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**Citation:** Halverson, T. F., Orleans-Pobee, M., Merritt, C., Sheeran, P., Fett, A-K. ORCID: 0000-0003-0282-273X and Penn, D. L. (2019). Pathways to functional outcomes in schizophrenia spectrum disorders: Meta-analysis of social cognitive and neurocognitive predictors. *Neuroscience & Biobehavioral Reviews*, 105, pp. 212-219. doi: 10.1016/j.neubiorev.2019.07.020

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**Link to published version:** <http://dx.doi.org/10.1016/j.neubiorev.2019.07.020>

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## COGNITION AND FUNCTIONAL OUTCOMES IN SCHIZOPHRENIA

### **Highlights**

- Meta-analysis of 166 studies (12,868 individuals) examining relationships between neurocognition and social cognition and functional outcomes.
- Domains of neurocognition and social cognition demonstrate small to medium relationships with functional outcomes.
- Neurocognition and social cognition did not demonstrate significantly different relationships with functional outcomes, however, social cognition domains explained more unique variance.
- Social cognition is a partial mediator between neurocognition and functional outcomes.

## COGNITION AND FUNCTIONAL OUTCOMES IN SCHIZOPHRENIA

### **Abstract**

The current meta-analysis explored relationships between functional outcomes in schizophrenia spectrum disorders and different domains of neurocognition and social cognition. Literature searches were conducted in PsycINFO, PubMed, and ProQuest to identify articles reporting correlations between cognition domains and functional outcomes. Of 1,361 articles identified, 166 met all inclusion criteria (12,868 participants; 518 correlations). Fifty-three random-effects meta-analyses yielded mean correlation estimates for relationships between neurocognition and social cognition and functional outcomes. Overall, associations between social cognition and neurocognition, and functional outcomes demonstrated significant small-to-medium effect sizes. Social cognition explained more unique variance in functioning than neurocognition (7.3% vs. 4.4%; 9.2% total average variance). Social cognition also mediated the relationship between neurocognition and functional outcomes. A significant proportion of the variance in the relationships between cognition and functional outcomes remained unexplained. These findings suggest that integrated interventions targeting both neurocognition and social cognition may optimally improve functional outcomes. Standardized measurement of cognition and functioning, longitudinal studies, and tests of additional moderators (e.g., first episode samples) in future research were identified as important future directions.

# COGNITION AND FUNCTIONAL OUTCOMES IN SCHIZOPHRENIA

## Pathways to Functional Outcomes in Schizophrenia Spectrum Disorders: Meta-Analysis of Social Cognitive and Neurocognitive Predictors

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Role of Funding: The authors received no specific funding for this work.

## 1. Introduction

Decades of research have established a strong link between functional outcomes in schizophrenia and impairments in both social cognition (SC) and neurocognition (NC) (Couture, Penn, & Roberts, 2006; Fett et al., 2011; Ludwig, Pinkham, Harvey, Kelsven, & Penn, 2017; Green, Kern, & Braff, 2011). As a result, interventions targeting NC (McGurk et al., 2007; Prikken et al., 2018; Reeder et al., 2017) *or* SC (Grant et al., 2017; Kurtz et al., 2016; Kurtz and Richardson, 2012), are widely disseminated yielding improvements in specific NC and SC abilities but equivocal effects on functional outcomes (e.g., Grant, Lawrence, Preti, Wykes, & Cella, 2017; Prikken et al., 2018). More nuanced understanding of interrelationships between NC and SC and effects on functioning is needed to clarify how to best target NC and SC to improve treatment development, implementation, and outcomes (Horan & Green, 2017).

Although both NC and SC exhibit some overlap (i.e., strong relationships with one another), they are demonstrably separate constructs that differentially relate to functional outcomes (Allen, Strauss, Donohue, & van Kammen, 2007; Ludwig, Pinkham, Harvey, Kelsven, & Penn, 2017; Nuechterlein et al., 2004). Pinkham, Penn, Green, & Harvey (2016) demonstrated that SC has incremental validity in explaining the variance in functional outcomes beyond NC in both first-episode and chronic schizophrenia populations, possibly as a mediator between NC and functional outcomes. Several studies support the role of SC as a mediator, providing additional evidence of a related but distinct relationship between NC, SC, and functional outcomes (Brekke et al., 2005; Schmidt et al., 2011; Vauth et al., 2004).

Despite support for SC as a mediator between NC and functional outcomes, the majority of interventions target either NC *or* SC impairments (Paquin et al., 2014). Interventions targeting only one domain of cognition may be one explanation for small or null effects on functional outcomes in schizophrenia (Horan & Green, 2017). A better understanding of the relationships between NC, SC, and functioning is necessary to inform development and dissemination of optimally effective interventions in schizophrenia.

27 We therefore undertook a meta-analysis of the relationships between functional outcomes in  
28 schizophrenia and social cognition and neurocognition. Meta-analysis is needed because the only  
29 previous quantitative review is 10 years old (studies reviewed up to 2007) and examined just 55 studies  
30 (Fett et al., 2011). Fett et al. (2011) found small to large mean correlations between NC and SC and  
31 functional outcomes. Interpreting the strongest individual correlations, the data suggested that SC  
32 explains more variance in functional outcomes than NC, with the strongest individual correlations  
33 observed between theory of mind and community functioning ( $\hat{u}_p = .48$ ; 23% variance explained) and  
34 attention and vigilance and social skills ( $\hat{u}_p = .39$ ; 15% variance explained), respectively. A search of  
35 PsychINFO indicated that more than 2,000 papers with “neurocognition” or “social cognition” and  
36 “functioning” in the title have been published during the interim. It is also the case that new work has  
37 emerged on SC domains such as attributional style and for participants in the early stages of  
38 schizophrenia (“first-episode psychosis” or FEP). Understanding how SC and NC relate to outcomes for  
39 FEP samples is important given the (a) qualitative differences between first-episode and chronic  
40 schizophrenia (e.g., Braw, Bloch, & Mendelovich, 2008), (b) increased focus on FEP treatments (e.g.,  
41 RAISE Early Treatment Program, Kane et al., 2015), and (c) need for intervention before impairments  
42 in social functioning stabilize (Velthorst et al., 2017).

43 The present meta-analysis will review all eligible studies published up to July 2017 to improve  
44 our current understanding of interrelationships between NC and SC with functional outcomes in  
45 schizophrenia by: 1) quantifying the relationships between functional outcomes and domains of NC and  
46 SC, 2) comparing the strength of relationships between NC and SC with functional outcomes, while  
47 accounting for important moderator variables; 3) analyzing the associations between specific NC and SC  
48 cognitive domains and functional outcomes in FEP samples; and 4) formally testing mediation of the  
49 NC-functional outcome relation by SC.

50

## 2. Method

51 The meta-analysis was registered through Prospero (CRD42018092456) and followed PRISMA  
52 guidelines, see Supplementary Table 1 for concordance with PRISMA Checklist for meta-analyses  
53 (Moher et al., 2009).

## 54 **2.1. Search Strategy**

55 Articles for potential inclusion were identified through searches completed in July 2017 in the  
56 databases PsychINFO and PubMed. To address the file-drawer effect (Rosenthal, 1979), unpublished  
57 findings were identified through dissertations published on ProQuest and pre-prints published on  
58 PsyArXiv (searches yielded no pre-prints). All studies from Fett et al. (2011) were also included.  
59 Searches spanned August 2009, the most recent time period included by Fett et al. (2011) to July 2017.  
60 Search terms were identified through consultation with an academic librarian and included:  
61 *schizophrenia spectrum and other psychotic disorders* (PubMed MeSH term) or (*schizophrenia,*  
62 *psychosis, psychotic, schizophrenia spectrum, prodrome*) combined with functional outcome search  
63 terms (*functional outcome, independent living skills, skills of daily living, community functioning, social*  
64 *functioning, work functioning, occupational functioning, vocational functioning, social skill, quality of*  
65 *life, community behavior, social behavior, life satisfaction, social adjustment, social dysfunction,*  
66 *employment*) and neurocognition search terms (*neuropsych\*, neurocog\**) or social cognition search  
67 terms (*emotional perception, affect perception, emotional recognition, attribution\*, theory or mind,*  
68 *mentalizing, mentalising, social cognition, prosody, social knowledge, mind reading, social cue, social*  
69 *judgment*). Search terms were identical to Fett et al. (2011) with the addition of: *schizophrenia spectrum*  
70 and *prodrome* and the use of PubMed MeSH term (*schizophrenia spectrum and other psychotic*  
71 *disorders*).

## 72 **2.2. Article Inclusion Criteria**

73 Articles were inspected for the following inclusion criteria: a) the article was written in English  
74 b) the sample consisted of individuals with a diagnosis of non-affective psychosis according to well



75 established diagnostic criteria (e.g., *Diagnostic and Statistical Manual of Mental Disorder* and the  
76 *International Classification of Diseases*), c) at least one cross-sectional correlation between a cognitive  
77 domain and functional outcome measure was reported, d) established and reproducible outcome  
78 measures were used that could be classified into domains of cognition and functioning. Correlations  
79 with study-specific factor scores and partial correlations were excluded as these indices could not  
80 meaningfully be combined across studies. Samples with special characteristics (e.g., geriatric and  
81 forensic) were excluded to minimize potential bias in effect size estimates; low statistical power  
82 precluded using special sample characteristics as moderators.

### 83 **2.2.1. Neurocognition Domains**

84 Domains of NC included: attention and vigilance, processing speed, reasoning and problem  
85 solving, verbal comprehension, verbal fluency, verbal learning and memory, visual learning and  
86 memory, working memory, and combined neurocognition – a composite score based on two or more NC  
87 domains (Supplementary Table 3). NC domains were based on NC factors identified by the  
88 Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) Committee  
89 (Nuechterlein et al., 2004).

### 90 **2.2.2. Social Cognition Domains**

91 Five domains of SC were included: attribution bias, emotion perception and processing, social  
92 knowledge and perception, theory of mind, and combined social cognition – a composite score based on  
93 two or more SC domains (Supplementary Table 3). SC domains were based on SC factors identified by  
94 the MATRICS Committee (Green, Olivier, Crawley, Penn, & Silverstein, 2005). The present review  
95 included attribution bias and combined social cognition domains, previously omitted in Fett et al.  
96 (2011), because new studies reported relationships between these SC domains and functional outcomes.

### 97 **2.2.3. Domains of Functional Outcome**

98 Four domains of functional outcomes were included in line with Fett et al. (2011): community  
99 functioning (e.g., activities of daily life and relationships), social behavior in the milieu (e.g., observed  
100 behaviors in a specific context), social problem solving (e.g., abilities to address a social problem or  
101 generate solutions), and social skills (e.g., social interaction abilities like eye contact and conversation  
102 skills, Supplementary Table 4). Functional outcomes are typically based on observer ratings (e.g.,  
103 Quality of Life Scale; Heinrichs, Hanlon, & Carpenter, 1984), performance on a task meant to simulate  
104 real-world scenarios and responsibilities (e.g., UCSD Performance Based Skills Assessment; Patterson,  
105 Goldman, McKibbin, Hughs, & Jeste, 2001), ratings of social interaction during role-play tasks (e.g.,  
106 Role Play Test; Penn, Mueser, Doonan, & Nishith, 1995), or observations made in-vivo such as work  
107 performance or behavior in a treatment setting (e.g., Work Personality Profile; Bolton & Roessler,  
108 1986). In general, domains of community functioning and social behavior in the milieu are based on  
109 ratings of perceived real-world performance while domains of social problem solving and social skill are  
110 considered measures of functional capacity measured by task-based performance (Bowie, Reichenberg,  
111 Patterson, Heaton, & Harvey, 2006). Hence, measures of functional capacity are not the same as  
112 measures of community functioning and we would not expect the same pattern of effects.

#### 113 **2.4. Effect Size Relationships**

114 Potential articles were pooled from all sources and duplicates were removed resulting in 1,361  
115 articles (see Figure 1 for the flow of information through phases of the present review). Article titles  
116 were inspected for inclusion, followed by abstracts, resulting in 533 articles reviewed at the full-text  
117 level. Reasons for exclusion at the full-text level included a) study did not report a cross-sectional  
118 correlation between a cognitive domain and functional outcome ( $n = 352$ ); b) sample included affective  
119 diagnoses ( $n = 8$ ); c) sample was a specialized population ( $n = 6$ ); d) article was not an empirical study  
120 ( $n = 1$ ). Penn, Mueser, Doonan, & Nishith (1995), previously included in Fett et al. (2011), was  
121 excluded during full-text review since the Conversation Role Play Test, previously categorized as a

122 measure of social cognition, is now considered a functional outcome and thus a correlation between a  
123 cognition domain and functional outcome was not present.

124 One hundred and sixty-six articles met inclusion criteria for the present review (see  
125 Supplementary Materials for full reference list and Supplementary Table 2 for sample characteristics). If  
126 studies reported multiple cognition-outcome correlations within the same domain (e.g., working memory  
127 and community functioning), correlations were pooled. Studies were allowed to contribute multiple  
128 cognition-outcome correlations across unique domains (e.g., working memory and community  
129 functioning *and* working memory and social skills) resulting in a total of 518 effect sizes.

### 130 **2.5. Coding Procedure**

131 Article coding categories were defined prior to article review and were based on categories  
132 included by and recommendations by PRISMA (Moher et al., 2009). Articles were coded for: year of  
133 publication, country of publication, inpatient percentage, schizophrenia spectrum diagnoses, illness  
134 duration, chlorpromazine (CPZ) equivalent dosage, percent of sample taking medication, age, percent  
135 male, percent white, years of education, cognitive measure and classification, functional measure and  
136 classification, and risk of bias. Risk of bias was evaluated by adapting items for correlational studies  
137 from Downs and Black (1998) and generating a summary score of 1 (low risk of bias) to 3 (high risk of  
138 bias). Socioeconomic status, reliability of measures, and diagnostic standard were included in the coding  
139 procedure but not discussed here due to infrequent reporting. Supplementary Table 2 provides coding  
140 categories and corresponding study values.

141 All articles were double-coded by TFH and CCM or MOP (doctoral students in clinical  
142 psychology). Discrepancies in objective categories (e.g., sample size) were reconciled by consulting  
143 original articles; discrepancies in subjective categories (e.g., risk of bias) were reconciled through a  
144 consensus meeting. Intraclass correlation coefficients (ICCs) prior to collation were excellent for  
145 objective coding categories (ICC = .99 for correlation effect sizes;  $M_{ICC} = .97$  (range .84 - .99) for study

146 characteristic categories). The reliability for coding of article quality was satisfactory,  $M_{\text{PABAK}} = .78$   
147 (Koo and Li, 2016).

## 148 **2.6. Overlapping Samples**

149 Overlapping samples were identified through 1) cross-referencing all authors and research  
150 groups, 2) cross-referencing grant numbers, and 3) cross-referencing committee members for  
151 unpublished dissertations. Samples with potential overlap underwent a second-round of full-text  
152 inspection. Samples with a probable degree of overlap were dealt with in the following ways: estimates  
153 from smaller sample sizes were deleted in the case of overlapping samples presenting identical  
154 cognition-outcome relationships (13 studies); overlapping studies were included if they presented unique  
155 cognition-outcome relationships (37 studies); identical overlapping samples presenting the same  
156 cognition-outcome pairs were averaged (7 studies; see Supplementary Table 2).

## 157 **2.7. Statistical Methods**

158 Correlation coefficients between SC, NC, and functional outcomes formed the indices of effect  
159 size. Correlation coefficients were converted using Fisher's *r*-to-*z* transformation to stabilize variance  
160 and estimate confidence intervals prior to all analyses (Fisher, 1922). All analyses were conducted in R  
161 using the 'metafor' package (Viechtbauer, 2010).

162 Random effects meta-analyses were conducted for each domain of cognition and functional  
163 outcome pair (e.g., processing speed and community functioning, theory of mind and social problem-  
164 solving) whenever there were three or more relevant observations. Random effects meta-analyses  
165 account for heterogeneity introduced by different methods or samples and allow for multiple effect  
166 estimates from a single sample (Hasselblad and Hedges, 1995; Hedges and Vevea, 1998; Viechtbauer,  
167 2010). Relationships between functional outcomes and overall NC domains (i.e., estimation of effect  
168 size across all neurocognitive domains) and overall SC domains were also conducted to provide overall  
169 effect estimates in addition to specific cognition-outcome pair estimates. Sample-weighted average

170 effect sizes ( $\hat{u}_p$ ), and heterogeneity statistics ( $I^2$ ,  $Q$ ) were calculated for each meta-analysis. Additionally,  
171 moderators (e.g., age, illness duration) were examined utilizing a mixed-effects model.

172 Funnel plots and regression tests for funnel plot asymmetry were generated for each meta-  
173 analysis to examine publication bias (Egger et al., 1997). For the subset of studies that reported  
174 relationships between all three domains (i.e., NC, SC, and functional outcomes), a random effects  
175 mediation analysis was conducted utilizing the ‘metaSEM’ package (Cheung, 2015) to examine SC as a  
176 potential mediator of the relationship between NC and functional outcome.

### 177 3. Results

#### 178 3.1. Sample Characteristics

179 The sample of studies in the present review included 12,868 participants with non-affective  
180 psychosis with a mean age of 39.84 ( $SD = 6.85$ ); 69.3% of the sample was male, 48.2% white, and had  
181 completed an average of 12.18 years of education ( $SD = 1.10$ ). Participants had a diagnosis of  
182 schizophrenia (87.9%), schizoaffective disorder (8.0%), psychosis NOS (0.2%), or other diagnoses  
183 within the non-affective psychosis spectrum (3.9%). Twenty-four studies reported aggregate  
184 schizophrenia spectrum sample sizes but did not report frequency of specific diagnoses (see  
185 Supplementary Table 2).

186 The majority of samples (78.9%) were outpatients, and average illness duration was 16 years  
187 (range: 0.44 – 34.45 years;  $SD = 7.64$ ). Most patients were taking psychotropic medication (95.8%) and  
188 the average CPZ equivalence was 549.2 mg ( $SD = 231.9$ ). Samples with an average illness duration less  
189 than or equal to five years ( $n = 11$ ) were classified as a FEP sample (Breitborde et al., 2009).

190 Seventeen studies included in the review were unpublished (10%). A meta-regression indicated  
191 publication status did not significantly predict effect sizes ( $\beta = -.01$ ,  $SE = .04$ ,  $p = .78$ ). Likewise, coder  
192 ratings of bias risk were not associated with relationship estimates ( $\beta = -.01$ ,  $SE = .03$ ,  $p = .67$ ). Meta-  
193 regression indicated effects were not characterized by small sample bias ( $\beta = -.04$ ,  $SE = .03$ ,  $p = .09$ ),

194 where small sample bias was defined as possessing sufficient power to detect a medium-sized effect  
195 (i.e.,  $N \geq 48$ ) or not ( $N < 48$ ).

196 Fifty-three random effects meta-analyses were conducted to quantify the relationship between  
197 the four functional outcomes (behavior in the milieu, community functioning, social problem-solving,  
198 and social skills) and each SC and NC domain, as well as overall SC (e.g., multilevel model providing  
199 weighted average for all individual domains of SC combined) and NC (i.e., see Figure 2 for estimated  
200 effects organized by functional outcome). An additional 15 relationships had fewer than 3 studies  
201 contributing effects so meta-analyses could not be conducted (see Supplementary Table 7 and  
202 relationships presented without effect sizes in Figure 2). Moderator analyses were conducted for overall  
203 SC and NC only, to ensure adequate power to detect moderation.

204 The majority of samples reported information for at least one moderator variable: mean age  
205 (99.2%), sex (100%), race or ethnicity (46%), mean years of education (75.8%), specific diagnosis  
206 (86.3%), duration of illness (75.8%), inpatient status (94.4%), and mean CPZ dosage (35.5%). Few  
207 studies included information for all moderators of interest, so moderators were applied to all overall  
208 models individually with Bonferroni correction for multiple comparisons rather than incrementally to  
209 maximize observations included in each analysis.

### 210 **3.2. Publication Bias**

211 Publication bias was examined through funnel plot inspection (See Supplementary Figure 1) and  
212 Egger's regression. Out of 41 tests for funnel plot asymmetry, only two regression equations for  
213 associations between cognition and functional outcomes were significant: the association between  
214 reasoning and problem solving and social skills ( $z = 2.42, p = .02$ ), and between theory of mind and  
215 community functioning ( $z = 2.84, p < .01$ ). The associations between reasoning and problem solving and  
216 social skills included only 4 observations, therefore any interpretation about funnel plot asymmetry  
217 should be made cautiously. A significant Egger's test with regards to the association between theory of

218 mind and community functioning was due to a single observation (-0.4). Removal of this observation  
219 from the model results in a non-significant Egger's test. Taken together, these findings suggest that  
220 publication bias is not a concern in the current analysis.

### 221 **3.3. Neurocognition**

#### 222 **3.3.1. Overall Neurocognition-Functional Outcome Associations**

223 A random-effects meta-analysis yielded a medium-sized average correlation between overall NC  
224 (i.e., across all NC domains) and functional outcomes and ( $\hat{u}_p = 0.21$ , 95% CI [0.18, 0.24],  $p < .01$ )  
225 based on 399 effect sizes; 60.88% of the variation in effect sizes was due to heterogeneity between  
226 studies ( $Q = 1556.36$ ,  $p < .001$ ;  $I^2 = 60.88$ ). Random-effects meta-analyses examining relationships  
227 between summary NC and specific functional outcome domains also yielded medium correlations ( $\hat{u}_p$ s =  
228 .14 - .26) based on 32-264 relationships. Significant variation (31% - 73%) due to heterogeneity between  
229 studies ( $Q$ s 108.9-988.9,  $p$ s  $< .001$ ) was present for functional outcomes of community functioning,  
230 social behavior in the milieu and social skills but not for social problem solving ( $Q = 31.3$ ,  $p = .45$ ; see  
231 Supplementary Table 5).

#### 232 **3.3.2. Associations between Specific Neurocognition Domains and Functional Outcomes**

233 Mean correlation estimates across specific NC functional outcome relationships were small to  
234 medium in size ( $\hat{u}_p = .06$  to  $.33$ ). The smallest effect was observed between verbal comprehension and  
235 social behavior in the milieu ( $\hat{u}_p = .06$ ,  $p = .60$ ). The largest effect was observed between overall  
236 neurocognition and social skills ( $\hat{u}_p = .33$ ,  $p < .001$ ). All relationships between specific NC domains and  
237 respective functional outcomes are presented in Supplementary Table 6, as well as in Figure 2.

#### 238 **3.3.3. Moderators of the Neurocognition-Functional Outcomes Association**

239 Random-effects meta-regression analyses were conducted to examine potential influence of  
240 moderator variables on NC – functional outcome relationships (See Supplementary Table 5). Most  
241 moderators did not significantly influence relationships between NC and functional outcomes, with



242 some exceptions: samples with more males showed weaker relationships between NC and summary  
243 functional outcomes ( $\beta = -.0038$ ,  $SE = .001$ ,  $p < .001$ ) and more racially diverse samples showed weaker  
244 relationships between NC and summary functional outcomes ( $\beta = -.0030$ ,  $SE = .001$ ,  $p = < .001$ ).  
245 Moderators should be interpreted with caution given the small observed associations and modest  
246 variance explained by moderators (all pseudo  $R^2$ s for significant moderators  $< 1\%$ ).

### 247 **3.4. Social Cognition**

#### 248 **3.4.1. Overall Social Cognition-Functional Outcome Associations**

249 A random-effects meta-analysis yielded an overall medium correlation between all domains of  
250 social cognition and functional outcomes, ( $\hat{u}_p = 0.24$ , 95% CI [0.19, 0.28],  $p < .01$ ) based on 119  
251 relationships with 62.29% of the variation in effect sizes due to heterogeneity between studies ( $Q =$   
252  $300.10$ ,  $p < .001$ ;  $I^2 = 62.29$ ). Random-effects meta-analyses examining relationships between summary  
253 SC and specific functional outcome domains also yielded medium correlations ( $\hat{u}_p$ s = .21 - .46,  $ps < .01$ )  
254 based on 3 – 82 relationships. Significant variation (2% - 67%) due to heterogeneity between studies ( $Q$ s  
255  $39.2-227.9$ ,  $ps < .01$ ) was present for functional outcomes of community functioning and social skills but  
256 not social problem solving and social skills ( $Q$ s = 2.6-13.2,  $p > .05$ ; see Supplementary Table 5). Caution  
257 is warranted with interpretation of the overall relationship between SC and social problem solving ( $\hat{u}_p =$   
258  $.46$ ). This estimate is based on only three relationships (two from emotion perception and processing and  
259 one from social perception and knowledge) and is presented only for comparison with overall NC  
260 relationships.

#### 261 **3.4.2. Associations between Specific Social Cognition Domains and Functional Outcomes**

262 Mean correlation estimates across specific SC-functional outcome relationships were small to  
263 medium in size ( $\hat{u}_p = .08$  to  $.38$ ). The smallest effect was observed between attribution bias and  
264 community functioning ( $\hat{u}_p = .08$ ,  $p = .16$ ). The largest effect was observed between theory of mind and



265 social skills ( $\hat{u}_p = .38, p < .001$ ). Relationships between specific SC domains and respective functional  
266 outcomes are presented in Supplementary Table 6 and Figure 2.

267 No significant differences emerged when directly comparing effect estimates between domains  
268 of NC and SC with functional outcomes. Eighty percent of the observed relationships (8 out of 10)  
269 between SC and functional outcomes were significant, compared with 68% (21 out of 31) of the  
270 observed relationships between NC and functional outcomes (proportion not significantly different  
271 between NC and SC ( $X^2(1) = 0.52, p = 0.48$ )).

### 272 **3.4.3. Moderators of the Social Cognition-Functional Outcomes Association**

273 Random-effects meta-regression meta-analyses were conducted to examine potential influence of  
274 moderator variables on SC – functional outcome relationships (See Supplementary Table 5). Most  
275 moderators did not significantly influence relationships between SC and functional outcomes, with one  
276 exception: samples with more inpatients were associated with weaker relationships between SC and  
277 community functioning ( $\beta = -.0024, SE = .001, p < .001$ ). However, caution in interpretation is warranted  
278 since inpatient status explained less than 1% of the variance in this relationship (pseudo  $R^2 < 1\%$ ).

### 279 **3.5. Hierarchical Regression of Functional Outcomes on Social Cognition and Neurocognition**

280 To better understand incremental variance explained by NC and SC, respectively, hierarchical  
281 regressions utilizing the subset of studies that reported relationships between NC, SC, *and* functional  
282 outcomes were conducted ( $n = 32$ ; 153 correlation matrices). NC and SC both has significant beta  
283 coefficients in respective equations and together explained 9.2% of variance in functional outcomes.  
284 However, NC explained an additional 1.9% of variance (4.4% total variance) in functional outcomes  
285 after accounting for SC,  $F(1, 2417) = 50.401, p < .01$ , whereas SC explained an additional 4.8% of  
286 variance (7.3% total variance) in functional outcomes after accounting for NC,  $F(1, 2417) = 127.05, p <$   
287  $.01$ .

### 288 **3.6. Mediation analyses.**

289 A random effects mediation analysis explored the potential role of SC as a mediator between NC  
290 and functional outcomes in the same subset of studies. Correlations between NC and SC allowed for  
291 modeling of dependency between these two domains. Results suggest SC is a partial mediator between  
292 NC and functional outcomes (Figure 3). Prior to mediation, NC was significantly correlated with SC ( $\hat{u}_p$   
293 = .29,  $p < .01$ ), SC was significantly correlated with functional outcomes ( $\hat{u}_p = .23$ ,  $p < .01$ ), and NC was  
294 significantly correlated with functional outcomes ( $\hat{u}_p = .23$ ,  $p < .01$ ). When SC was included as a  
295 mediator in the model, the relationship between NC and functional outcome decreased but was still  
296 significant ( $\hat{u}_p = .14$ ,  $p < .01$ ).

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## 4. Discussion

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### 4.1. Current Findings

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With respect to a priori aims, 1) domains of NC and SC demonstrated small to medium relationships with functional outcomes. Specific domains of cognition exhibited a range of effect estimates based on functional outcome. This range likely reflects differences in the type of functional outcome (e.g., community functioning and social behavior in the milieu measure real-world functional performance while social problem solving and social skills measure task-based functional capacity). Specific NC domains of verbal learning and memory (community functioning), working memory (social behavior in the milieu and social skills) and reasoning and problem solving (social problem solving) demonstrated the strongest relationships with specific functional outcomes (2 - 10% variance explained). For SC, the strongest associations were present for social knowledge and perception (community functioning) and theory of mind (social behavior in the milieu and social skills) explaining 7-14% of variance in functioning; 2) Relationships between overall NC and SC with functional outcomes were not significantly different in bivariate analyses. However, SC did explain more *unique* variance in functioning (4.8%) than NC (1.9%) in a subset of studies examining both domains, suggesting distinct relationships for respective domains of cognition with functional outcomes; 3) Relationships were not

313 moderated by FEP sample status, suggesting similar associations between NC and SC with functional  
314 outcomes are already present in the early stages of illness; 4) Consistent with previous theoretical and  
315 empirical work, the role of SC as a partial mediator between NC and functional outcomes was  
316 substantiated (Addington, Girard, Christensen, & Addington, 2010; Green & Nuechterlein, 1999;  
317 Schmidt et al., 2011; Vaskinn et al., 2008).

318 In line with previous findings of Fett et al. (2011), specific domains of NC and SC generally  
319 demonstrated small to medium relationships with functional outcomes irrespective of sample  
320 characteristics. Results of the present review substantiate the previous finding that SC explains more  
321 unique variance in functional outcomes than NC with the inclusion of 18 previously unreported  
322 cognition-functional outcome relationships (see Supplementary Table 7). Whereas theory of mind  
323 exhibited the strongest SC association with community functioning, the current results show that social  
324 knowledge and perception exhibits the strongest relationship with community functioning. Verbal  
325 learning had the strongest NC association with community functioning, which replicates Fett et al.'s  
326 (2011) results.

327 Of note, relationships between NC, SC, and functional outcomes were generally weaker (i.e.,  
328 smaller effect estimates) than relationships presented in Fett et al. (2011). The present review includes  
329 three times the number of studies with a sample size almost five times bigger, spanning an additional ten  
330 years of published and unpublished results. The phenomenon of observing decreasing, but more robust,  
331 effect sizes over time with the expansion of areas of research (i.e., the “in silico effect”; Monsarrat &  
332 Vergnes, 2018) may be one explanation for the present results. Many of the smaller effect sizes observed  
333 also exhibited smaller confidence intervals in line with the in silico effect. Another potential explanation  
334 for smaller effect estimates may be the novel inclusion of unpublished findings to address the file-  
335 drawer effect (Rosenthal, 1979). Although publication status did not significantly predict effect size,  
336 effect estimates from unpublished work were slightly smaller than published estimates and likely

337 contributed to overall smaller effect estimates. Finally, whereas Fett et al. (2011) only presented  
338 individual effect estimates (e.g., verbal learning and community functioning), the present review utilized  
339 random effects approaches to model summary estimates between NC, SC, and functional domains for  
340 the first time (e.g., all domains of NC with community functioning). When combining these individual  
341 effect estimates to produce summary effect estimates across domains of functional outcomes, the  
342 average variance explained by NC (2-7%) and SC (4-10%) is smaller than individual relationship  
343 estimates. However, the largest individual effect estimates do replicate Fett et al. (2011) in terms of  
344 variance explained.

345         This meta-analysis is the first to investigate the relationships between specific NC and SC  
346 domains with functional outcomes in a large sample of 166 studies in conjunction with a mediation  
347 analysis that is vital for the comprehensive understanding of cognition-outcome relationships. Mediation  
348 results demonstrated SC is a mediator in the relationship between NC and functional outcomes.  
349 According to the proximal-distal approach (e.g., Brenner, Curbow, & Legro, 1995; Green, Horan, &  
350 Lee, 2019; Ryan, 2009), the proximity of SC to functional outcomes offers support for SC as a primary  
351 treatment target for optimal improvement in functioning. However, correlation analyses based on the  
352 entire sample of studies demonstrated medium effect sizes from both NC and SC domains and seem to  
353 support the increasing focus on integrated interventions targeting both domains of NC and SC in  
354 schizophrenia populations (Fisher et al., 2017; Horan & Green, 2017, 2019; Peña et al., 2016).

355         Additionally, results recommend consideration of the desired type of functional outcome  
356 improvement when planning interventions. Perhaps unsurprisingly, SC was particularly more strongly  
357 associated with measures of outcome that are social skill and behavior-related (e.g., social behavior in  
358 the milieu and social skills) while NC and SC seemed to be equally associated with community  
359 functioning which is more related to activities of daily living. SC may be particularly important with  
360 respect to social behavior, which in turn may improve community outcomes through better helping

361 networks, while NC may be particularly important for independent living which makes these networks  
362 possible. Overall, results suggest integrated approaches to interventions targeting both NC and SC may  
363 engender optimal improvements in functioning.

#### 364 **4.2. Limitations**

365         The effect size estimates are correlations between functional outcomes and NC and SC  
366 which means that caution is warranted in drawing causal conclusions. Longitudinal research  
367 examining cognitive domains and functional outcomes will be important to delineate directional  
368 relationships between these domains. Second, a surprisingly small proportion of studies ( $n = 11$ )  
369 included FEP populations; thus, the effect estimates for this population need to be considered with  
370 caution. The lack of significant moderators observed in the relationship between cognitive domains and  
371 functional outcomes also leaves a significant amount of heterogeneity in the observed relationships  
372 between NC, SC, and functional outcomes unexplained. Routine reporting of clinical factors such as  
373 symptoms (Ventura et al., 2009), as well as motivation and social competence (Schmidt et al., 2011)  
374 would allow for investigation of these as moderators and may explain more heterogeneity between  
375 cognition and outcomes.

#### 376 **4.3. Future Directions**

377         Notwithstanding these limitations, results from this meta-analysis point to important areas for  
378 future development and research. Although measures were grouped into categories of respective NC,  
379 SC, and functional outcomes, a wide range of methods and measures were used to quantify these  
380 different domains. Categorization of cognitive domains and functional outcomes allows for taxonomic  
381 organization of relationships in a meaningful way, but these classifications were defined in different  
382 ways across studies. The sheer number of different measures precludes the inclusion of moderators  
383 specific to each instrument, but future research should continue the work of the MATRICS and SCOPE  
384 studies to examine psychometric properties (e.g., reliability, internal and external validity) of cognition

385 measures within schizophrenia populations (Nuechterlein et al., 2008; Pinkham et al., 2014). The large  
386 number of studies included in the present meta-analysis suggests we *are* measuring SC, NC, and  
387 functional outcomes in schizophrenia populations but more research into *how* we measure these domains  
388 is an important future direction. Focusing not just on capturing these domains, but doing so in a way that  
389 is accurate, reliable, and standardized may reduce heterogeneity related to measurement methods and  
390 allow for meaningful discoveries regarding why relationships between cognitive domains vary across  
391 studies and individuals. Investigation of the relationships between domains of functional outcomes (e.g.,  
392 social behavior in the milieu and social skills) and real-world functioning is also needed to better  
393 understand which relationships are essential treatment targets for genuine improvements in functioning.  
394 Finally, the relationships between NC, SC, and functional outcomes leaves much of the variance in  
395 functional outcomes unexplained. One implication of this finding may be to shift focus away from NC  
396 and SC to identify factors that are more closely linked with functioning (e.g., motivation; Green, Horan,  
397 & Lee, 2019). Alternatively, examining NC and SC in isolation may be overly simplistic and may  
398 underestimate the role of cognition. More complex models examining relationships between NC, SC,  
399 and functioning with intervening variables (e.g., motivation, metacognition) may provide a more  
400 comprehensive understanding of this relationship via identification of indirect effects of NC and SC on  
401 functional outcomes (Galderisi et al., 2014; Grant & Beck 2009; Green, Horan, & Lee, 2019; Lysaker et  
402 al., 2010).

#### 403 **4.4. Conclusions**

404 NC and SC exhibit reliable relationships with different functional outcomes within schizophrenia  
405 spectrum populations with SC accounting for greater unique variance. Importantly, findings demonstrate  
406 SC mediates the relationship between NC and functional outcomes. Future research is needed to explain  
407 significant heterogeneity observed within these relationships and more research on additional  
408 moderators such as clinical factors and measurement methods may provide a promising next step.

409 Findings suggest observed cognition-outcome relationships are already established in FEP, highlighting  
410 the importance of early intervention, but more research with FEP populations is needed. Additionally,  
411 longitudinal studies and experimental studies that improve NC and SC and assess change in functioning  
412 will provide more comprehensive understanding of the direction and strength of the relationships among  
413 NC, SC, and functional outcomes.

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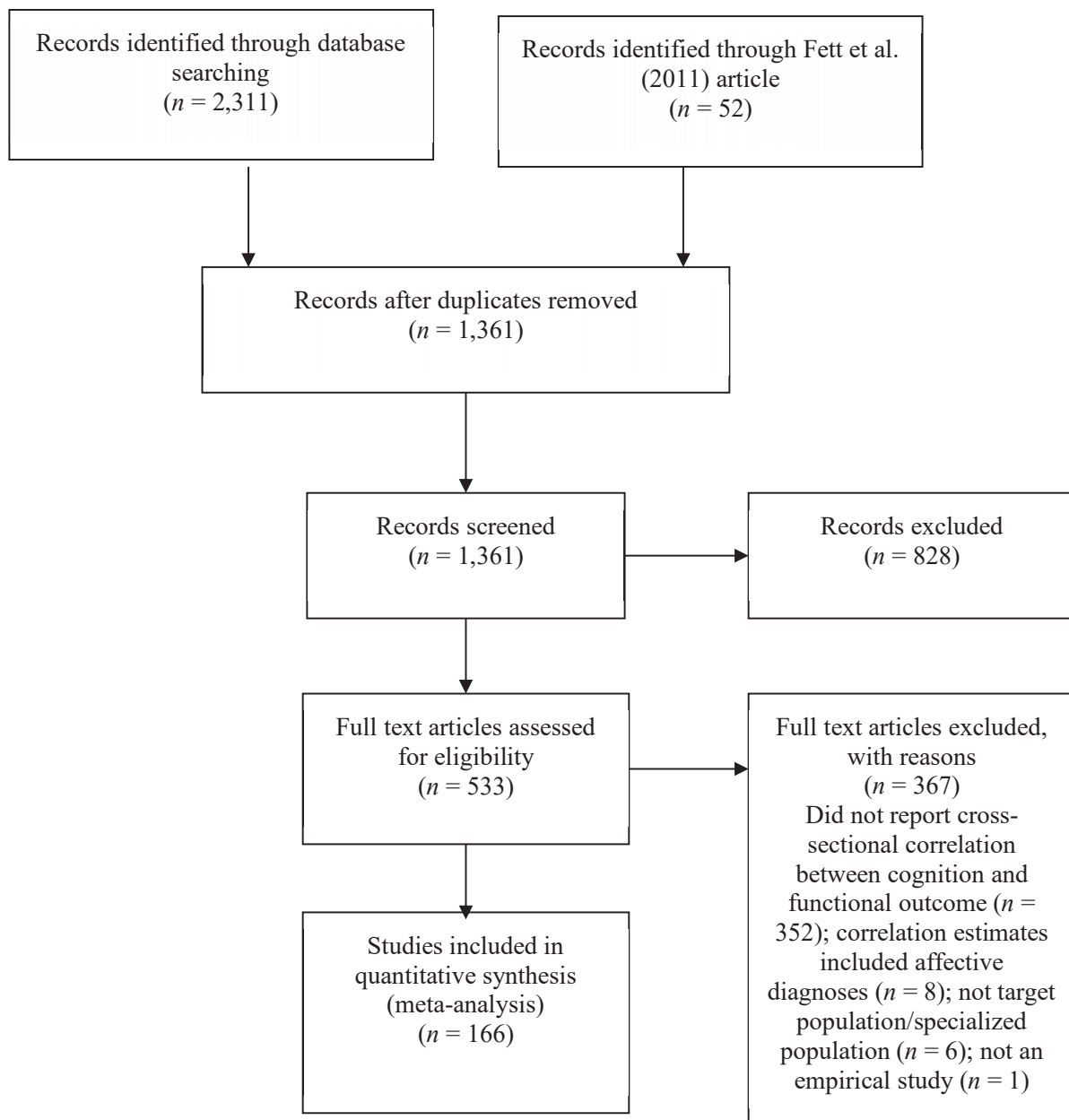


Figure 1. Consort diagram for article inclusion.



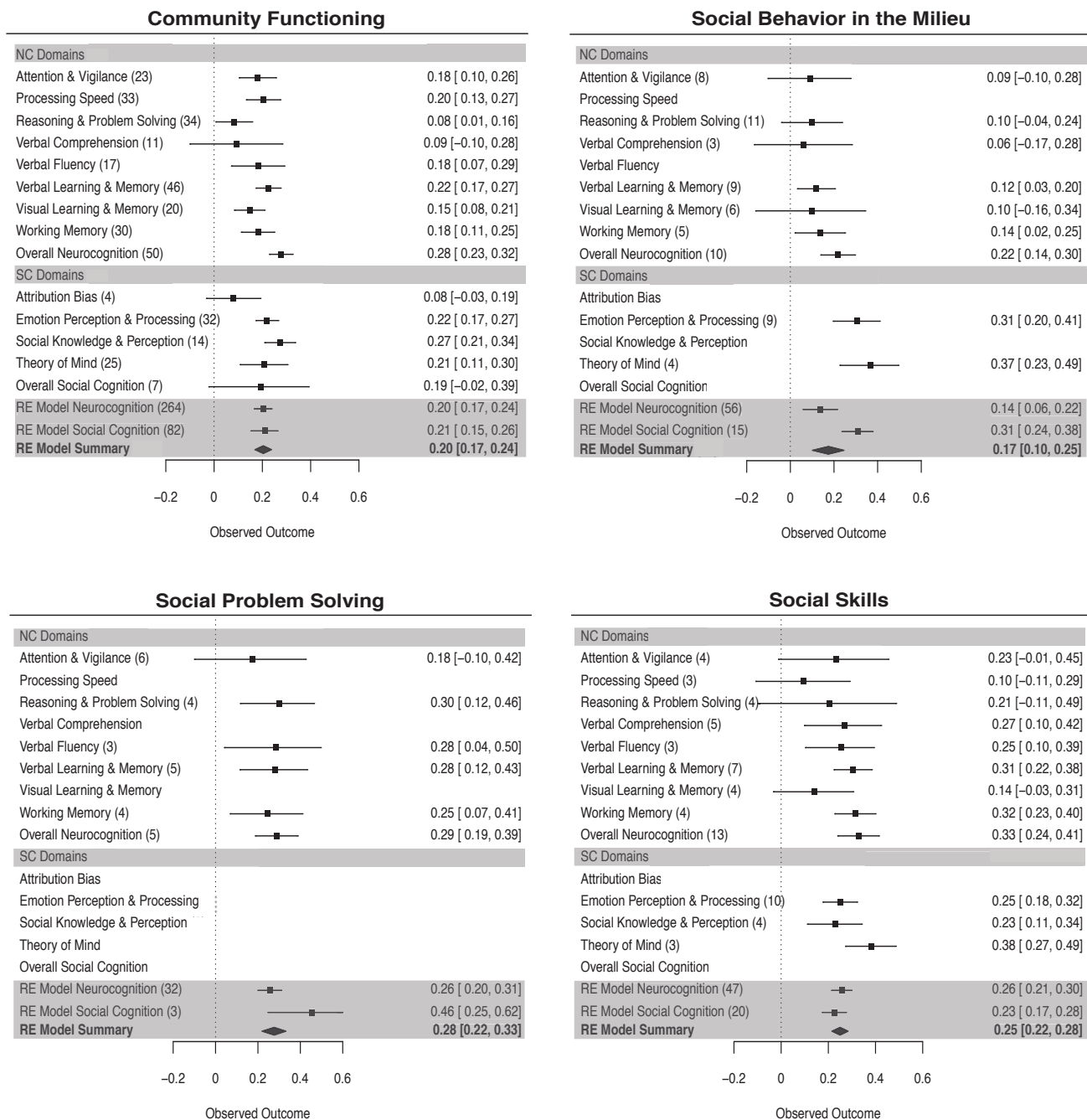
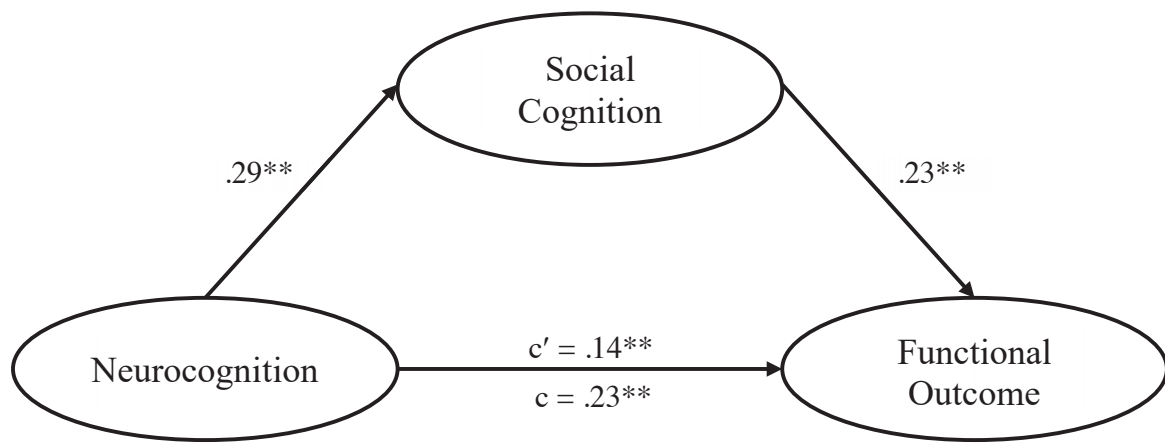


Figure 2. Forest plots displaying correlation coefficients [95% CI] by functional outcome. Diamond polygons represent summary correlation coefficient estimates among all cognition domains. Note: (n) = number of studies (K) included in estimates, RE = random effects, relationships with K ≤ 3 not presented. RE Model Social Cognition based on effect estimates from emotion perception & processing (K = 2) and social perception and knowledge (K = 1), specific SC domains not presented since K ≤ 3, RE model effect estimate presented for comparison with NC but should be interpreted with caution.



*Figure 3.* Mediation analysis examining NC, SC, and functional outcome relationships. *Note:*  $c$  = direct effect,  $c'$  = mediated (i.e., partial) effect.  $**p < .01$

Pathways to Functional Outcomes in Schizophrenia Spectrum Disorders: Meta-Analysis of  
Social Cognitive and Neurocognitive Predictors

Supplementary Materials

Table S1. PRISMA Checklist.

Section/topic	#	Checklist item	Reported on page #
<b>TITLE</b>			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title Page
<b>ABSTRACT</b>			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Abstract Page
<b>INTRODUCTION</b>			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	2-3
<b>METHODS</b>			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	3-6
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	3-7
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	3
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	3-6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6-8
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6-7
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., $I^2$ ) for each meta-analysis.	6-8
<b>Risk of bias across studies</b>			
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	9-10

Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	7-8
<b>RESULTS</b>			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	3-4; Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Supplementary Table 2
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Supplementary Table 2
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Figure 2; Supplementary Tables 5 and 6
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Figure 2; Supplementary Tables 5 and 6
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	10-13
<b>DISCUSSION</b>			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	13-15
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	16
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	16-18
<b>FUNDING</b>			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Funding Support Page

Table S2. Study Characteristics

Authors (year)	N	Age (yrs)	Male (%)	White (%)	Education (yrs)	Illness Duration (yrs)	Inpatient (%)	CPZ (mg)	Schizophrenia (%)	Schizoaff (%)	Psychosis NOS (%)	Other (%)	Risk of Bias	Cognitive Domain	Functional Domain
Abram et al. (2014) <sup>d</sup>	59	36	63	44	-	15		363	100				1	ON, EPP	CF, SS
Achim et al. (2012)	31	25	84	-	12	2	10	-	74	6	6	13	1	SPK, ToM	CF
Addington et al. (2006a) <sup>d</sup>	103	30	66	86	-	-		535	82	1	3	14	1	ON, SPK	CF, SPS
Addington et al. (2006b) <sup>d</sup>	103	30	66	86	-	-		-	82	1	3	14	1	ON, EPP	CF
Aksaray et al. (2002)	57	39	67	-	11	15		387	100				2	RPS	CF
Alessandrini et al. (2016) <sup>d</sup>	271	36	71	-	-	13		847	100				1	AV, PS, VF, VeLM	CF
Allen et al. (2007)	114	36	100	-	12	13	100	-	100				1	RPS, VC, WM, OSC	CF
Bambini et al. (2016) <sup>c</sup>	47	40	62	-	12	15		439	100				1	ON, ToM	CF
Bechi et al. (2013)	30	38	46	-	11	12		382	100				2	ToM	CF
Bechi et al. (2017)	79	41	62	-	-	17		-	100				1	ON, EPP, ToM	CF
Bellack & Sayers (1994)	27	30	56	52	12	8	100	-	100				2	VeLM, WM, ON	SPS, SS
Bora et al. (2006)	50	31	66	-	11	9		494	100				1	PS, VC, ViLM, WM, ToM	CF
Bougioukas (2009) <sup>b, d</sup>	50	58	48	40	11	36	100	-	48	52			2	ON	CF, SS
Bowen et al. (1994)	30	36	80	-	13	-	100	-	100				2	AV, WM	SPS
Bowie et al. (2011)	90	-	76	54	-	-		-	-	-	-	-	2	ON	CF, SS
Bowie et al. (2007) <sup>d</sup>	67	57	76	61	13	35		-	76	24		-	2	ON	CF
Boyer et al. (2012) <sup>d</sup>	113	39	70	-	-	14		568	96	4			2	AV, PS, VF, VeLM	CF
Bozikas et al. (2006)	40	36	63	-	11	12		-	100				1	PS, RPS, VeLM, ViLM, WM, ON	CF
Brekke et al. (2005) <sup>d</sup>	139	38	69	42	12	14		-	-	-	-	-	2	ON, EPP	CF
Brekke et al. (2001)	40	33	63	48	13	12		400	58	43			2	RPS	CF
Brissos et al. (2012)	104	38	69	-	9	13	27	-	100	-	-	-	3	PS, VeLM, WM	CF
Brittain et al. (2010)	64	42	53	-	14	18		462	100				2	SPK	CF
Brown et al. (2014) <sup>d</sup>	45	36	51	-	11	12		489	100				2	AB, EPP, ToM	CF
Brüne (2005) <sup>d</sup>	23	39	78	-	-	12	-	-	100				2	RPS, ON, EPP, ToM	SBiM
Brüne et al. (2007) <sup>c</sup>	38	36	42	-	-	9	100	770	100				2	RPS, ON, ToM	SBiM

Authors (year)	N	Age (yrs)	Male (%)	White (%)	Education (yrs)	Illness Duration (yrs)	Inpatient (%)	CPZ (mg)	Schizophrenia (%)	Schizoaff (%)	Psychosis NOS (%)	Other (%)	Risk of Bias	Cognitive Domain	Functional Domain
Brüne et al. (2009)	50	39	44	-	-	10	100	668	76	18	6		2	RPS, ON, ToM	SBiM
Brüne et al. (2011) <sup>d</sup>	69	36	65	-	-	11	-	-	88	12			2	RPS, ON, ToM	SBiM
Buck et al. (2014) <sup>d</sup>	45	39	67	64	12	15		-	-	-			2	EPP	CF, SS
Bulzacka et al. (2016)	100	31	81	-	-	8		-	75	25			2	RPS	CF
Caqueo-Urizar et al. (2015) <sup>c</sup>	253	36	66	-	-	15		-	100				2	ON	CF
Caqueo-Urizar et al. (2016) <sup>c</sup>	253	36	66	-	-	15		-	100				2	ON	CF
Chang et al. (2017)	321	38	44	-	11	2		-	44	1	6	50	2	PS, RPS, VF, VeLM, WM	CF
Cohen et al. (2006)	28	33	86	43	12	-	100	-	100				2	AV, RPS, VC, VeLM, ViLM, ON, EPP	SBiM, SS
Corrigan & Toomey (1995)	26	34	7	69	12	14	100	1218	-	-			2	AV, RPS, VeLM, WM, SPK	SPS
Couture (2006) <sup>b</sup>	44	28	89	71	13	6		-	-	-			2	PS, VF, ViLM, ON, EPP, ToM, OSC	CF
Eack & Keshavan (2008) <sup>d</sup>	58	26	69	69	-	3		-	66	34			2	ON	CF
Eack et al. (2010) <sup>d</sup>	64	26	70	67	-	3		-	58	36		6	2	EPP	CF, SBiM
Farreny et al. (2013)	62	41	68	-	-	18		-	87	11			2	ON	CF
Fervaha et al. (2014) <sup>c</sup>	1312	41	74	61	12	14		-	100				2	ON	CF
Fervaha et al. (2015) <sup>c</sup>	166	26	83	66	12	3		-	100				2	ON	CF
Fiszdon et al. (2008)	151	43	78	61	13	20		685	70	30			1	PS, RPS, VeLM, WM	CF
Fiszdon et al. (2010)	48	49	81	56	12	26		-	83	17			1	ON, EPP	CF, SS
Fox et al. (2017) <sup>d</sup>	28	33	64	43	-	15		330	100				2	SPK	SS
Fujimaki et al. (2012)	217	55	59	-	11	34	100	798	100				2	VF, ON	CF
Gard et al. (2010) <sup>d</sup>	91	40	75	-	13	20		-	100				2	ON, OSC	CF
Gavron (2016) <sup>b, d</sup>	47	44	66	43	13	-		-	-	-			1	EPP	CF
Gelder et al. (2015)	19	50	68	-	-	-		-	63	37			1	AV, VC, VF, VeLM, ON	CF
Giusti et al. (2014)	76	46	58	-	11	21	100	-	100				1	ON	CF
Gold et al. (2012)	138	40	62	54	13	-		-	90				2	VC, WM, ON	CF

Authors (year)	N	Age (yrs)	Male (%)	White (%)	Education (yrs)	Illness Duration (yrs)	Inpatient (%)	CPZ (mg)	Schizophrenia (%)	Schizoaffect (%)	Psychosis NOS (%)	Other (%)	Risk of Bias	Cognitive Domain	Functional Domain
González-Blanch et al. (2011)	131	27	65	-	10	2	100	-	59	3	5	33	2	PS	CF
Grant & Beck (2009) <sup>c</sup>	55	37	65	-	-	14	-	-	91	9	-	-	2	ON	CF
Grant & Beck (2010)	123	39	66	-	-	-	-	-	82	18	-	-	1	ON, EPP	CF
Green et al. (2012)	191	47	68	-	13	24	-	-	91	9	-	-	1	AV, EPP, SPK	CF
Harvey et al. (2013)	195	44	69	55	13	-	-	-	100	-	-	-	2	ON	CF
Hasson-Ohayon et al. (2015)	39	39	59	-	12	-	-	-	100	-	-	-	2	EPP, ToM	CF
Hatashita-Wong et al. (2002) <sup>d</sup>	44	36	51	80	-	18	-	-	64	39	-	-	2	AV, PS, RPS, VC, VF, VeLM, WM, ON	SPS
Healey et al. (2015) <sup>d</sup>	62	40	66	65	12	17	-	-	44	56	-	-	1	OSC	CF, SS
Hegeman (2002) <sup>b, d</sup>	55	47	86	87	14	23	-	417	82	18	-	-	2	AV, VF, VeLM, ON	CF, SBiM
Herrera (2017) <sup>b, e</sup>	93	38	81	-	-	15	-	897	81	19	-	-	2	AV, PS, RPS, ViLM, EPP	CF
Hooker & Park (2002)	20	39	75	75	13	19	100	1043	100	-	-	-	1	ViLM, EPP	SBiM
Hooker et al. (2011)	21	44	81	-	13	24	-	-	57	43	-	-	1	PS, RPS, VeLM, ViLM, ON, ToM	CF
Horan et al. (2012)	55	22	76	18	13	1	-	-	100	-	-	-	2	EPP, SPK, OSC	CF
Horton & Silverstein (2007)	65	46	66	46	-	26	-	-	77	23	-	-	2	AV, VeLM	CF
Ihnen et al. (1998)	26	33	58	35	12	-	-	698	100	-	-	-	1	EPP, SPK	SS
Jung et al. (2014)	56	33	55	-	15	11	-	-	73	16	-	14	1	ToM	CF
Kalin et al. (2015) <sup>e</sup>	179	42	65	42	13	-	-	-	54	46	-	-	2	AB, EPP, SPK, ToM	CF, SS
Kalwa et al. (2012)	34	57	38	-	13	31	24	-	71	-	-	-	2	PS, VF	CF
Kanie et al. (2014)	52	38	54	-	14	13	60	707	100	-	-	-	2	VeLM, AB, SPK, ToM, OSC	CF
Keats (2015) <sup>b</sup>	38	43	63	40	12	-	100	100	55	45	-	-	2	ToM	SS
Kee et al. (2009) <sup>d</sup>	50	34	62	62	14	10	-	-	100	-	-	-	1	EPP	CF
Keefe et al. 2006)	56	35	84	-	12	-	98	-	100	-	-	-	2	PS, RPS, VF, VeLM, WM, ON	CF
Kennedy (2002) <sup>b</sup>	110	39	75	67	14	16	-	633	88	12	-	-	2	RPS, ON	CF
Kern et al. (2009) <sup>d</sup>	50	35	63	84	14	-	-	-	-	-	-	-	2	SPK	CF



COGNITION AND FUNCTIONAL OUTCOMES IN SCHIZOPHRENIA

Authors (year)	N	Age (yrs)	Male (%)	White (%)	Education (yrs)	Illness Duration (yrs)	Inpatient (%)	CPZ (mg)	Schizophrenia (%)	Schizoaffect (%)	Psychosis NOS (%)	Other (%)	Risk of Bias	Cognitive Domain	Functional Domain
Kimhy et al. (2012) <sup>c</sup>	44	30	64	54	-	-	-	240	80	7	7	7	2	EPP	CF
Kimhy et al. (2015)	77	33	58	60	-	-	-	-	77	14	8	1	2	EPP	CF
Krishnadas et al. (2007)	25	40	64	-	9	11	-	-	100	-	-	-	2	PS, RPS, VeLM, ViLM, WM, ON	CF
Kurtz & Tolman (2011) <sup>d</sup>	71	31	75	-	12	10	4	-	-	-	-	-	2	PS, RPS, VC, VF, VeLM, WM	CF
Laes & Sponheim (2006) <sup>d</sup>	39	44	74	-	14	-	-	-	100	-	-	-	2	AV, RPS, VF, VeLM, ON	SBiM
Lalchandani (2009) <sup>b, d</sup>	102	40	76	66	13	20	-	-	100	-	-	-	2	PS, RPS, VeLM	CF
Lancaster (2004) <sup>b, d</sup>	63	48	100	-	12	23	-	720	52	48	-	-	2	AV, RPS, VeLM, WM, EPP	SBiM
Langdon et al. (2014)	23	21	96	-	11	20	-	-	91	4	4	-	2	ON, ToM	CF
Li et al. (2012)	64	25	52	-	12	3	64	-	100	-	-	-	2	AV, PS, RPS	CF
Li et al. (2017)	40	27	53	-	14	5	-	-	73	8	10	10	2	VeLM	CF
Lin et al. (2013)	302	38	61	-	11	14	100	496	100	-	-	-	2	AV, PS, RPS, VeLM, ViLM, WM, EPP	CF
Lindenmayer et al. (2017)	63	41	81	-	12	-	90	-	-	-	-	-	2	AV, PS, RPS, VeLM, ViLM, WM, ON	CF
Lo & Siu (2015)	30	42	53	-	9	17	-	-	100	-	-	-	2	RPS, AB, EPP, ToM	SBiM
Ludwig et al. (2017)	38	23	87	76	14	-	-	-	66	16	18	-	2	ON, AB, EPP, SPK, ToM	CF, SS
Lynch (2006) <sup>b</sup>	22	44	64	68	13	16	-	643	-	-	-	-	2	AV, VC, VeLM, ViLM, ON, EPP	CF, SBiM
Lysaker & Davis (2004) <sup>d</sup>	65	48	100	55	12	23	-	860	63	37	-	-	1	RPS, VC, VeLM	CF
Lysaker et al. (2010)	102	47	85	40	13	19	-	-	67	33	-	-	1	ON	CF
Lystad et al. (2016) <sup>d</sup>	131	33	70	-	12	7	-	-	89	8	2	2	2	AV, PS, RPS, VeLM, ViLM, WM, ON	SBiM
Lystad et al. (2014) <sup>d</sup>	131	33	70	-	12	7	-	-	89	8	2	2	2	AV, PS, RPS, VeLM, ViLM, WM, ON	CF
Macaulay & Cohen (2014)	26	42	69	59	12	-	-	-	100	-	-	-	2	ON	CF

COGNITION AND FUNCTIONAL OUTCOMES IN SCHIZOPHRENIA

Authors (year)	N	Age (yrs)	Male (%)	White (%)	Education (yrs)	Illness Duration (yrs)	Inpatient (%)	CPZ (mg)	Schizophrenia (%)	Schizoaff (%)	Psychosis NOS (%)	Other (%)	Risk of Bias	Cognitive Domain	Functional Domain
Mancuso et al. (2011)	85	49	89	31	13	26	-	68	22	9			2	ON	CF, SPS, SS
Mann-Wrobel (2009) <sup>b</sup>	20	46	65	15	12	24	-	70	30				2	RPS, VeLM	CF
Martinez-Dominguez et al. (2015)	21	39	71	-	16	13	-	249	100				2	AV, PS, VeLM, ViLM, WM, ON, EPP, ToM, OSC	CF
Mathews et al. (2011)	40	37	65	48	13	18	-	75	25				2	EPP, SPK	CF
Mazza et al. (2012)	227	33	69	-	12	9	100	186	100				2	ToM	CF
McClure et al. (2007)	181	58	71	68	13	-	-	-	-				2	PS, RPS, VF, VeLM, WM	CF, SS
Meyer et al. (2009) <sup>d</sup>	53	35	72	74	13	12	-	659	-	-			2	AV, RPS, VC, VeLM, EPP	SS
Michaels et al. (2014) <sup>c</sup>	52	35	69	46	-	15	-	373	100				2	ON	CF, SS
Mohamed et al. (2008)	1386	41	75	60	-	17	-	-	100				2	ON	CF
Moore et al. (2013)	72	51	51	43	12	26	-	85	15				2	ON	CF, SS
Moriarty (2002) <sup>b,d</sup>	28	58	96	-	11	38	100	-	100				2	AV, PS, VC, VF, VeLM, ViLM, WM, EPP, SPK	CF
Mueser et al. (1991) <sup>d</sup>	45	33	56	47	11	-	100	-	60	40			2	VC, ViLM, WM, ON	SS
Mueser et al. (1995)	38	38	53	74	12	15	100	601	74	26			2	AV, VC, VF, VeLM, ViLM, ON	SS
Mueser et al. (1996)	28	45	46	93	11	24	100	650	71	29			1	ViLM, ON	SBiM, SS
Nakagami et al. (2008) <sup>d</sup>	120	38	69	43	12	14	-	-	-				2	AV, RPS, VF, VeLM, WM	CF
Narvaez et al. (2008) <sup>c</sup>	88	47	67	66	13	22	-	318	42	58			2	ON	CF
Nemoto et al. (2007)	40	30	75	-	14	6	-	593	100				2	PS, RPS, VF, VeLM, WM	CF
Nienow (2004) <sup>b</sup>	56	42	75	34	12	19	100	-	-	-			2	AV, EPP	SPS
Oh et al. (2010)	42	36	55		12	8	-	500	100				2	AV, PS, VeLM, EPP, SPK, ToM	CF
Ohmuro et al. (2016)	40	23	28		13	-	-	372	60	20	15		2	ToM	CF
Olbert et al. (2013)	173	43	72	51	13	21	-	-	100				1	ON, EPP	CF, SS
Pan et al. (2009)	40	31	50	-	14	6	-	449	100				2	AV, PS, WM, ON, EPP	CF

Authors (year)	N	Age (yrs)	Male (%)	White (%)	Education (yrs)	Illness Duration (yrs)	Inpatient (%)	CPZ (mg)	Schizophrenia (%)	Schizoaffect (%)	Psychosis NOS (%)	Other (%)	Risk of Bias	Cognitive Domain	Functional Domain
Park et al. (2008)	20	39	65	-	14	-	-	297	100	-	-	-	2	EPP	CF
Peña et al. (2012)	58	28	84	-	11	0	-	390	57	7	-	36	2	AV, PS, RPS, VF, ViLM, WM	CF
Penadés et al. (2010)	40	35	58	-	10	14	-	361	100	-	-	-	2	PS, RPS, VeLM, ViLM, WM	CF
Penn et al. (1996) <sup>d</sup>	38	36	55	-	-	-	100	1081	87	13	-	-	2	AV, RPS	SS
Perivoliotis (2006) <sup>b</sup>	77	53	75	78	12	28	-	-	-	-	-	-	2	ON	CF
Perlick et al. (2008)	309	47	96	41	12	25	-	-	-	-	-	-	2	PS, RPS, VeLM	CF
Pijnenborg et al. (2009) <sup>d</sup>	46	27	74	100	-	7	7	-	100	-	-	-	2	PS, VeLM, ON, EPP, ToM	CF
Pinkham et al. (2006)	49	33	57	80	14	10	-	353	71	24	4	-	1	PS, VC, VeLM, EPP, SPK, ToM	SS
Pinkham et al. (2016) <sup>e</sup>	179	42	65	42	13	-	-	-	54	46	-	-	2	PS, VF, VeLM, WM, AB, EPP, SPK, ToM	CF, SS
Poole et al. (1999) <sup>c</sup>	26	40	54	58	14	15	-	-	100	-	-	-	2	ON	CF
Poole et al. (2000) <sup>c</sup>	40	41	78	63	13	-	-	300	90	10	-	-	2	EPP	CF
Puig et al. (2008)	29	35	55	-	-	13	-	-	100	-	-	-	1	VeLM	CF
Quinlan (2014) <sup>b</sup>	165	47	64	61	12	22	-	-	-	-	-	-	2	ON	CF, SS
Revheim & Medalia (2004)	162	37	62	20	11	15	54	-	67	33	-	-	2	VC, VeLM	CF
Revheim et al. (2006) <sup>e</sup>	38	39	74	34	12	19	63	1151	76	24	-	-	2	AV, PS, RPS, VF, VeLM, ViLM, WM	CF
Reynolds (2015) <sup>b, d</sup>	52	53	73	63	12	-	50	-	60	40	-	-	2	ON	CF, SBiM
Riccardi et al. (2016)	30	38	70	-	10	14	-	-	100	-	-	-	2	RPS, ON, EPP, ToM	CF
Robertson et al. (2013)	216	41	74	-	-	17	-	562	-	-	-	-	2	ON, ToM	CF
Sabbag et al. (2013)	195	44	-	54	13	-	-	-	-	-	-	-	2	ON	CF
Sánchez et al. (2009)	95	36	82	-	10	14	100	-	100	-	-	-	2	PS, RPS, VeLM, WM	CF
Savilla et al. (2008)	57	36	75	-	-	-	-	-	100	-	-	-	2	AV, RPS, VF, VeLM, WM, ON	CF
Schroeder et al. (2013)	45	30	80	-	11	-	100	-	80	11	9	-	2	AV, PS, RPS, VC, VeLM, WM, ON	CF

Authors (year)	N	Age (yrs)	Male (%)	White (%)	Education (yrs)	Illness Duration (yrs)	Inpatient (%)	CPZ (mg)	Schizophrenia (%)	Schizoaff (%)	Psychosis NOS (%)	Other (%)	Risk of Bias	Cognitive Domain	Functional Domain
Sergi et al. (2006) <sup>c</sup>	75	47	92	-	13	21	-	-	100				2	AV, SPK	CF
Smith et al. (1999) <sup>d</sup>	46	39	63	94	-	21	-	-	57	43			2	AV, RPS, VeLM, ViLM, WM	CF, SBiM
Smith et al. (2002) <sup>c</sup>	46	37	59	81	-	18	-	-	61	39			2	VeLM, WM	SBiM
Smith et al. (2012) <sup>d</sup>	46	35	65	39	-	15	-	347	100				2	VeLM, ON	CF
Stewart et al. (2009)	18	36	94	-	12	9	-	-	83	11	6	-	2	ToM	CF
Stratta et al. (2009) <sup>c</sup>	20	35	85	-	11	-	-	-	100				2	RPS	CF
Tas et al. (2013) <sup>d</sup>	28	34	46	-	11	11	100	512	100				2	AV, PS, RPS, VeLM, ViLM, ON, AB, EPP, ToM	CF
Thomas et al. (2017)	1415	46	69	44	13	24	-	-	-	-			2	VeLM, ViLM, WM	CF
Tso et al. (2010)	33	39	67	-	14	18	-	505	-	-			2	RPS, VC, VeLM, ON, EPP, ToM	CF, SBiM
Tyson et al. (2008)	36	38	86	-	-	13	14	-	100				2	AV, ON	CF
Urbach et al. (2013)	206	41	72	-	-	-	100	-	100				3	ToM	CF
Vaskinn et al. (2018)	26	32	65	-	13	7	-	390	100				1	AV, PS, RPS, VC, VF, VeLM, ON, EPP	SPS
Vauth et al. (2004)	133	29	65	-	-	7	100	-	100				2	AV, PS, RPS, VeLM, WM, SPK	SBiM
Velligan et al. (2004) <sup>d</sup>	339	41	64	32	11	-	-	-	-	-			2	ON	CF
Velligan et al. (2007) <sup>d</sup>	264	40	61	35	12	-	-	-	-	-			2	VF	CF
van Beilen et al. (2003) <sup>d</sup>	52	28	75	-	-	4	46	-	-	-	-	-	2	AV, RPS, VeLM	CF
Ventura et al. (2008) <sup>c</sup>	35	39	66	29	14	-	-	-	82	3		14	2	ON	CF
Ventura et al. (2015)	77	21	78	48	12	1	-	-	65	9		26	2	ToM	CF
Ventura et al. (2010)	176	44	76	59	12	-	-	-	86	14			2	ON	CF
Villalta-Gil et al. (2006)	113	42	68	-	-	19	-	-	100				2	VeLM, ON	CF
Walther et al. (2016)	28	38	71	-	14	14	-	295	89			11	2	SPK	CF
Wölwer & Frommann (2011)	38	37	68	-	-	-	100	-	82	18			2	SPK	CF
Woon et al. (2010)	83	31	64		12	6	-	240	100				2	VeLM, WM	CF
Woonings et al. (2003)	44	31	86	-	-	9	-	-	100				2	AV, RPS, VeLM, WM	SBiM

Authors (year)	N	Age (yrs)	Male (%)	White (%)	Education (yrs)	Illness Duration (yrs)	Inpatient (%)	CPZ (mg)	Schizophrenia (%)	Schizoaffect (%)	Psychosis NOS (%)	Other (%)	Risk of Bias	Cognitive Domain	Functional Domain
Xiang et al. (2010)	110	32	65	-	10	1	100	483	100				2	RPS, VeLM	CF
Xiao (2013) <sup>b</sup>	103	38	70	42	12	13		-	-	-			2	ON, EPP	CF
Zanello et al. (2006)	20	33	50	-	-	8		168	80	20			2	AV, RPS, VF, VeLM, ViLM, ToM	SPS
Zhu et al. (2007)	40	30	45	-	11	9	100	171	100				2	ToM	CF
Zuo et al. (2012)	40	46	100	-	11	23	100	422	100				2	VeLM, WM	CF

*Note:* <sup>a</sup>included in Fett et al. (2011) meta-analysis; <sup>b</sup>unpublished dissertation; <sup>c</sup>overlapping sample, effect sizes removed from analysis because larger samples contribute identical relationship; <sup>d</sup>overlapping sample, unique effect sizes included; <sup>e</sup>overlapping sample, effect sizes averaged because identical samples presenting identical relationships; - indicates data not reported by study, blank cells indicate a value of 0; AB = attribution bias, AV = attention and vigilance, EPP = emotion perception and processing, ON = overall neurocognition, OSC = overall social cognition, PS = processing speed, RPS = reasoning and problem-solving, SKP = social knowledge and perception, ToM = theory of mind, VC = verbal comprehension, VeLM = verbal learning and memory, VF = verbal fluency, ViLM = visual learning and memory, WM = working memory; SBiM = social behavior in the milieu, CF = community functioning, SPS = social problem-solving, SS = social skills.

Table S3. Cognition Domains and Measures

<b>Cognition Domain</b>	<b>Measure</b>
Attention and Vigilance	Audio Recorded Cognitive Screen - Attention (ARCS; Schofield et al., 2010) Brief Assessment of Cognition in Schizophrenia - Attention and Information Processing (BACS; Keefe, 1999) Brief Test of Attention – Letters and Numbers (BTA; Schretlen, 1996) Continuous Performance Task (CPT; Nuechterlein & Dawson, 1984) D2 Attention Task (Brickenkamp, 1978) Degraded Stimulus-CPT (DS-CPT; Nuechterlein & Asarnow, 1992) Early Visual Processing Masking Procedure (Green et al., 2003) Color-Word Interference Test (Delis et al., 2001) MATRICS Consensus Cognitive Battery – Attention and Vigilance (MCCB; Nuechterlein et al., 2008) Penn CPT (PCPT; Kurtz et al., 2001) Span of Apprehension (Asarnow et al., 1991) Speech Sounds Perception Test (SSPT; Boll, 1991) Test of Everyday Attention (TEA; Robertson et al., 1994) Wechsler Memory Scale - Attention and Concentration (WMS; Wechsler, 1987)
Processing Speed	Digit Symbol Substitution Test (Wechsler, 1955) Letter Cancellation (Brickenkamp, 1978; Diller et al., 1974) MCCB - Speed of Processing (Nuechterlein et al., 2008) Stroop Color-Word Test (SCWT; Stroop, 1935; Lezak et al., 2004) Trail Making Test A and B (Reitan, 1958) Wechsler Adult Intelligence Scale Processing Speed (WAIS; Wechsler, 1997) WMS Mental Tracking (Wechsler, 1987)
Reasoning and Problem Solving	Block Design (Wechsler, 1981) Wisconsin Card Sorting Test (Heaton, 1981) Hamburg-Wechsler-Intelligence Test-Revised, Picture Completion Task (HAWIE-R; Tewes, 1991) Idea Fluency Test (IFT; Takano, 1989) Key Search Test (KST; Wilson et al., 1996) MCCB – Problem Solving (Nuechterlein et al., 2008) Multiple Errands Test (MET; Shallice & Burgess, 1991)

	<p>Penn Conditional Exclusion Test (PCET; Kurtz et al., 2004)  Social Cognition Screening Questionnaire – Jumping to Conclusions (SCSQ-JTC; Roberts et al., 2010)  WAIS Similarities (Wechsler, 1997)  Standard Progressive Matrices (Raven, 1958)  Tower of London/Hanoi (ToL; Shallice, 1982)  WAIS Perceptual Organization (Wechsler, 1997)  WAIS Picture Completion (Wechsler, 1997)  WMS Logical Reasoning (Wechsler, 1987)  Zoo Map Test (ZMT; Wilson et al., 1996)</p>
Verbal Comprehension	<p>ARCS Language (Schofield et al., 2010)  MCCB Language (Nuechterlein et al., 2008)  National Adult Reading Test (NART; McGurn et al., 2004)  WAIS Verbal Comprehension (Wechsler, 1997)  Wide Range Achievement Test – Reading Scale (WRAT; Wilkinson, 1993)  Modified Boston Naming Test (Morris et al., 1989)</p>
Verbal Fluency	<p>ARCS Verbal Fluency (Schofield et al., 2010)  BACS Verbal Fluency (Keefe, 1999)  Category/Semantic/Letter Fluency Tasks  Controlled Oral Word Association Test (COWAT; Benton 1967)  Delis-Kaplan Executive Function System - Semantic Fluency (DKEFS; Delis et al., 2003)</p>
Verbal Learning and Memory	<p>Word List Learning Test (WLT; Saan &amp; Deelman, 1986)  ARCS Memory (Schofield et al., 2010)  BACS Verbal Memory (Keefe, 1999)  California Verbal Learning Test (CVLT; Delis et al., 1987)  Hong Kong List Learning Test (HKLT; Chan, 2006)  Hopkins Verbal Learning Test (HVLT; Brandt, 1991)  MCCB Verbal Learning and Memory (Nuechterlein et al., 2008)  Penn Word Memory Test (PWMT; Gur et al., 1993)  Rey Auditory Verbal Learning Test (RAVLT; Rey, 1964)  SCSQ Verbal Memory (Roberts et al., 2010)  Spain Verbal Learning Test – Complutense (TAVEC; Benedet &amp; Alejandre, 1998)  WMS Logical Memory Scale (Wechsler, 1987)</p>

Visual Learning and Memory	ARCS Visuospatial Functioning (Schofield et al., 2010) Benton Facial Recognition Test (BFRT; Benton, 1992) Benton Lines Test (Benton, Hamsher, Varney, & Spreen, 1983) Brief Visual Memory Test (Benedict & Groninger, 1995) Line Orientation Test (Benton et al., 1983) MCCB Visual Learning and Memory (Nuechterlein et al., 2008) MCCB Visuospatial Functioning (Nuechterlein et al., 2008) Penn Face Memory Test (Gur et al., 1993) Penn Visual Object (Gur et al., 2010) Rey Complex Figure Test (Rey, 1941) WMS-R Visual Memory (Wechsler, 1987) Design Fluency Task (DFT; Jones-Gotman et al., 1977)
Working Memory	Auditory Consonant Trigrams (Anil et al., 2003) BACS Working Memory (Keefe, 1999) Digit Span (Wechsler, 1955) Digit Span Distractibility Test (DSDT; Olthmanns & Neale, 1975) Dot Probe expectancy Task (DPX; MacDonald et al., 2005) Letter Number Sequencing (Wechsler, 1997) MCCB Working Memory (Nuechterlein et al., 2008) N-Back (Gur et al., 2001) Varied Mapping Task (Schneider & Shiffrin, 1977) WAIS Working Memory (Wechsler, 1997)
Overall Neurocognition	ARCS Composite (Schofield et al., 2010) BACS Composite (Keefe, 1999) Brief Assessment of Dysexecutive Syndrome Composite (BADS; Wilson et al., 1996) Cognitive Assessment Interview (CAI; Ventura et al., 2010) Clinical Global Impression of Cognition in Schizophrenia (CGI-CogS; Ventura et al., 2008) Frontal Assessment Battery (FAB; Dubois et al., 2000) GEOPTE Scale of Social Cognition for Psychosis – Neurocognition Items (SanJuan et al., 2003) MCCB Composite (Nuechterlein et al., 2008) Multiple Choice Verbal Comprehension Test (MWT; Lehl, 1976) Positive and Negative Syndrome Scale – Cognitive (PANSS; Kay et al., 1987)



	<p>Hasegawa Dementia Scale (HDS; Hasegawa, 1990)          Schizophrenia Cognition Rating Scale (SCoRS; Keefe et al., 2006)          Delis–Kaplan Executive Function System Composite (D–KEFS; Delis et al., 2003)          WAIS Intelligence Quotient (IQ; Wechsler, 1997)          Two or more neurocognition measures combined</p>
Attribution Bias	<p>Ambiguous Intentions and Hostility Questionnaire (AIHQ; Combs et al., 2007)          Internal Personal and Situational Attributions Questionnaire (IPSAQ)          SCSQ Attribution Bias (Roberts et al., 2010)</p>
Emotion Perception and Processing	<p>Bell-Lysaker Emotion Recognition Test (BLERT; Bell et al., 1997)          Diagnostic Analysis of Non-Verbal Accuracy – Facial Expression (DANVA-2; Tseng, 2003)          Emotional Differentiation Task (Kohler et al., 2000)          Emotion in Biological Motion (Heberlein et al., 2004)          Facial Affect Perception (FAP; Derntl et al., 2009)          Facial Affect Recognition (Biehl et al., 1997; Ekman &amp; Friesen, 1976)          Facial Emotion Discrimination Test (FEDT; Kerr et al., 1993)          Facial Emotion Identification Test (FEIT; Kerr &amp; Neale, 1993)          Facial Expression of Emotion (Young et al., 2000)          Mayer-Salovey-Caruso Emotional Intelligence Test (MSCEIT; Mayer et al., 2002)          Movie Stills Task (Majewska et al., 2001)          Narrative of Emotions Task (NET; Buck et al., 2014)          Penn Emotion Acuity Test (PEAT; Erwin et al., 1992)          Penn Emotion Recognition Task (ER-40; Kohler et al., 2003)          Pictures of Facial Affect (POFA; Ekman &amp; Friesen, 1976)          Point-Light Motion Displays (Heberlein et al., 2001)          Prosody Task (Pijnenborg et al., 2007)          Vocal Affect Recognition (Bowers et al., 1991; Nowicki &amp; Duke, 1994)          Toronto Alexithymia Scale (TAS-20; Bagby et al., 1994)</p>
Social Perception and Knowledge	<p>Half Profile of Nonverbal Sensitivity (Ambady et al., 1995)          Relationships Across Domains (RAD; Sergi et al., 2009)          Schema Component Sequencing Task (SCST; Corrigan &amp; Addis, 1995)          Situational Features Recognition Test (SFRT; Corrigan &amp; Green 1993)          Social Behavior Sequencing Task (SBST; Kwon et al., 2003)          SCSQ Schematic Inference (Roberts et al., 2010)</p>

	Social Cue Recognition Task (SCRT; Corrigan & Green 1993) Social Knowledge Task (Achim et al., 2012) Social Stimuli Sequencing Task (Corrigan et al., 1992) The Awareness of Social Inference Test (TASIT; McDonald, 2002)
Theory of Mind	False Belief Task (Langdon et al., 1997) Advanced Theory of Mind Task (Happé, 1994) Animated Theory of Mind Task (Abell et al., 2000) Faux Pas Task (Stone et al., 1998) Hinting Task (Concoran et al., 1995) Theory of Mind Jokes (Marjoram et al., 2005) Picture Stories (Brune, 2003) Conversation Task (Blackshaw et al., 2001; Platt & Spivack, 1975) Reading the Mind in the Eyes Test (Eyes/RMET; Baron-Cohen et al., 2001) Scale for the Evaluation of Communication Disorders (SCD; Olivier et al., 1997) SCSQ Theory of Mind (Roberts et al., 2010) Theory of Mind Movie Task (Mehl et al., 2010) Unexpected Outcomes Test (UOT; Dyck et al., 2001) Versailles-Situational Intention Reading (V-SIR; Bazin et al., 2009)
Overall Social Cognition	Observable Social Cognition: A Rating Scale (OSCARS; Healey et al., 2015) SCSQ Composite (Roberts et al., 2010) WAIS Social Cognition (Wechsler, 1997) Two or more social cognition measures combined

Table S4. Functional Outcome Domains and Measures

Functional Outcome Domain	Measure
Community Functioning	Activities of Daily Living (ADL; Nouri & Lincoln, 1987)
	Brief Psychiatric Rating Scale - Social Competence (BPRS; Overall & Gorham, 1962)
	Clinical Global Impression (CGI; Guy, 1970)
	Clinical Global Impression of Cognition in Schizophrenia (Bilder et al., 2003)
	Community Adjustment Form (Test et al., 1991)
	Comprehensive Occupational Therapy Evaluation Scale (Brayman et al., 1976)
	Disability Assessment Scale (DAS; WHO, 1998)
	Functional Needs Assessment (FNA; Dombrowski et al., 1990)
	Functional Remission of General Schizophrenia (FROGS; Llorca et al., 2009)
	Global Assessment of Functioning (GAF; APA, 1994)
	General Self-Efficacy Scale (Schwarzer & Jerusalem, 1995)
	Global Assessment Scale (Endicott et al., 1976)
	Global Social and Role Functioning Scale (GSRFS; Auther et al., 2006, Niendam et al., 2006)
	Groningen Social Disability Scale (GSDS; Wiersma et al., 1988)
	Independent Living Skills (Menditto et al., 1999)
	Indian Disability Evaluation Scale (IPA, 2002)
	Lehman Work and Productivity Scale (Lehman, 1997)
	Life Assessment Scale for the Mentally Ill (LASMI; Iwasaki et al., 1994)
	Life Skills Profile (LSP; Rosen et al., 1987)
	Multnomah Community Ability Scale (MCAS; Barker et al., 1994)
	Performance Potential Inventory (Hogarty et al., 2008)
	Personal and Social Performance Scale (PSP; Morosini et al., 2000)
	Physical, Cognitive, Affective, Social, Economic, Ego functions (PCASEE; Bech, 1993)
	Provision of Social Relations Scale (PSRS; Turner et al., 1983)
	Quality of Life Interview (QOLI; Lehmann, 1989)
	Quality of Life Scale (QLS; Heinrichs et al., 1984)
	Quality of Life Self Assessment Inventory (Skantze & Malm, 1994)
	Real World Functioning (Perivoliotis, 2006)
	Role Functioning Scale (RFS; Goodman et al., 1993)
	Subjective Quality of Life (Stein & Test, 1980)
Schizophrenia Quality of Life Scale (Boyer et al., 2010)	

	<p>Sheehan Disability Scale (Sheehan, 1983)  Social and Adaptive Functioning Scale (SAFE; Harvey et al., 1997)  Social and Occupational Assessment of Functioning Scale (SOFAS; APA, 1994)  Social Autonomy Scale (Leguay et al., 1998)  Social Functioning Scale (SFS; Birchwood et al., 1990)  Specific Levels of Function Scale (SLOF; Schneider &amp; Struening, 1983)  Subjective Well-Being Under Neuroleptic Treatment (SWN; Naber, 1995; Naber, 2001)  UCSD Performance Based Skills Assessment (UPSA; Patterson et al., 2001)  World Health Organization Quality of Life (WHOQOL Group, 1998)  Wisconsin Quality of Life Index for Mental Health (Becker et al., 1993)  Zigler Social Competence Scale (Zigler &amp; Levine, 1981)  Test of Adaptive Behaviors in Schizophrenia (TABS; Velligan et al., 2007)</p>
Social Behavior in the Milieu	<p>Rehabilitation Evaluation Hall and Baker (REHAB; Baker &amp; Hall, 1988)  Social Adjustment Scale (SAS; Schooler &amp; Weissman, 1979)  Social Behavior Schedule (SBS; Wykes &amp; Sturt, 1986)  Social Dysfunction Index (SDI; Munroe-Blum et al., 1996)  Vocational Cognitive Rating Scale (VCRS; Greig et al., 2004)  Work Behavior Inventory (WBI; Bryson et al., 1997)  Work Personality Profile (Bolton &amp; Roessler, 1986)</p>
Social Problem Solving	<p>Assessment of Interpersonal Problem Solving Skills (AIPSS; Donahoe et al., 1990)  Response Evaluation Test (Mueser et al., 1993)  Response Generation Test (Sayers et al., 1993)  Social Problem Solving Assessment (SPSA; Sayers et al., 1995)</p>
Social Skills	<p>Conversation Probe Role Play Test (Penn et al., 1995)  Maryland Assessment of Social Competence (MASC; Bellack et al., 1994)  Role Play Test (Penn et al., 1995)  Social Skills Performance Assessment (SSPA; Patterson et al., 2001)</p>

Table S5. Meta-regression of effect sizes on cognition domains, functional outcomes, and sample characteristics.

	Cognition Domain	Functional Outcome				
		Summary Outcome	Community Functioning	Social Behavior in the Milieu	Social Problem Solving	Social Skills
Correlation Coefficient $\hat{u}_p$ [CI 95%]	NC	<b>.21</b> [.18, .24]	<b>.20</b> [.17, .24]	<b>.14</b> [.06, .22]	<b>.26</b> [.20, .31]	<b>.26</b> [.21, .30]
	<i>K</i>	399	264	55	32	47
	SC	<b>.24</b> [.19, .28]	<b>.21</b> [.15, .26]	<b>.31</b> [.24, .38]	<b>.46</b> [.25, .62]	<b>.23</b> [.17, .28]
	<i>K</i>	119	82	15	3	20
Moderator		$\beta$ (SE)				
Age ( <i>M</i> , years)	NC	-.0010 (.002)	-.0014 (.003)	-.0037 (.006)	-.0003 (.001)	-.0023 (.003)
	SC	.0005 (.004)	-.0001 (.004)	.0029 (.006)	-.0335 (.024)	-.0001 (.005)
Male (%)	NC	<b>-.0038 (.001)</b>	-.0028 (.002)	-.0007 (.003)	.0010 (.002)	-.0016 (.002)
	SC	-.0028 (.002)	-.0013 (.002)	-.0017 (.003)	-.0053 (.004)	-.0004 (.003)
White (%)	NC	<b>-.0030 (.001)</b>	-.0019 (.001)	-.0043 (.004)	-.0004 (.003)	-.0044 (.002)
	SC	.0005 (.001)	.0003 (.001)	-.0011 (.006)	-	.0010 (.002)
Education ( <i>M</i> , years)	NC	.0084 (.015)	.0162 (.019)	-.0174 (.029)	.0011 (.084)	-.0460 (.042)
	SC	.0334 (.024)	.0480 (.028)	.0400 (.033)	.1235 (.379)	-.0509 (.054)
Illness Duration ( <i>M</i> , years)	NC	.0021 (.002)	.0021 (.003)	-.0109 (.007)	-.0013 (.007)	.0140 (.006)
	SC	.0005 (.004)	.0007 (.005)	.0032 (.006)	-.0175 (.027)	-.0014 (.011)
First Episode (yes/no)	NC	-.0882 (.060)	-.0940 (.066)	-	-	-
	SC	-.0193 (.102)	.0155 (.113)	-.1619 (.135)	-	-
Inpatient (%)	NC	.0005 (.001)	-.0002 (.001)	.0014 (.001)	.0004 (.001)	.0007 (.001)
	SC	-.0008 (.001)	<b>-.0024 (.001)</b>	.0002 (.001)	-.0006 (.004)	.0018 (.001)
Schizophrenia Dx (%)	NC	.0021 (.001)	.0025 (.002)	-.0037 (.002)	-.0021 (.002)	.0026 (.003)
	SC	.0008 (.002)	-.0001 (.003)	-.0016 (.003)	-	-.0004 (.001)
CPZ ( <i>M</i> , mg)	NC	.0001 (.001)	.0001 (.001)	-.0001 (.001)	.0001 (.001)	.0001 (.001)
	SC	.0001 (.001)	.0001 (.001)	-.0003 (.001)	-	-.0005 (.001)

Note: Bold values indicate significant,  $p < .05$ , Bonferroni adjusted for multiple comparisons.

Less than three first episode samples available for moderator investigation of social skills, social problem solving, and social behavior in the milieu (NC only) functional outcomes. Less than three samples reported specific schizophrenia diagnosis and average CPZ dosage for social problem solving (SC only) functional outcome.

Table S6. Estimated mean correlation coefficients and heterogeneity characteristics from individual cognition domains and functional outcomes.

NC Domains		Functional Outcome			
		Community Functioning	Social Behavior in the Milieu	Social Problem Solving	Social Skills
Attention & Vigilance	$\hat{u}_p$ [CI 95%]	<b>.18</b> [.10, .26]	.09 [-.10, .28]	.18 [-.10, .42]	.23 [-.01, .45]
	$N (K)$	1849 (23)	522 (8)	202 (6)	157 (4)
	$Q$	46.78**	28.67**	15.90**	6.99
	$I^2$	57.9%	76.6%	71.2%	56.7%
Processing Speed		<b>.20</b> [.13, .27]			.10 [-.10, .32]
		3171 (33)			409 (3)
		125.71	-	-	9.27**
		72.5%			77.0%
Reasoning & Problem Solving		<b>.08</b> [.01, .16]	.10 [-.04, .24]	<b>.30</b> [.12, .46]	.21 [-.11, .49]
		3033 (34)	666 (11)	116 (4)	300 (4)
		149.67**	27.19**	0.48	24.14**
		73.63%	66.2%	0%	82.5%
Verbal Comprehension		.09 [-.10, .28]	.06 [-.17, .28]		<b>.27</b> [.10, .42]
		747 (11)	83 (3)		213 (5)
		88.76**	0.80	-	6.27
		84.1%	0%		36.4%
Verbal Fluency		<b>.18</b> [.07, .29]		<b>.28</b> [.04, .50]	<b>.25</b> [.1, .39]
		1998 (17)		90 (3)	398 (3)
		81.56**	-	2.32	4.05
		82.0%		21.5%	51.7%
Verbal Learning & Memory		<b>.22</b> [.17, .27]	<b>.12</b> [.03, .20]	<b>.28</b> [.12, .43]	<b>.31</b> [.22, .38]
		5348 (46)	555 (9)	143 (5)	555 (7)
		130.06**	9.83	0.88	7.73
		64.8%	2.7%	0%	4.0%
Visual Learning & Memory		<b>.15</b> [.08, .21]	.10 [-.16, .34]		.14 [-.03, .31]
		2690 (20)	275 (6)		139 (4)
		31.92*	17.58**	-	1.61
		34.0%	2.7%		0%
Working Memory		<b>.18</b> [.11, .25]	<b>.14</b> [.02, .25]	<b>.25</b> [.07, .41]	<b>.32</b> [.23, .40]
		4092 (30)	417 (5)	127 (4)	432 (4)
		87.92**	5.48	0.30	1.68
		73.7%	25.5%	0%	0%
Overall Neurocognition		<b>.28</b> [.23, .32]	<b>.22</b> [.14, .30]	<b>.29</b> [.19, .39]	<b>.33</b> [.24, .41]
		5755 (50)	600 (10)	338 (5)	918 (13)
		122.8**	4.78	2.20	22.29*
		66.8%	0%	0%	48.7%
SC Domains					
Attribution Bias		.08 [-.03, .19]			
		314 (4)			
		1.58	-	-	-
		0%			

Emotion Perception & Processing	<b>.22</b> [.17, .27] 2418 (32) 38.50 21.2%	<b>.31</b> [.20, .41] 311 (9) 7.93 1.6%	-	<b>.25</b> [.18, .32] 677 (10) 9.66 0%
Social Perception & Knowledge	<b>.27</b> [.21, .34] 939 (14) 19.26 4.6%	-	-	<b>.23</b> [.11, .34] 271 (4) 1.98 0%
Theory of Mind	<b>.21</b> [.11, .30] 1683 (25) 114.72** 73.3%	<b>.37</b> [.23, .49] 182 (4) 3.14 5.6%	-	<b>.38</b> [.27, .49] 255 (3) 1.89 0%
Overall Social Cognition	.19 [-.02, .39] 439 (7) 29.69** 79.0%	-	-	-

*Note:*  $\hat{u}_p$  estimates in bold reflect  $p < .05$ .  $\hat{u}_p$  = estimated average correlation coefficient,  $N$  = individuals,  $K$  = number of samples,  $Q$  = Q-test for heterogeneity,  $I^2$  = percentage of total variability in observed effect size due to heterogeneity between samples, - denotes  $K \leq 3$ .

Table S7. Cognition-functional outcome unreported and novel relationships.

<b>Unreported<sup>a</sup> Relationships</b>				
Cognition Domains	Functional Outcome			
	Community Functioning	Social Behavior in the Milieu	Social Problem Solving	Social Skills
NC Domains	-	Processing Speed Verbal Fluency	Processing Speed Verbal Comprehension Visual Learning and Memory	-
Social Cognition Domains	-	Attribution Bias Social Knowledge and Perception Combined SC	Attribution Bias Emotion Perception and Processing Social Knowledge and Perception Theory of Mind Combined SC	Attribution Bias Theory of Mind Combined SC
<b>Novel<sup>b</sup> Relationships</b>				
NC Domains	Verbal Comprehension	Working Memory Verbal Comprehension Combined NC	Verbal Fluency Combined NC	Processing Speed Working Memory Verbal Fluency Combined NC
Social Cognition Domains	Attribution Bias Combined SC	Attribution Bias Theory of Mind	Attribution Bias	Attribution Bias Theory of Mind Emotion Perception and Processing

Note: <sup>a</sup>Unreported refers to relationships with less than 3 observations; <sup>b</sup>Novel refers to relationships presented in the present analyses but not presented in Fett et al. (2011).



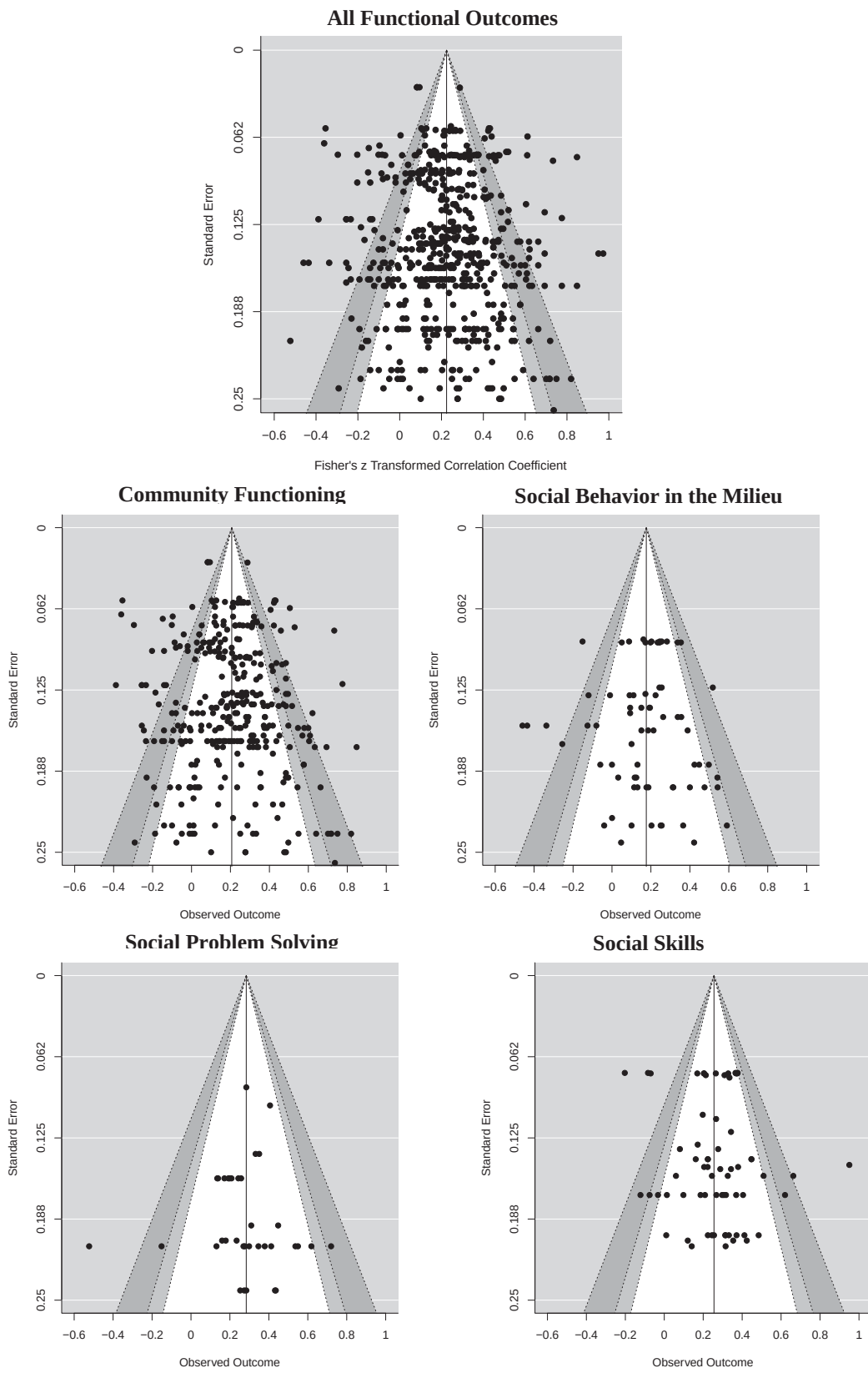


Figure S1. Funnel plot asymmetry for associations between all cognitive domains and each domain of functioning

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\*studies listed contributed effect sizes

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