning was evaluated with the Italian version of the Specific Level of  
160 Functioning Scale (SLOF; Montemagni et al., 2015; Mucci et al., 2014) (see supplementary  
161 materials for details). The SLOF was administered to the key caregiver, i.e., the person most  
162 frequently and closely in contact with the patient (Galderisi et al., 2020, Rocca et al., 2021).  
163 Higher scores indicate better real-life functioning.

164 Experienced psychiatrists (C.B., C.M.) performed psychopathological and metacognitive  
165 assessments. To reduce interrater variability, the two raters were trained to administer the  
166 PANSS, BNSS, CDSS, and MAS according to common standards. At the beginning of the  
167 study, the two psychiatrists performed independent ratings of the interviews that they  
168 conducted together with the first 20 patients participating in the study. This procedure was  
169 followed by a discussion about each interview to reach consensual ratings. The agreement  
170 (within 1 point) between the raters varied from 80% to 95% for all the PANSS items employed  
171 to rate positive symptoms and disorganization; from 80% to 90% for all BNSS items; from



172 85% to 95% for all CDSS items; and was 80% for the MAS total score. To maintain interrater  
173 reliability across the entire study period, the two raters participated every three months in an  
174 in-depth review of a random sample of interviews with the last author (P.R.).

175

### 176 **2.3 Statistical analyses**

177 Following the methodology proposed in a previous network analysis study on SZ (Duran et  
178 al., 2021), participants with a DOI  $\leq 5$  years were included in the early phase SZ group while  
179 those with a DOI  $> 5$  years in the late phase one. The normal distribution of the continuous  
180 variables was verified with the Kolmogorov-Smirnov test. Between-group comparisons were  
181 performed with the  $\chi^2$  test, one-way analysis of variance (ANOVA), and the Kruskal-Wallis  
182 test according to the type of variable and its distribution. Bonferroni-Holm correction was  
183 applied to control for multiple comparisons.

184 Missing data were imputed using an expectation-maximization algorithm, assuming that the  
185 pattern of missing data was random. Sixty-one values were imputed corresponding to 1.9% of  
186 the total values in the early phase SZ group and 1.5% in the late phase SZ group. No variable  
187 was eliminated because of a high missing rate.

188 This part of the statistical analysis was conducted using SPSS Statistics (IBM) 28.0, with a  
189 critical p-value of 0.05.

190 A network analysis was performed to compare the pattern of relationships among  
191 psychopathological, cognitive, and functioning variables between early and late phase SZ  
192 groups. Fourteen continuous variables were included in the network analysis. These variables  
193 were chosen in order to assess the principal domains of symptoms and cognition in SZ.

194 We calculated and depicted two networks, one for the early phase and one for the late phase  
195 SZ groups. Since most variables included were not normally distributed, we applied a non-  
196 paranormal transformation to relax the normality assumption (Liu et al., 2012). To reduce the

197 number of false-positive edges we employed the least absolute shrinkage and selection operator  
198 (LASSO) (Costantini et al., 2015) that negatively selects small edges by giving them a zero  
199 weight. In addition, the number of edges was optimized using a shrinkage parameter. The  
200 extended Bayesian information criterion (EBIC) was employed to determine this parameter  
201 (Foygel et al., 2010). We followed the Fruchterman-Reingold algorithm to establish the  
202 location of the nodes within the networks (Fruchterman et al., 1991).

203 As proposed by Epskamp et al. (2018), we calculated the following three centrality indices  
204 of the two networks for all variables: strength or degree centrality, betweenness, and closeness.  
205 Strength or degree centrality indicates the sum of the absolute values of the edges reaching a  
206 given node, betweenness the number of times a node lies on the shortest path length between  
207 any two other nodes, and closeness how easy it is to reach all other nodes from the node of  
208 interest. These three centrality indices were standardized to be comparable and graphically  
209 represented. These three centrality indices were standardized to be comparable and graphically  
210 represented (Epskamp et al., 2018).

211 The robustness of the two networks was evaluated with non-parametric bootstrapping  
212 procedures that estimated the accuracy of edge weights and the stability of the centrality indices  
213 (Epskamp et al., 2018). These procedures are described in detail in the supplementary materials.

214 This part of the network analysis was performed using the statistical package JASP 16.2.0.  
215 See supplementary materials for a more detailed explanation of this statistical methodology.

216 To compare the networks of the early and late phase SZ groups we employed the network  
217 comparison test (NCT) R-package (van Borkulo et al., 2017) within the R-studio desktop  
218 software. Two permutation tests for independent samples were used to compare the structure  
219 (M-test) and the global strength (S-test) of the two networks. For the between-group  
220 comparison of each edge, we utilized the edge invariance test of the NCT R-package that

221 applies Holm-Bonferroni correction for multiple comparisons (van Borkulo et al., 2017).  
222 Statistical significance was set at  $p < 0.05$ .

223

### 224 **3. Results**

#### 225 **Differences between early and late phase SZ groups**

226 Socio-demographic, psychopathological, cognitive, and functioning characteristics of early  
227 ( $n = 75$ ) and late ( $n = 92$ ) phase SZ groups are shown in table 1. Patients of the early phase  
228 group were significantly younger, with lower scores in PANSS-disorganization, better  
229 performances in working memory and verbal learning tasks, and better metacognitive abilities.  
230 They also exhibited significantly higher real-world functioning.

231

232 --- PLEASE INSERT TABLE 1 AROUND HERE ---

233

#### 234 **Network description**

235 Figure 1 shows the early and late phase SZ groups networks. Visual inspection revealed  
236 broad similarities between the two networks. Nodes belonging to the same construct were  
237 highly interconnected and spatially contiguous. This is the case of neurocognitive domains, the  
238 two domains of negative symptoms, and disorganization and positive symptoms. In both  
239 groups, real-life global functioning was highly interconnected with negative symptoms,  
240 disorganization, and metacognition.

241

242 --- PLEASE INSERT FIGURE 1 AROUND HERE ---

243 Centrality indices of the network variables of the two groups are shown in Figure 2. In both  
244 groups, visual learning and disorganization exhibited high centrality indices as they connected

245 neurocognitive domains with social cognition, metacognition, symptoms, and global  
246 functioning. Verbal learning and working memory had higher centrality indices in the late-  
247 phase SZ group, while avolition showed higher strength in patients with a DOI  $\leq$  5 years.

248

249 --- PLEASE INSERT FIGURE 2 AROUND HERE ---

### 250 **Network comparison**

251 There was no significant difference between the structure of the two networks (M-test =  
252 0.33;  $p = 0.550$ ). The overall strength of the connections among variables was almost the same  
253 in the two groups: 5.38 in the early phase SZ group and 5.44 in the late phase SZ group. This  
254 difference was not significant: S-test = 0.07;  $p = 0.97$ . The main significant edge difference  
255 between the two groups was the strong correlation between disorganization and metacognition  
256 present exclusively in the late-phase SZ group.

257

### 258 **Network stability**

259 The edge weight estimations were accurate for both groups. In particular, the bootstrap mean  
260 of each edge and the original edge value were almost overlapping and the CIs of edge weights  
261 estimates were all narrow. Strength centrality means calculated with the bootstrapping  
262 procedure of “reduced networks” were correlated with the mean of strength centrality of the  
263 original network. Correlations with  $r > 0.70$  were obtained until 43% of nodes (i.e., at least 6  
264 out of 14) were sampled. This indicates that the relationships between variables remained  
265 globally stable even after the random elimination of more than half of the network nodes.

266

## 267 **4. Discussion**

268 The aims of the study were to evaluate the differences in the structure of the networks  
269 generated by the relationships between psychopathology, cognition, metacognition, and real-

270 world functioning, in early and late phase SZ and to identify which variables included in the  
271 network analysis were more strongly associated with real-life functioning in the two groups.

272 As for the first aim, contrary to our hypothesis, we did not find any significant difference in  
273 the global structure of the networks (fig. 1). This result agrees with Duran et al. (2021) about  
274 which it adds information on the stability of relationships between cognitive, metacognitive  
275 and real-life functioning variables, regardless of the phase of the disorder. From a clinical point  
276 of view, this might indicate that treatments aimed at improving symptoms, cognitive deficits,  
277 and real-life functioning to reduce the strength of the connections between these aspects of the  
278 disorder should be tested in all patients with SZ, including those with longer DOI. This is in  
279 line with two recent large meta-analyses that did not find the DOI among the significant  
280 moderators of the treatment effect of cognitive remediation (Vita et al., 2021) and  
281 metacognitive training (Penney et al., 2022).

282 At the level of single relationships between variables (edges), the main difference between  
283 the two groups concerns the relationship between metacognition and disorganization, found  
284 exclusively in subjects with longer DOI (fig.1). Disorganization includes thought and cognitive  
285 symptoms, namely conceptual disorganization, difficulty in abstraction, and poor attention.  
286 These symptoms may worsen in later stages of SZ (Fountoulakis et al., 2020) and, also in our  
287 sample, are more severe in the late-stage SZ group. The severity of disorganization is associated  
288 with a decrease in metacognitive abilities (Minor et al., 2014; Minor et al., 2015), which were  
289 lower in our sample of patients with a longer DOI. As suggested by Minor and Collaborators  
290 (2014), this relationship is probably due to the destructive effects of disorganization on one's  
291 ability to synthesize discrete information into an organized whole, which is one of the most  
292 important aspects of metacognition.

293 Focusing on the centrality indices (fig. 2), we found that disorganization and visual learning  
294 were central in both groups while experiential negative symptoms, i.e., avolition dimension,

295 are more central in the early phase SZ group and verbal learning and working memory in the  
296 late phase one. According to our data, disorganization acts like a “bridge” between  
297 neurocognition, negative symptoms, and real-life functioning (fig. 1). This psychopathological  
298 dimension is a core feature of SZ and is negatively associated with real-life functioning,  
299 especially with interpersonal functioning (Rocca et al., 2018). This relationship may be  
300 motivated by the fact that disorganization entails difficulties in communication and social  
301 interactions, often in the absence of compensatory mechanisms that limit this negative impact  
302 (Ventura et al., 2010). Moreover, its link with negative symptoms was confirmed by a study  
303 on the random speech structure of patients with SZ (Mota et al., 2017), where the authors  
304 demonstrate a strong correlation between poorly connected speech, which is a quantitative  
305 measure of conceptual disorganization, and the severity of negative symptoms. This study  
306 suggests that thought and speech might be a common ground for both disorganization and  
307 expressive dimension of negative symptoms, (Mota et al., 2017). Finally, focusing on the  
308 connection between disorganization and neurocognition, our results are consistent with those  
309 of Ventura et al. (2010) and Vignapiano et al. (2019). These two studies demonstrated a partial  
310 superimposition between many neurocognitive domains and two of the three symptoms  
311 combined in the present study to assess disorganization, namely conceptual disorganization  
312 and difficulty in abstract thinking (Ventura et al., 2010; Vignapiano et al., 2019).

313 In our sample, visual learning connects neurocognitive domains with disorganization,  
314 avolition, and metacognition (fig. 1). The high centrality of this neurocognitive domain is in  
315 agreement with the results of Hasson-Ohayon et al. (2018), who supposed that visual learning,  
316 i.e. the ability to acquire, store and retrieve information about objects and spatial locations for  
317 more than a few minutes (Green et al., 2019), influences how people are able to think about  
318 themselves and others and to understand the inter-relationships between events. This  
319 explanation motivates and partly unfolds the connection between visual learning, other

320 neurocognitive domains, and metacognition. Moreover, this neurocognitive ability is strictly  
321 related to visual perception (Hasson-Ohayon et al., 2018), and, according to the structural  
322 equation model proposed by Green et al. 2012, visual perception and cognition impairments  
323 are strongly related to more severe experiential negative symptoms. These inter-relationships  
324 might partially explain the connection between visual learning and the avolition dimension of  
325 negative symptoms.

326 Verbal learning, i.e., the ability to acquire, store and retrieve verbal information for more  
327 than a few minutes (Green et al., 2019) and working memory, that is the ability to hold and  
328 manipulate information in a temporary store, showed higher centrality indices in late phase SZ  
329 group (fig.1, fig. 2). This was mainly due to their stronger relationships with others  
330 neurocognitive domains in this subsample of patients. In previous studies, verbal learning  
331 performance showed a negative association with the DOI (Rannikko et al., 2012, Tuulio-  
332 Henriksson et al., 2004) and working memory with multiple psychotic episodes (Forbes et al.,  
333 2009). This is consistent with our results as the performances in verbal learning and working  
334 memory tests were significantly worse in the late-phase SZ group.

335 The experiential dimension of negative symptoms including avolition, anhedonia, and  
336 asociality, showed higher strength in the early-stage SZ group as it was more connected to  
337 metacognition and visual learning. The negative relationship between negative symptoms and  
338 metacognitive abilities in FEP was already demonstrated by Trauelsen et al. 2016. The authors  
339 suggested that poor metacognitive skills may affect how experiences are perceived and  
340 interpreted facilitating the avoidance behaviors such as asociality and avolition.

341 Regarding the second aim, no differences were found between early and late phase SZ as in  
342 both groups the factors more strongly associated with real-life functioning were negative  
343 symptoms, disorganization, and metacognition. These results are in agreement with previous  
344 network analyses on this topic. In particular, experiential negative symptoms were linked to

345 global psychosocial functioning (Chang et al., 2019) and interpersonal functioning (Galderisi  
346 et al., 2018; Hajduk et al., 2021) while disorganization showed an association with everyday  
347 life skills (Galderisi et al., 2018) and work skills (Melo Moura et al, 2022).

348 Finally, focusing on metacognitive abilities, no study focused simultaneously on both  
349 metacognition and functioning with a network approach. However, the connection between  
350 these two variables was already examined with other statistical tools (e.g., structural equation  
351 modeling, repeated measures ANOVA, meta-analysis) showing that impaired metacognitive  
352 abilities were associated with poorer social and working functioning (Davies et al., 2018;  
353 Lysaker et al., 2010; Lysaker et al., 2011).

354 The main limitation of the present work is the cross-sectional nature of the study which does  
355 not allow to verify longitudinally the stability of the networks in the two groups. Moreover,  
356 with a network analysis approach, we could not verify the direction of the associations between  
357 variables. Therefore, the impossibility to assess causal relations limits the clinical significance  
358 of the present study. Another limitation of the study is the relatively small sample size of the  
359 two groups that prevents increasing the number of variables, otherwise the networks would  
360 lose strength and stability. Furthermore, we evaluated only one domain of SC, i.e., emotion  
361 management with the MSCEIT managing emotion section. A more complete and broad  
362 assessment of SC abilities should be tested in future studies with more complete instruments  
363 like those proposed by the Social Cognition Psychometric Evaluation study (Pinkham et al.,  
364 2018). In addition, we did not use as input variables the main sociodemographic factors, i.e.  
365 age, gender, and education. The inclusion of these variables in the network analysis might have  
366 led to partially different findings. Finally, all patients were clinically stable and the vast  
367 majority of them was in treatment with an antipsychotic drug. Consequently, these findings  
368 cannot be generalized to drug naïve or drug-free subjects with SZ and to acute patients that  
369 usually exhibit more severe positive symptoms.



370 Despite these limitations, this study has some strengths. Firstly, it expanded the results of  
371 Duran et al. (2021) comparing not only psychopathological variables but also cognition,  
372 metacognition, and real-life functioning between early and late phase SZ patients. Furthermore,  
373 to our knowledge, this is the first study that includes metacognition and real-life functioning in  
374 the same network analysis thus clarifying the relationship between these two variables in  
375 connection with symptoms and cognition.

376 In conclusion, there are no substantial differences in the relationships between  
377 psychopathology, cognition, metacognition, and real-life functioning between subjects with  
378 early or late phase SZ. Some neurocognitive domains and disorganization are the variables with  
379 higher central rates while metacognition seemed to act as a “bridge” between neurocognition  
380 and real-life functioning. Considering these findings, rehabilitative interventions targeting  
381 these cognitive deficits might have a positive impact in terms of reduction of the strength of  
382 the connections between the network variables both in early and late phase SZ. Moreover, this  
383 weakening of the network could indirectly facilitate an improvement in patients’ real-life  
384 functioning. However, longitudinal pre- versus post-treatment network comparison studies are  
385 needed to test this hypothesis.

386

### 387 **Data Availability**

388 Due to the anonymity guaranteed in the informed consent paperwork at the time when data  
389 were collected, data cannot be publicly shared, and are controlled by the Comitato Etico  
390 Interaziendale of the A.O.U. Città della Salute e della Scienza di Torino. Researchers who wish  
391 to request access to these data may contact the corresponding author ([claudio.brasso@unito.it](mailto:claudio.brasso@unito.it)).

392

### 393 **References**

394 Addington, D., Addington, J., Maticka-Tyndale, E., 1993. Assessing depression in  
395 schizophrenia: the Calgary Depression Scale. *Br J. Psychiatry Suppl.* 163(S22), 39-44.

- 396 Altamura, A. C., Serati, M., Buoli, M. 2015. Is duration of illness really influencing  
397 outcome in major psychoses? *Nord. J. Psychiatry* 69(6), 1685-1699.  
398 <https://doi.org/10.3109/08039488.2014.990919>.
- 399 American Psychiatric Association, 2013. *Diagnostic and statistical manual of mental*  
400 *disorders*, fifth ed. American Psychiatric Association Publishing, Washington, D.C.  
401 <https://doi.org/10.1176/appi.books.9780890425596>
- 402 Borsboom, D., Fried, E. I., Epskamp, S., Waldorp, L. J., van Borkulo, C. D., van der  
403 Maas, H., Cramer, A., 2017. False alarm? A comprehensive reanalysis of 'Evidence that  
404 psychopathology system networks have limited replicability' by Forbes, Wright, Markon,  
405 and Krueger (2017). *J. Abnorm. Psychol.* 126(7), 989-999.  
406 <https://doi.org/10.1037/abn0000306>
- 407 Borsboom, D., Cramer, A. O., 2013. Network analysis: an integrative approach to the  
408 structure of psychopathology. *Annu. Rev. Clin. Psychol.* 9, 91-121.  
409 <https://doi.org/10.1146/annurev-clinpsy-050212-185608>
- 410 Brune, M., Dimaggio, G., H Lysaker, P., 2011. Metacognition and social functioning in  
411 schizophrenia: Evidence, mechanisms of influence and treatment implications. *Current*  
412 *Psychiatr. Rev.* 7(3), 239-247. <http://doi.org/10.2174/157340011797183210>
- 413 Chang, W. C., Wong, C., Or, P., Chu, A., Hui, C., Chan, S., Lee, E., Suen, Y. N., Chen,  
414 E., 2020. Inter-relationships among psychopathology, premorbid adjustment, cognition  
415 and psychosocial functioning in first-episode psychosis: a network analysis  
416 approach. *Psychol. Med.* 50(12), 2019-2027.  
417 <https://doi.org/10.1017/S0033291719002113>
- 418 Charlson, F. J., Ferrari, A. J., Santomauro, D. F., Diminic, S., Stockings, E., Scott, J. G.,  
419 McGrath, J. J., Whiteford, H. A., 2018. Global Epidemiology and Burden of  
420 Schizophrenia: Findings From the Global Burden of Disease Study. *Schizophr. Bull.*  
421 44(6), 1195-1203. <https://doi:10.1093/schbul/sby058>
- 422  
423 Costantini, G., Epskamp, S., Borsboom, D., Perugini, M., Möttus, R., Waldorp, L.J.,  
424 Cramer, A.O.J., 2015. State of the art personality research: a tutorial on network analysis  
425 of personality data. *J. Res. Pers.* 54,13-29. <https://doi.org/10.1016/j.jrp.2014.07.003>
- 426  
427 Davies, G., Greenwood, K., 2020. A meta-analytic review of the relationship between  
428 neurocognition, metacognition and functional outcome in schizophrenia. *J. Ment.*  
429 *Health*, 29(5), 496-505. <https://doi.org/10.1080/09638237.2018.1521930>
- 430  
431 Đuran, N., Sušac, J., Vidović, D., Bošnjak, D., Vukojević, J., Bajić, Ž., Henigsberg, N., &  
432 Jukić, V., 2021. Difference of Symptoms Networks in Early and Late Phase  
433 Schizophrenia; A Cross-Sectional Network Analysis. *Psychiatr. Danub.*, 33(Suppl 4),  
434 710-718.
- 435  
436 Epskamp S, Borsboom D, Fried EI., 2018. Estimating psychological networks and their  
437 accuracy: a tutorial paper. *Behav. Res. Methods* 50, 195-212.  
438 [doi:10.3758/s13428-017-0862-1](https://doi.org/10.3758/s13428-017-0862-1)
- 439  
440 First, M. B., Williams, J. B., Karg, R. S., Spitzer, R. L., 2015. Structured clinical  
441 interview for DSM-5—Research version (SCID-5 for DSM-5, research version; SCID-5-  
442 RV). American Psychiatric Association, Arlington, VA, pp. 1-94.
- 443 Forbes, N. F., Carrick, L. A., McIntosh, A. M., Lawrie, S. M., 2009. Working memory in  
444 schizophrenia: a meta-analysis., *Psychol. Med.* 39(6), 889-905.  
445 <https://doi.org/10.1017/S0033291708004558>

- 446 Fountoulakis, K. N., Dragioti, E., Theofilidis, A. T., Wiklund, T., Atmatzidis, X.,  
447 Nimatoudis, I., Thys, E., Wampers, M., Hranov, L., Hristova, T., Aptalidis, D., Milev, R.,  
448 Iftene, F., Spaniel, F., Knytl, P., Furstova, P., From, T., Karlsson, H., Walta, M.,  
449 Salokangas, R., De Hert, M., 2021. Modeling psychological function in patients with  
450 schizophrenia with the PANSS: an international multi-center study. *CNS Spectr.* 26(3),  
451 290-298. <https://doi.org/10.1017/S1092852920001091>  
452
- 453 Foygel, R., Drton, M., 2010. Extended Bayesian information criteria for Gaussian  
454 graphical models. *Adv. Neural Inf. Process. Syst.*, 23, 604-12.  
455 <https://doi.org/10.48550/arXiv.1011.6640>  
456
- 457 Fried, E. I., van Borkulo, C. D., Cramer, A. O., Boschloo, L., Schoevers, R. A.,  
458 Borsboom, D., 2017. Mental disorders as networks of problems: a review of recent  
459 insights. *Soc. Psychiatry Psychiatr. Epidemiol.* 52(1), 1-10.  
460 <https://doi.org/10.1007/s00127-016-1319-z>  
461
- 462 Fruchterman TMJ, Reingold EM., 1991. Graph drawing by force-directed placement.  
463 *Soft. Pract. Exper.* 21, 1129-64. <https://doi.org/10.1002/spe.4380211102>  
464
- 465 Galderisi, S., Rossi, A., Rocca, P., Bertolino, A., Mucci, A., Bucci, P., Rucci, P.,  
466 Gibertoni, D., Aguglia, E., Amore, M., Bellomo, A., Biondi, M., Brugnoli, R., Dell'Osso,  
467 L., De Ronchi, D., Di Emidio, G., Di Giannantonio, M., Fagiolini, A., Marchesi, C.,  
468 Monteleone, P., ... Italian Network For Research on Psychoses, 2014. The influence of  
469 illness-related variables, personal resources and context-related factors on real-life  
470 functioning of people with schizophrenia. *World Psychiatry*, 13(3), 275-287.  
471 <https://doi.org/10.1002/wps.20167>  
472
- 473 Galderisi, S., Rucci, P., Kirkpatrick, B., Mucci, A., Gibertoni, D., Rocca, P., Rossi, A.,  
474 Bertolino, A., Strauss, G. P., Aguglia, E., Bellomo, A., Murri, M. B., Bucci, P.,  
475 Carpiniello, B., Comparelli, A., Cuomo, A., De Berardis, D., Dell'Osso, L., Di Fabio, F.,  
476 Gelao, B., ... Italian Network for Research on Psychoses, 2018. Interplay among  
477 psychopathologic variables, personal resources, context-related factors, and real-life  
478 functioning in individuals with schizophrenia: a network analysis. *JAMA Psychiatry*  
479 75(4), 396-404. <https://doi.org/10.1001/jamapsychiatry.2017.4607>
- 480 Galderisi, S., Rucci, P., Mucci, A., Rossi, A., Rocca, P., Bertolino, A., Aguglia, E.,  
481 Amore, M., Bellomo, A., Bozzatello, P., Bucci, P., Carpiniello, B., Collantoni, E.,  
482 Cuomo, A., Dell'Osso, L., Di Fabio, F., di Giannantonio, M., Gibertoni, D., Giordano, G.  
483 M., Marchesi, C., ... Italian Network for Research on Psychoses, 2020. The interplay  
484 among psychopathology, personal resources, context-related factors and real-life  
485 functioning in schizophrenia: stability in relationships after 4 years and differences in  
486 network structure between recovered and non-recovered patients. *World Psychiatry* 19(1),  
487 81-91. <https://doi.org/10.1002/wps.20700>
- 488 Green, M. F., Helleman, G., Horan, W. P., Lee, J., Wynn, J. K., 2012. From perception  
489 to functional outcome in schizophrenia: modeling the role of ability and motivation. *Arch.*  
490 *Gen. Psychiatry* 69(12), 1216-1224. <https://doi.org/10.1001/archgenpsychiatry.2012.652>
- 491 Green, M. F., Horan, W. P., Lee, J., 2019. Nonsocial and social cognition in  
492 schizophrenia: current evidence and future directions. *World Psychiatry* 18(2), 146-161.  
493 <https://doi.org/10.1002/wps.20624>
- 494 Griffiths, S. L., Leighton, S. P., Mallikarjun, P. K., et al., 2021. Structure and stability of  
495 symptoms in first episode psychosis: a longitudinal network approach. *Transl.*  
496 *Psychiatry* 11(1), 1-8. <https://doi.org/10.1038/s41398-021-01687-y>

- 497 Hasson-Ohayon, I., Goldzweig, G., Lavi-Rotenberg, A., Luther, L., Lysaker, P. H., 2018.  
498 The centrality of cognitive symptoms and metacognition within the interacting network of  
499 symptoms, neurocognition, social cognition and metacognition in  
500 schizophrenia. *Schizophr. Res.* 202, 260-266. <https://doi.org/10.1016/j.schres.2018.07.007>
- 501 Herniman, S. E., Phillips, L. J., Wood, S. J., Cotton, S. M., Liemburg, E. J., Allott, K. A.,  
502 2021. Interrelationships between depressive symptoms and positive and negative  
503 symptoms of recent onset schizophrenia spectrum disorders: a network analytical  
504 approach. *J. Psychiatr. Res.* 140, 373-380.  
505 <https://doi.org/10.1016/j.jpsychires.2021.05.038>
- 506 Huxley, P., Krayner, A., Poole, R., Prendergast, L., Aryal, S., Warner, R., 2021.  
507 Schizophrenia outcomes in the 21st century: A systematic review. *Brain. Behav.* 11(6),  
508 e02172. <https://doi.org/10.1002/brb3.2172>
- 509 Isvoranu, A. M., Ziermans, T., Schirmbeck, F., Borsboom, D., Geurts, H. M., de Haan,  
510 L., GROUP Investigators van Amelsvoort Therese Bartels-Velthuis Agna A Simons  
511 Claudia JP van Os Jim., 2022. Autistic symptoms and social functioning in psychosis: a  
512 network approach. *Schizophr. Bull.* 48(1), 273-282.  
513 <https://doi.org/10.1093/schbul/sbab084>
- 514 Izquierdo, A., Cabello, M., de la Torre-Luque, A., Ayesa-Arriola, R., Setien-Suero, E.,  
515 Mayoral-van-Son, J., Vazquez-Bourgon, J., Ayuso-Mateos, J. L., Crespo-Facorro, B.,  
516 PAFIP Group Study, 2021. A network analysis approach to functioning problems in first  
517 psychotic episodes and their relationship with duration of untreated illness: Findings from  
518 the PAFIP cohort. *J. Psychiatr. Res.*, 136, 483-491.  
519 <https://doi.org/10.1016/j.jpsychires.2020.10.019>
- 520 Izquierdo, A., Cabello, M., Leal, I., Ayora, M., Rodriguez-Jimenez, R., Ibáñez, Á., Díaz-  
521 Marsá, M., Bravo-Ortiz, M. F., Baca-García, E., Madrigal, J., Fares-Otero, N. E., Díaz-  
522 Caneja, C. M., Arango, C., Ayuso Mateos, J. L., AGES-CM group, 2021. How does  
523 neighbourhood socio-economic status affect the interrelationships between functioning  
524 dimensions in first episode of psychosis? A network analysis approach. *Health &*  
525 *Place* 69, 102555. <https://doi.org/10.1016/j.healthplace.2021.102555>
- 526 Izquierdo, A., Cabello, M., Leal, I., Mellor-Marsá, B., Ayora, M., Bravo-Ortiz, M. F.,  
527 Rodriguez-Jimenez, R., Ibáñez, A., MacDowell, K. S., Malpica, N., Díaz-Marsá, M.,  
528 Baca-García, E., Fares-Otero, N. E., Melero, H., López-García, P., Díaz-Caneja, C. M.,  
529 Arango, C., Ayuso-Mateos, J. L., AGES-CM group, 2021. The interplay between  
530 functioning problems and symptoms in first episode of psychosis: an approach from  
531 network analysis. *J. Psychiatr. Res.* 136, 265-273.  
532 <https://doi.org/10.1016/j.jpsychires.2021.02.024>
- 533 J. Ventura, A.D. Thames, R.C. Wood, L.H. Guzik, G.S., 2010. Disorganization and  
534 reality distortion in schizophrenia: a meta-analysis of the relationship between positive  
535 symptoms and neurocognitive deficits. *Schizophr. Res.* 121 (1-3), 1-14.  
536 <https://doi.org/10.1016/j.schres.2010.05.033>
- 537 Jimeno, N., Gomez-Pilar, J., Poza, J., Hornero, R., Vogeley, K., Meisenzahl, E., Haidl, T.,  
538 Rosen, M., Klosterkötter, J., Schultze-Lutter, F., 2020. Main symptomatic treatment  
539 targets in suspected and early psychosis: new insights from network analysis. *Schizophr.*  
540 *Bull.* 46(4), 884-895. <https://doi.org/10.1093/schbul/sbz140>
- 541 Kern, R. S., Nuechterlein, K. H., Green, M. F., Baade, L. E., Fenton, W. S., Gold, J. M.,  
542 Keefe, R. S., Mesholam-Gately, R., Mintz, J., Seidman, L. J., Stover, E., Marder, S. R.,  
543 2008. The MATRICS Consensus Cognitive Battery, part 2: co-norming and  
544 standardization. *Am. J. Psychiatry* 165, 214-  
545 20. <https://doi.org/10.1176/appi.ajp.2007.07010043>

- 546 Liu, H., Han, F., Yuan, M., Lafferty, J., & Wasserman, L. The nonparanormal SKEPTIC.  
547 Proceedings of the 29th International Conference on Machine Learning, ICML 2012;2:  
548 1415-22.
- 549 Lysaker, P. H., Hamm, J. A., Hasson-Ohayon, I., Pattison, M. L., Leonhardt, B. L., 2018.  
550 Promoting recovery from severe mental illness: implications from research on  
551 metacognition and metacognitive reflection and insight therapy. *World J. Psychiatry* 8(1),  
552 1-11. <https://doi.org/10.5498/wjp.v8.i1.1>
- 553 Lysaker, P. H., Kukla, M., Leonhardt, B. L., Hamm, J. A., Schnakenberg Martin, A.,  
554 Zalzal, A. B., Gagen, E. C., Hasson-Ohayon, I., 2020. Meaning, integration, and the self  
555 in serious mental illness: Implications of research in metacognition for psychiatric  
556 rehabilitation. *Psychiatr. Rehabil. J.* 43(4), 275-283. <https://doi.org/10.1037/prj0000436>
- 557 Lysaker, P. H., McCormick, B. P., Sneathen, G., Buck, K. D., Hamm, J. A., Grant, M.,  
558 Nicolò, G., Dimaggio, G., 2011. Metacognition and social function in schizophrenia:  
559 associations of mastery with functional skills competence. *Schizophr. Res.* 131(1-3), 214-  
560 218. <https://doi.org/10.1016/j.schres.2011.06.011>
- 561 Lysaker, P. H., Minor, K. S., Lysaker, J. T., Hasson-Ohayon, I., Bonfils, K., Hochheiser,  
562 J., Vohs, J. L., 2020. Metacognitive function and fragmentation in schizophrenia:  
563 Relationship to cognition, self-experience and developing treatments. *Schizophr. Res.*  
564 *Cog.*, 19, 100142. <https://doi.org/10.1016/j.scog.2019.100142>
- 565 Lysaker, P. H., Shea, A. M., Buck, K. D., Dimaggio, G., Nicolò, G., Procacci, M.,  
566 Salvatore, G., Rand, K. L., 2010. Metacognition as a mediator of the effects of  
567 impairments in neurocognition on social function in schizophrenia spectrum  
568 disorders. *Acta Psychiatr. Scand.*, 122(5), 405-413.  
569 <https://doi.org/10.1111/j.1600-0447.2010.01554.x>
- 570 Minor, K. S., Lysaker, P. H., 2014. Necessary, but not sufficient: links between  
571 neurocognition, social cognition, and metacognition in schizophrenia are moderated by  
572 disorganized symptoms. *Schizophr. Res.*, 159(1), 198-204.  
573 <https://doi.org/10.1016/j.schres.2014.08.005>
- 574 Minor, K. S., Marggraf, M. P., Davis, B. J., Luther, L., Vohs, J. L., Buck, K. D., Lysaker,  
575 P. H., 2015. Conceptual disorganization weakens links in cognitive pathways:  
576 disentangling neurocognition, social cognition, and metacognition in  
577 schizophrenia. *Schizophr. Res.*, 169(1-3), 153-158.  
578 <https://doi.org/10.1016/j.schres.2015.09.026>
- 579 Montemagni, C., Rocca, P., Mucci, A., Galderisi, S., & Maj, M. (2015). Italian version of  
580 the “Specific Level of Functioning”. *J. Psychopathol.* 21(3), 287-96.
- 581 Mota, N. B., Copelli, M., Ribeiro, S., 2017. Thought disorder measured as random speech  
582 structure classifies negative symptoms and schizophrenia diagnosis 6 months in advance.  
583 *NPJ Schizophr.* 3(1), 1-10. <https://doi.org/10.1038/s41537-017-0019-3>
- 584 Moura, B. M., Isvoranu, A. M., Kovacs, V., Van Rooijen, G., Van Amelsvoort, T.,  
585 Simons, C., Bartels-Velthuis, A. A., Bakker, P. R., Marcelis, M., De Haan, L.,  
586 Schirmbeck, F., 2022. The Puzzle of Functional Recovery in Schizophrenia-Spectrum  
587 Disorders-Replicating a Network Analysis Study. *Schizophr. Bull.* 48(4), 871-880.  
588 <https://doi.org/10.1093/schbul/sbac018>
- 589 Moura, B. M., van Rooijen, G., Schirmbeck, F., Wigman, H., Madeira, L., Harten, P. V.,  
590 van Os, J., Bakker, P. R., Marcelis, M., Genetic Risk and Outcome of Psychosis  
591 (GROUP) investigators, 2021. A Network of Psychopathological, Cognitive, and Motor

- 592 Symptoms in Schizophrenia Spectrum Disorders. *Schizophr. Bull.* 47(4), 915-926.  
593 <https://doi.org/10.1093/schbul/sbab002>
- 594 Mucci, A., Rucci, P., Rocca, P., Bucci, P., Gibertoni, D., Merlotti, E., Galderisi, S., Maj,  
595 M., Italian Network for Research on Psychoses, 2014. The Specific Level of Functioning  
596 Scale: construct validity, internal consistency and factor structure in a large Italian sample  
597 of people with schizophrenia living in the community. *Schizophr. Res.* 159(1), 144-150.  
598 <https://doi.org/10.1016/j.schres.2014.07.044>  
599
- 600 Mucci, A., Galderisi, S., Merlotti, E., Rossi, A., Rocca, P., Bucci, P., Piegari, G., Chieffi,  
601 M., Vignapiano, A., Maj, M., Italian Network for Research on Psychoses, 2015. The  
602 Brief Negative Symptom Scale (BNSS): Independent validation in a large sample of  
603 Italian patients with schizophrenia. *Eur. Psychiatry* 30(5), 641-647.  
604 <https://doi.org/10.1016/j.eurpsy.2015.01.014>
- 605 Nuechterlein, K. H., Green, M. F., Kern, R. S., Baade, L. E., Barch, D. M., Cohen, J. D.,  
606 Essock, S., Fenton, W. S., Frese, F. J., 3rd, Gold, J. M., Goldberg, T., Heaton, R. K.,  
607 Keefe, R. S., Kraemer, H., Mesholam-Gately, R., Seidman, L. J., Stover, E., Weinberger,  
608 D. R., Young, A. S., Zalcman, S., Marder, S. R., 2008. The MATRICS Consensus  
609 Cognitive Battery, part 1: test selection, reliability, and validity. *American J.*  
610 *Psychiatry* 165(2), 203–213. <https://doi.org/10.1176/appi.ajp.2007.07010042>
- 611 Pena-Garijo, J., & Monfort-Escrig, C., 2021. The centrality of secure attachment within  
612 an interacting network of symptoms, cognition, and attachment dimensions in persons  
613 with schizophrenia-spectrum disorders: A preliminary study. *J Psychiatr Res*, 135, 60-67.  
614 [doi:10.1016/j.jpsychires.2021.01.002](https://doi.org/10.1016/j.jpsychires.2021.01.002)
- 615 Penney, D., Sauvé, G., Mendelson, D., Thibaudeau, É., Moritz, S., & Lepage, M. (2022).  
616 Immediate and Sustained Outcomes and Moderators Associated With Metacognitive  
617 Training for Psychosis: A Systematic Review and Meta-analysis. *JAMA psychiatry*,  
618 79(5), 417–429. <https://doi.org/10.1001/jamapsychiatry.2022.0277>
- 619 Pinkham, A. E., Harvey, P. D., & Penn, D. L. (2018). Social Cognition Psychometric  
620 Evaluation: Results of the Final Validation Study. *Schizophr. Bull.*, 44(4), 737–748.  
621 <https://doi.org/10.1093/schbul/sbx117>
- 622 Rannikko, I., Paavola, L., Haapea, M., Huhtaniska, S., Miettunen, J., Veijola, J., Murray,  
623 G. K., Barnes, A., Wahlberg, K. E., Isohanni, M., Jääskeläinen, E., 2012. Verbal learning  
624 and memory and their associations with brain morphology and illness course in  
625 schizophrenia spectrum psychoses. *J. Clin. Exp. Neuropsychol.* 34(7), 698-713.  
626 <https://doi.org/10.1080/13803395.2012.668875>
- 627 Rasmussen, A. R., Raballo, A., Preti, A., Sæbye, D., & Parnas, J., 2022. Anomalies of  
628 Imagination, Self-Disorders, and Schizophrenia Spectrum Psychopathology: A Network  
629 Analysis. *Front. Psychiatry*, 12, 808009. <https://doi.org/10.3389/fpsy.2021.808009>
- 630 Rocca, P., Brasso, C., Montemagni, C., Bellino, S., Rossi, A., Bertolino, A., Gibertoni,  
631 D., Aguglia, E., Amore, M., Andriola, I., Bellomo, A., Bucci, P., Buzzanca, A.,  
632 Carpiniello, B., Cuomo, A., Dell'Osso, L., Favaro, A., Giordano, G. M., Marchesi, C.,  
633 Monteleone, P., ... Italian Network for Research on Psychoses, 2021. Accuracy of self-  
634 assessment of real-life functioning in schizophrenia. *NPJ Schizophr.*, 7(1), 11.  
635 <https://doi.org/10.1038/s41537-021-00140-9>
- 636 Rocca, P., Galderisi, S., Rossi, A., Bertolino, A., Rucci, P., Gibertoni, D., Montemagni,  
637 C., Bellino, S., Aguglia, E., Amore, M., Bellomo, A., Biondi, M., Carpiniello, B., Cuomo,  
638 A., D'Ambrosio, E., dell'Osso, L., Girardi, P., Marchesi, C., Monteleone, P., Montemitro,  
639 C., ... Italian Network for Research on Psychoses, 2018. Disorganization and real world  
640 functioning in schizophrenia: Results from the multicenter study of the Italian Network

- 641 for Research on Psychoses. *Schizophr. Res.* 201, 105–112.  
642 <https://doi.org/10.1016/j.schres.2018.06.00>
- 643 Semerari A, Carcione A, Dimaggio G, Falcone M, Nicolo G, Procaci M, Alleva, G.,  
644 2003. How to evaluate metacognitive function in psychotherapy? The Metacognition  
645 Assessment Scale its applications. *Clin. Psychol. Psychother.* 10:238-61
- 646 Strauss, G. P., Hong, L. E., Gold, J. M., Buchanan, R. W., McMahon, R. P., Keller, W.  
647 R., Fischer, B. A., Catalano, L. T., Culbreth, A. J., Carpenter, W. T., Kirkpatrick, B.,  
648 2012. Factor structure of the Brief Negative Symptom Scale. *Schizophr. Res.* 142(1-3),  
649 96–98. <https://doi.org/10.1016/j.schres.2012.09.007>.
- 650 Trauelsen, A. M., Gumley, A., Jansen, J. E., Pedersen, M. B., Nielsen, H. L., Trier, C. H.,  
651 Haahr, U. H., Simonsen, E., 2016. Metacognition in first-episode psychosis and its  
652 association with positive and negative symptom profiles. *Psychiatry. Res.* 238, 14–23.  
653 <https://doi.org/10.1016/j.psychres.2016.02.003>
- 654 Tuulio-Henriksson, A., Partonen, T., Suvisaari, J., Haukka, J., Lönnqvist, J., 2004. Age at  
655 onset and cognitive functioning in schizophrenia. *Br. J. Psychiatry.* 185, 215-219.  
656 <https://doi.org/10.1192/bjp.185.3.215>
- 657 van Borkulo, C. D., van Bork, R., Boschloo, L., Kossakowski, J. J., Tio, P., Schoevers, R.  
658 A., Borsboom, D., Waldorp, L. J., 2022. Comparing network structures on three aspects:  
659 A permutation test. *Psychol Methods.* Published online ahead of print, 2022 Apr 11.  
660 <https://doi.org/10.1037/met0000476>
- 661 van Rooijen, G., Isvoranu, A. M., Kruijt, O. H., van Borkulo, C. D., Meijer, C. J.,  
662 Wigman, J., Ruhé, H. G., de Haan, L., GROUP investigators, 2018. A state-independent  
663 network of depressive, negative and positive symptoms in male patients with  
664 schizophrenia spectrum disorders. *Schizophr. Res.* 193, 232–239.  
665 <https://doi.org/10.1016/j.schres.2017.07.035>
- 666 Vignapiano, A., Koenig, T., Mucci, A., Giordano, G. M., Amodio, A., Altamura, M.,  
667 Bellomo, A., Brugnoli, R., Corrivetti, G., Di Lorenzo, G., Girardi, P., Monteleone, P.,  
668 Niolu, C., Galderisi, S., Maj, M., Italian Network for Research on Psychoses (2019).  
669 Disorganization and cognitive impairment in schizophrenia: New insights from  
670 electrophysiological findings. *Int. J. Psychophysiol.* 145, 99–108.  
671 <https://doi.org/10.1016/j.ijpsycho.2019.03.008>
- 672 Vita, A., Barlati, S., 2018. Recovery from schizophrenia: is it possible?. *Curr. Opin.*  
673 *Psychiatry.* 31(3), 246-255. <https://doi.org/10.1097/YCO.0000000000000407>
- 674 Vita, A., Barlati, S., Ceraso, A., Nibbio, G., Ariu, C., Deste, G., & Wykes, T. (2021).  
675 Effectiveness, Core Elements, and Moderators of Response of Cognitive Remediation for  
676 Schizophrenia: A Systematic Review and Meta-analysis of Randomized Clinical Trials.  
677 *JAMA psychiatry*, 78(8), 848–858. <https://doi.org/10.1001/jamapsychiatry.2021.0620>
- 678 Wallwork, R. S., Fortgang, R., Hashimoto, R., Weinberger, D. R., & Dickinson, D.  
679 (2012). Searching for a consensus five-factor model of the Positive and Negative  
680 Syndrome Scale for schizophrenia. *Schizophr Res.* 137(1-3):246-250.  
681 [doi:10.1016/j.schres.2012.01.031](https://doi.org/10.1016/j.schres.2012.01.031)  
682