

Executive functioning

Introduction

Executive functions are a group of cognitive processes including control, mental flexibility, planning, inhibition, decision-making, initiation, abstraction, self-monitoring and pursuit of goals. Executive functions are important in situations involving error correction and behaviour evaluation in response to environmental feedback.

Executive functioning is most commonly measured using the Wisconsin Card Sorting Task (WCST). This task requires the ability to shift cognitive sets. Study participants are told to match stimulus cards containing varying-coloured shapes, based first on colour, then quantity, then design. The participant is then given additional cards and asked to match each one without being told any matching rules, so participants usually match according to the previous rule. Feedback is provided as to whether their match was correct or incorrect, based on a new and undisclosed matching rule that changes during the task. Other common tasks assessing executive functioning include the Trail Making Test (TMT), which requires participants to connect, in order, letters and/or numbers as quickly as possible. Also, the Stroop Colour Word Test (SCWT), presents colour names printed in an ink congruent to the colour name (e.g., blue), or incongruent to the colour name (e.g., red). Participants are asked to either read the word or name the ink colour. Any impairment in executive functioning can also reflect impairments in other cognitive functions such as processing speed, attention, and memory.

Method

We have included only systematic reviews with detailed literature search, methodology, and inclusion/exclusion criteria that were published in full text, in English, from the year 2000. Reviews were identified by searching the databases MEDLINE, EMBASE, and

PsycINFO. Reviews with pooled data are prioritized for inclusion. Reviews reporting fewer than 50% of items on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA¹) checklist have been excluded from the library. The evidence was graded guided by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group approach². The resulting table represents an objective summary of the available evidence, although the conclusions are solely the opinion of staff of NeuRA (Neuroscience Research Australia).

Results

We found 47 systematic reviews that met our inclusion criteria³⁻⁴⁹.

- Moderate to high quality evidence suggests people with schizophrenia, including those with first-episode, youth-onset, or late-onset schizophrenia, show a medium-sized effect of impaired executive functioning compared to healthy controls, regardless of medication status. This is seen on various tasks; planning, WCST categories, perseverative errors, semantic fluency, phonemic fluency, inhibition tasks, TMT-B, SCWT, commission/omission errors on the Go/No-Go task and The Behavioural Assessment of the Dysexecutive Syndrome test. Moderate to low quality evidence suggests no difference in the ratio of WCST perseverative to non-perseverative errors between people with schizophrenia and controls.
- Moderate to high quality evidence shows a large effect of poorer executive functioning in people with schizophrenia and violent behaviours compared to people without a mental illness or violent behaviours. There was a medium-sized effect of more perseverative errors on the WCST in people with schizophrenia and antisocial traits

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compared to people with schizophrenia without antisocial traits.

- Moderate to high quality evidence finds a small to medium-sized effect of poorer performance on the WCST in first-degree relatives of people with schizophrenia compared to controls.
- Moderate to high quality evidence finds a medium-sized effect of poorer executive functioning in people at clinical high-risk for psychosis compared to controls. There was poorer executive functioning in individuals at clinical high-risk of psychosis who made the transition to psychosis compared to individuals at clinical high-risk of psychosis who did not make the transition to psychosis. There was better executive functioning in individuals at clinical high-risk of psychosis compared to people with first-episode psychosis.
- High quality evidence suggests similar, small improvements on executive functioning tasks over time (1 to 5 years) in people at high risk of psychosis, in people with first-episode psychosis, and in controls.
- Compared to people with affective psychoses (including bipolar disorder), moderate to high quality evidence shows a small effect of poorer performance in people with schizophrenia on TMT-A, TMT-B, and WCST categories, but not on WCST perseverative errors or the SCWT test. Samples matched on clinical and demographic variables show a medium-sized effect of poorer performance on verbal fluency and executive control tasks. Moderate quality evidence finds similar deficits in semantic inhibition between schizophrenia and affective psychosis or schizoaffective disorder.
- Moderate to high quality evidence suggests a medium-sized association between better insight and better executive functioning in people with schizophrenia. There are also medium-sized associations between poorer

executive functioning and more negative or disorganised symptoms (including formal thought disorder), with no association with positive symptoms.

- Moderate to high quality evidence shows greater improvements in verbal fluency in patients receiving second generation antipsychotics compared to patients receiving first generation antipsychotics, with no differences in cognitive flexibility and abstraction. Moderate quality evidence suggests patients receiving quetiapine, olanzapine, or clozapine may show improvements on verbal fluency with treatment, however patients receiving risperidone may show no improvement.
- Moderate quality evidence suggests a medium to strong association between increased executive functioning scores and increased scores on attention, memory, verbal learning, visual learning, processing speed, reasoning, abstraction, and flexibility in people with schizophrenia.
- Moderate to high quality evidence finds a medium-sized effect of better planning ability in people with schizophrenia with a history of cannabis use compared to people with schizophrenia without a history of cannabis use. There were no differences between tobacco smokers and non-smokers.



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Aleman A, Agrawal N, Morgan KD, David AS

Insight in psychosis and neuropsychological function: Meta-analysis

British Journal of Psychiatry 2006; 189: 204-212

[View review abstract online](#)

Comparison	Association between executive functioning and insight in people with schizophrenia.
Summary of evidence	Moderate to high quality evidence (medium-sized sample, direct, consistent, precise) suggests a medium association between better executive functioning and better insight.
Executive functioning	
<i>A medium effect size suggests increased executive functioning and performance on the WCST were associated with increased insight in people with schizophrenia;</i> Executive functioning: 5 studies, N = 331, $r = 0.19$, 95%CI 0.08 to 0.30, $p = 0.001$, $Q_w = 5.0$, $p = 0.97$ WCST: 5 studies, N = 311, $r = 0.25$, 95%CI 0.14 to 0.36, $p < 0.0001$, $Q_w = 4.3$, $p = 0.37$	
Consistency [‡]	Consistent
Precision [§]	Precise
Directness	Direct

Bora E, Yucel M, Pantelis C

Cognitive functioning in schizophrenia, schizoaffective disorder and affective psychoses: meta-analytic study

The British Journal of Psychiatry 2009; 195: 475-482

[View review abstract online](#)

Comparison	Cognitive functioning in people with schizophrenia vs. people with affective psychosis or schizoaffective disorder. Note: the schizophrenia group had more males, with a younger
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	mean age and with fewer years of education, which may account for any observed effects.
Summary of evidence	Moderate to high quality evidence (unclear sample size, direct, precise, consistent) shows a small effect of worse performance on the Wisconsin Card Sorting Task in people with schizophrenia compared with people with affective psychosis, and to a lesser extent, compared with people with schizoaffective disorder. Moderate quality evidence (inconsistent) suggests this may also be applicable to the Trial Making Test Part B, but only in the comparison with affective psychosis.
Executive functioning	
<i>A significant, small effect suggests worse executive functioning in people with schizophrenia compared with people with affective psychosis or schizoaffective disorder;</i> 19 studies (N not reported), $d = 0.23$, 95%CI 0.08 to 0.38, $p = 0.003$, $Q_w p = 0.002$ <i>Subgroup analysis shows that this effect is only significant when compared with affective psychosis, and not when compared with schizoaffective psychosis;</i> Schizophrenia vs. affective psychosis: 12 studies, $d = 0.28$, 95%CI 0.11 to 0.46, $p = 0.002$, $Q_w p = 0.04$ Schizophrenia vs. schizoaffective disorder: 9 studies, $d = 0.12$, 95%CI -0.06 to 0.31, $p = 0.19$, $Q_w p = 0.11$ <i>Subgroup analysis shows that the effect sizes were non-significant when using only gender-matched studies, and that heterogeneity was substantially reduced (statistics not reported).</i> <u>Results for individual executive functioning tasks:</u> <i>Wisconsin Card Sorting Test – worse performance in schizophrenia for all comparisons;</i> Schizophrenia vs. affective psychosis/schizoaffective: 15 studies, $d = 0.25$, 95%CI 0.12 to 0.38, $p < 0.05$, $Q_w p = 0.39$ Schizophrenia vs. affective psychosis: 9 studies, $d = 0.30$, 95%CI 0.10 to 0.50, $p = 0.004$, $Q_w p = 0.20$ Schizophrenia vs. schizoaffective disorder: 7 studies, $d = 0.21$, 95%CI 0.03 to 0.39, $p = 0.02$, $Q_w p = 0.57$ <i>Trial Making Test Part B – worse performance in schizophrenia vs. affective psychosis only;</i> Schizophrenia vs. affective psychosis/schizoaffective: 10 studies, $d = 0.23$, 95%CI 0.00 to 0.47, $p = 0.06$, $Q_w p = 0.001$ Schizophrenia vs. affective psychosis: 8 studies, $d = 0.27$, 95%CI 0.01 to 0.52, $p = 0.04$, $Q_w p = 0.009$	



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Schizophrenia vs. schizoaffective disorder: 5 studies, $d = 0.17$, 95%CI -0.15 to 0.49, $p = 0.30$, $Q_w p = 0.24$

Meta-regression to investigate significant heterogeneity in the overall analysis showed that schizophrenia samples with more severe negative symptoms (particularly males), or fewer years of education showed the greatest impairments compared with affective psychosis/schizoaffective;

Negative symptoms: 6 studies, $B = 0.41$, $SE = 0.09$, $p < 0.001$

Years of education (number of studies not reported): $B = 0.89$, $SE = 0.30$, $p = 0.003$

Consistency	Consistent for schizophrenia vs. schizoaffective disorder subgroup analyses and Wisconsin Card Sorting Test only
Precision	Precise
Directness	Direct

Bora E, Murray RM

Meta-analysis of cognitive deficits in ultra-high risk to psychosis and first-episode psychosis: Do the cognitive deficits progress over, or after, the onset of psychosis?

Schizophrenia Bulletin 2014; 40(43): 744-755

[View review abstract online](#)

Comparison	Changes in cognitive functioning over time in people at ultra-high risk of psychosis (UHR) compared with people with first-episode psychosis (FEP) or controls.
Summary of evidence	High quality evidence (medium to large samples, precise, direct, consistent) suggests similar, small improvements on executive functioning tasks over time in people at ultra-high risk of psychosis, people with first-episode psychosis, and controls.
Executive functioning over time (1 to 5 years)	
Significant, small improvement in executive functioning over time in UHR, FEP and controls, with no significant differences between groups;	
FEP: 12 studies, $N = 678$, $d = 0.38$, 95%CI 0.20 to 0.56, $p < 0.001$, $I^2 = 0.05\%$, Q-test $p = 0.006$	
UHR: 5 studies, $N = 208$, $d = 0.37$, 95%CI 0.17 to 0.56, $p < 0.001$, $I^2 = 0\%$, Q-test $p = 0.99$	
Controls: 6 studies, $N = 265$, $d = 0.39$, 95%CI 0.13 to 0.65, $p = 0.003$, $I^2 = 0.05\%$, Q-test $p = 0.06$	



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$Q_B p > 0.05$

In FEP studies, a decrease in negative symptoms was significantly associated with greater improvement in executive functioning at follow-up.

Authors report no publication bias and no effects of medication status.

Consistency	Consistent
Precision	Precise
Directness	Direct

Bora E, Binnur Akdede B, Alptekin K

Neurocognitive impairment in deficit and non-deficit schizophrenia: a meta-analysis

Psychological Medicine 2017; 47: 2401-13

[View review abstract online](#)

Comparison	Executive functioning in people with deficit schizophrenia vs. people with non-deficit schizophrenia. Both groups were also compared to controls.
Summary of evidence	Moderate to high quality evidence (large samples, mostly inconsistent, precise, direct) suggests people with deficit schizophrenia are more impaired than people with non-deficit schizophrenia on measures of executive functioning.

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Significant, medium-sized effects of poorer executive functioning in people with deficit schizophrenia compared to people with non-deficit schizophrenia;

Executive functioning: 16 studies, $N = 1,928$, $d = 0.39$, 95%CI 0.23 to 0.55, $p < 0.001$, $I^2 = 54\%$, $p = 0.004$

TMT B: 9 studies, $N = 832$, $d = 0.53$, 95%CI 0.29 to 0.76, $p < 0.001$, $I^2 = 58\%$, $p = 0.01$

Stroop interference: 5 studies, $N = 447$, $d = 0.49$, 95%CI 0.31 to 0.68, $p < 0.001$, $I^2 = 2\%$, $p = 0.40$

WCST categories: 8 studies, $N = 1,433$, $d = 0.44$, 95%CI 0.20 to 0.68, $p < 0.001$, $I^2 = 73\%$, $p < 0.001$

WCST preservative: 10 studies, $N = 1,517$, $d = 0.39$, 95%CI 0.21 to 0.57, $p < 0.001$, $I^2 = 54\%$, $p = 0.02$



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Significant, large effects of poorer executive functioning in people with deficit schizophrenia compared to controls and in people with non-deficit schizophrenia compared to controls;

Deficit: 10 studies, $N = 1,030$, $d = 1.23$, 95%CI 1.02 to 1.44, $p < 0.001$, $I^2 = 52\%$, $p = 0.03$

Non-deficit: 10 studies, $N = 1,162$, $d = 1.00$, 95%CI 0.85 to 1.14, $p < 0.001$, $I^2 = 25\%$, $p = 0.21$

Consistency in results	Mostly inconsistent.
Precision in results	Precise
Directness of results	Direct

Catalan A, Salazar De Pablo G, Aymerich C, Damiani S, Sordi V, Radua J, Oliver D, McGuire P, Giuliano AJ, Stone WS, Fusar-Poli P

Neurocognitive Functioning in Individuals at Clinical High Risk for Psychosis: A Systematic Review and Meta-analysis

JAMA Psychiatry 2021; 78(8): 859-67

[View review abstract online](#)

Comparison 1	Executive functioning in individuals at clinical high-risk of psychosis vs. controls.
Summary of evidence	Moderate to high quality evidence (large sample, inconsistent, precise, direct) shows a medium-sized effect of poorer executive functioning in people at clinical high-risk for psychosis compared to controls.
Executive functioning	
<i>A medium-sized effect showed people at clinical high-risk of psychosis performed more poorly than controls on executive functioning tasks:</i> 29 studies, $N = 3,374$, $g = -0.42$, 95%CI -0.60 to -0.24, $p < 0.001$ (Trail Making Test - Part B, Wisconsin Card Sorting Test - Categories, Perseverative errors, and Perseverative responses. There were no differences on the Wisconsin Card Sorting Test - Number of responses or the Stroop - Interference)	
Consistency in results	Authors report moderate to high heterogeneity
Precision in results	Precise



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Directness of results	Direct
Comparison 2	Executive functioning in individuals at high-risk of psychosis who made the transition to psychosis vs. individuals at high-risk of psychosis who did not make the transition to psychosis.
Summary of evidence	Moderate to high quality evidence (large sample, inconsistent, precise, direct) shows a medium-sized effect of poorer executive functioning in individuals at high-risk of psychosis who made the transition to psychosis compared with individuals at high-risk of psychosis who did not make the transition to psychosis.
Executive functioning	
<i>A medium-sized effect showed people at clinical high-risk of psychosis who transitioned to psychosis performed more poorly than people at clinical high-risk of psychosis who did not transition to psychosis on executive functioning:</i> 5 studies, $N = 491$, $g = -0.42$, 95%CI -0.77 to -0.07, $p = 0.05$ (Wisconsin Card Sorting Test - Perseverative errors)	
Consistency in results	Authors report moderate to high heterogeneity
Precision in results	Precise
Directness of results	Direct
Comparison 3	Executive functioning in individuals at clinical high-risk for psychosis vs. people with first-episode psychosis
Summary of evidence	Moderate to high quality evidence (large sample, inconsistent, some imprecision, direct) shows a medium-sized effect of better executive functioning in individuals at high-risk of psychosis compared to people with first-episode psychosis.
Executive functioning	
<i>Small to medium-sized effect showed people at clinical high-risk of psychosis performed better than people with first-episode psychosis on executive functioning tasks:</i> 8 studies, $N = 843$, $g = 0.34$, 95%CI 0.11 to 0.56, $p < 0.001$ (Wisconsin Card Sorting Test – Categories, Perseverative errors, STROOP - Interference)	
Consistency in results	Authors report moderate to high heterogeneity
Precision in results	Precise



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Directness of results	Direct
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Christensen T

The influence of neurocognitive dysfunctions on work capacity in schizophrenia patients: a systematic review of the literature

International Journal of Psychiatry in Clinical Practice 2007; 11(2): 89-101

[View review abstract online](#)

Comparison	Association between work capacity and cognitive performance in people with schizophrenia. Note: work capacity is the ability to obtain and maintain competitive work and work behaviours and skills.
Summary of evidence	Moderate to low quality evidence (medium-sized sample, direct, unable to assess consistency or precision) suggests that lower levels of work capacity are associated with poor executive functioning.
Executive functioning	
7 studies (N = 366) reported that poor executive functioning was associated with worse task orientation, social skills, full time employment, occupational functioning, work behaviour improvement, wages earned, contact with employment specialist, cooperativeness, work quality and general impression.	
Consistency	Unable to assess; no measure of consistency is reported.
Precision	Unable to assess; no measure of precision is reported.
Directness	Direct

Daban C, Martinez-Aran A, Torrent C, Tabarés-Seisdedos R, Balanzá-Martínez V, Salazar-Fraile J, Selva-Vera G, Vieta E

Specificity of cognitive deficits in bipolar disorder versus schizophrenia: A systematic review

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Psychotherapy and Psychosomatics 2006; 75: 72-84

[View review abstract online](#)

Comparison	Cognitive performance in people with schizophrenia vs. people with bipolar disorder.
Summary of evidence	Moderate quality evidence (large samples, unable to assess consistency or precision, direct) suggests poorer executive functioning in people with schizophrenia.
Executive functioning	
8 studies (N = 872) reported worse executive functioning (WCST) in people with schizophrenia compared with people with bipolar disorder. However, 9 studies (N = 953) reported no differences in WCST performance. 1 study (N = 107) reported an association between increase negative symptoms and poorer performance. 3 studies (N = 226) reported that people with schizophrenia showed worse WCST categories performance but similar perseverative errors than people with bipolar disorder. 6 studies (N = 729) reported impaired TMT-B performance in people with schizophrenia compared with people with bipolar disorder. However, 8 studies (N = 707) reported no difference in TMT-B performance. 1 study (N = 108) reported that people with psychotic symptoms performed more poorly than those without psychotic symptoms.	
Consistency	Unable to assess; no measure of consistency is reported.
Precision	Unable to assess; no measure of precision is reported.
Directness	Direct

de Gracia Domingues M, Viechtbauer W, Simons C, van Os J

Are psychotic psychopathology and neurocognition orthogonal? A systematic review of their associations

Psychological Bulletin 2009; 135(1): 157-171

[View review abstract online](#)

Comparison	Association between executive functioning and symptom dimensions in people with non-affective psychosis.
Summary of evidence	Moderate to high quality evidence (unclear sample size, direct, precise, consistent) shows a medium size association between



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	increased negative symptoms and lower verbal fluency.
Executive functioning and verbal fluency	
<i>A significant, medium association between increased negative symptoms and lower verbal fluency;</i> 23 studies, $\mu_p = -0.291$, 95%CI -0.356 to -0.224, $p = 0.00$, $I^2 = 42$ <i>No association between negative symptoms and executive control</i> 10 studies, $\mu_p = -0.131$, 95%CI -0.265 to 0.008, $p = 0.063$, $I^2 = 56$ <i>No association with positive or disorganised symptoms;</i> <i>Positive symptoms and executive control:</i> 9 studies, $\mu_p = 0.082$, 95%CI -0.017 to 0.179, $p = 0.10$, $I^2 = 7\%$ <i>Positive symptoms and verbal fluency:</i> 20 studies, $\mu_p = -0.035$, 95%CI -0.101 to 0.031, $p = 0.29$, $I^2 = 17\%$ <i>Disorganised symptoms and executive control:</i> 7 studies, $\mu_p = -0.089$, 95%CI -0.202 to -0.026, $p = 0.13$, $I^2 = 20\%$ <i>Disorganised symptoms and verbal fluency:</i> 13 studies, $\mu_p = -0.092$, 95%CI -0.208 to 0.027, $p = 0.13$, $I^2 = 61\%$	
Consistency	Consistent
Precision	Precise
Directness	Direct

Dibben CR, Rice C, Laws K, McKenna PJ

Is executive impairment associated with schizophrenic syndromes? A meta-analysis

Psychological Medicine 2009; 39(3): 381-392

[View review abstract online](#)

Comparison	Association between executive impairment and negative symptoms in people with schizophrenia.
Summary of evidence	Moderate to high quality evidence (unclear sample size, consistent in overall analysis, precise, direct) shows a weak association of more impaired executive function and increased



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	negative symptoms. This association was increased in patients who were untreated or who were chronically hospitalised. Verbal fluency tasks report the strongest association. Moderate quality evidence (unable to assess consistency) shows a weak association of lower IQ in people with schizophrenia with increased negative symptoms.
Executive impairment and negative symptoms	
<i>Small effect size suggests an association of reduced executive function with negative symptoms in people with schizophrenia;</i> 83 studies, N not reported, $r = -0.21$, 95%CI -0.24 to -0.18, p-value not reported, $Q = 321.84$, $p < 0.0001$ Excluding 21 outliers gave a similar effect, with homogenous results; $r = -0.20$, 95%CI -0.23 to -0.17, $Q = NS$	
Subgroup analyses: <i>Greater association of executive dysfunction and negative symptoms were reported for neuroleptic treated patients vs. patients who were not receiving treatment;</i> Treated: 58 studies, $r = -0.19$, Untreated: 7 studies, $r = -0.29$ $Q_B = 6.28$, $p = 0.01$ <i>Greater association of executive dysfunction and negative symptoms were reported for chronically hospitalized (persistent) patients vs. acutely ill patients;</i> Acutely ill: 19 studies, $r = -0.13$, Chronically ill: 35 studies, $r = -0.24$ $Q_B = 20.93$, $p = 0.0001$ No moderating effect of age: 80 studies, N not reported, $p = 0.71$ No moderating effect of duration of illness: 72 studies, N not reported, $p = 0.28$	
Task specific executive impairments: <i>All tasks showed a small to medium size association with negative symptoms;</i> Verbal fluency: 40 studies, $r = -0.27$ 95%CI -0.31 to -0.23 Trail-making tasks B: 24 studies, $r = -0.24$, 95%CI -0.29 to -0.18 WCST, set shifting: 43 studies, $r = -0.16$, 95%CI -0.20 to -0.13 Executive working memory: 13 studies, $r = -0.14$, 95%CI -0.22 to -0.07 Stroop/Hayling: 16 studies, $r = -0.13$, 95%CI -0.21 to -0.05 Significant between-group differences in effect sizes were reported between the cognitive tasks, with the association between negative symptoms and verbal fluency being the strongest and between negative symptoms and STROOP being the weakest ($Q_B = 42.27$, $p < 0.001$)	



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General intellectual impairment: IQ <i>Small effect size suggests an association of reduced intellectual function with negative symptoms;</i> 30 studies, N not reported, $r = -0.21$, 95%CI -0.26 to -0.17, Q = not reported Excluding 6 outliers did not change results: $r = -0.23$, 95%CI -0.28 to -0.17, Q = not reported	
Consistency	Inconsistent where reported, apart from reduced overall analysis
Precision	Precise
Directness	Direct
Comparison 2	Association between executive impairment and disorganised symptoms in people with schizophrenia.
Summary of evidence	Moderate to high quality evidence (unclear sample size, consistent in overall analysis, precise, direct) shows a medium association of more impaired executive function in people with schizophrenia and increased disorganised symptoms. This association was increased in patients who were older, who had a longer duration of illness, who were untreated or who were chronically hospitalized. TMT-B task reports the strongest association. Moderate quality evidence (unable to assess consistency) shows a weak association of lower IQ in people with schizophrenia with increased disorganised symptoms.
Executive impairment and disorganised symptoms	
Overall executive impairment: <i>Small effect size suggests an association of reduced executive function with disorganised symptoms in people with schizophrenia;</i> 40 studies, N not reported, $r = -0.17$, 95%CI -0.21 to -0.13, p-value not reported Q = 148.14, $p < 0.0001$ Excluding 8 outliers resulted in a medium effect with homogenous results: $r = -0.28$, 95%CI -0.33 to -0.23, Q = NS	
Subgroup analyses: <i>Greater association of executive impairment with disorganised symptoms in older people with schizophrenia;</i> 40 studies, N not reported, $p = 0.05$ <i>Greater association of executive impairment with disorganised symptoms in people with</i>	



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schizophrenia with a longer duration of illness;

36 studies, N not reported, $p = 0.0006$

Greater association of executive dysfunction and disorganised symptoms were reported for neuroleptic treated patients;

Treated: 27 studies, $r = -0.22$, Untreated: 5 studies, $r = -0.14$

$Q_B = 4.09$, $p = 0.04$

Greater association of executive dysfunction and disorganised symptoms were reported for chronically hospitalized (persistent) patients;

Acutely ill: 11 studies, $r = -0.12$, Chronically ill: 16 studies, $r = -0.28$

$Q_B = 18.46$, $p = 0.0001$

Task specific executive impairment:

All tasks showed a small to medium size association with disorganised symptoms;

Trail-making task B: 10 studies, $r = -0.31$, 95%CI -0.40 to -0.22

Stroop/Hayling: 10 studies, $r = -0.29$, 95%CI -0.38 to -0.21

WCST, set shifting: 19 studies, $r = -0.19$, 95%CI -0.24 to -0.14

Executive working memory: 6 studies, $r = -0.12$, 95%CI -0.23 to -0.00

Verbal fluency: 18 studies, $r = -0.11$ 95%CI -0.17 to -0.05

Significant between-group differences in effect sizes were reported between the cognitive tasks, with the association between disorganised symptoms and trail-making B being the strongest and between disorganised symptoms and verbal fluency being the weakest ($Q_B = 33.71$, $p < 0.001$).

General intellectual impairment: IQ

Small effect size suggests an association of reduced intellectual function with disorganised symptoms;

N not reported, $r = -0.21$, 95%CI -0.28 to -0.14, $Q =$ not reported

Excluding 2 outliers, $r = -0.28$, 95%CI -0.35 to -0.19, $Q =$ not reported

Consistency	Consistent, no unexplained heterogeneity
Precision	Precise
Directness	Direct
Comparison 3	Association between executive impairment and positive symptoms in people with schizophrenia.
Summary of evidence	Moderate quality evidence (unclear sample size, inconsistent, precise, direct) suggests no association between executive



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	functioning and positive symptoms.
Executive impairment and positive symptoms	
Overall executive impairment: <i>No association;</i> 34 studies, N not reported, $r = -0.01$, 95%CI -0.04 to 0.05, p-value not reported, $Q = 321.84$, $p < 0.0001$ <i>Excluding 4 outliers did not change results;</i> $r = -0.02$, 95%CI -0.03 to 0.07, $Q =$ not reported	
Consistency	Inconsistent
Precision	Precise
Directness	Direct

Dickinson D, Ramsey ME, Gold JM

Overlooking the Obvious: A meta-analytic comparison of digit symbol coding tasks and other cognitive measures in schizophrenia

Archives of General Psychiatry 2007; 64: 532-542

[View review abstract online](#)

Comparison	Executive functioning in people with schizophrenia vs. controls.
Summary of evidence	Moderate quality evidence (direct, precise, unable to assess consistency) suggests a large effect of poorer executive functioning performance on WCST categories, WCST perseverative errors, TMT-B and stroop colour-word condition compared with controls.
Executive functioning	
<i>Large effect size suggests people with schizophrenia showed poorer executive functioning compared with controls on tasks including;</i> WCST categories: 20 studies, N = 1,876, $g = -1.00$, SE = 0.10, 95%CI -1.19 to -0.81 WCST perseverative errors: 23 studies, N = 2,224, $g = -0.81$, SE = 0.07, 95%CI -0.94 to -0.67	



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TMT-B: 21 studies, $N = 1,944$, $g = -0.92$, $SE = 0.05$, 95%CI -1.02 to -0.82

Stroop colour-word condition: 8 studies, $N = 892$, $g = -0.99$, $SE = 0.14$, 95%CI -1.26 to -0.72

Consistency	Unable to assess; no measure of consistency is reported.
Precision	Precise
Directness	Direct

Dickinson D, Gold JM

Less unique variance than meets the eye: Overlap among traditional neuropsychological dimensions in schizophrenia

Schizophrenia Bulletin 2008; 34(3): 423-434

[View review abstract online](#)

Comparison	Association between individual and composite measures of executive functioning and other neuropsychological tests on people with schizophrenia.
Summary of evidence	Moderate quality evidence (mixed sample sizes, direct, unable to assess consistency, precise) suggests a strong to medium association between increased scores on executive functioning and increased scores on other Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) domains including attention, memory, verbal learning, visual learning, processing speed, reasoning, abstraction and flexibility.

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9 studies ($N = 1,860$) Meta-analysis combined multiple correlations within each study into a single study-level effect size, and then calculated an overall weighted effect size between studies.

Weighted effect size of these 9 studies indicated a significant correlation across composite MATRICS cognitive scores; such that increased performance on executive functioning tasks was associated with increased performance on other cognitive tests, $r = 0.45$, 95%CI 0.35 to 0.54, $p < 0.001$.

1 study ($N > 1,123$), reported a large association between increased executive functioning (WCST) and increased verbal learning, processing speed, reasoning, working memory and vigilance; $r = 0.50$, 95%CI 0.47 to 0.53.



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- 1 study (N = 148 outpatients), reported a large association between increased executive functioning (trails B, WCST variables and digit span) and increased verbal learning, visual learning and processing speed; $r = 0.61$, 95%CI 0.65 to 0.66.
- 1 study (N = 62 outpatients), reported a large association between increased executive functioning (WCST variables) and increased attention, memory and fluency; $r = 0.54$, 95%CI 0.33 to 0.70.
- 1 study (N = 53 outpatients), reported a large association between increased executive functioning (WCST variables) and increased verbal learning; $r = 0.54$, 95%CI 0.40 to 0.66.
- 1 study (N = 45 first episode), reported a large association between executive functioning (WCST variables, Stroop, trail B and letter fluency) and increased verbal learning, visual learning and attention; $r = 0.52$, 95%CI 0.38 to 0.64.
- 1 study (N = 40 first episode), reported a medium association between increased executive functioning (trails, digit symbol, executive functioning) and increased verbal learning, visual learning and working memory; $r = 0.35$, 95%CI 0.21 to 0.47.
- 1 study (N = 219 first-episode), reported a medium association between increased executive functioning (WCST variables) and increased verbal learning and working memory; $r = 0.34$, 95%CI 0.27 to 0.40.
- 1 study (N = 40 patients), reported a medium association between executive functioning (WCST and complex reaction time variables) and increased verbal memory, attention and visual memory, $r = 0.39$, 95%CI 0.28 to 0.50.
- 1 study (N = 113 outpatients), reported a small association between abstraction and flexibility (WCST, Stroop and trails B) and increased attention and verbal learning; $r = 0.16$, 95%CI 0.08 to 0.23.
- 1 study (N = 204 inpatients), reported a medium association between increased individual measures of executive functioning (WCST perseverative errors) and increased scores on logical memory, digit span, category fluency and visual reproduction; $r = 0.24$, 95%CI 0.18 to 0.30.
- 1 study (N = 219 first episode), reported a medium association between increased individual measures of executive functioning (WCST perseverative errors) and increased scores on CVLT, letter fluency, trails A and B combined and identical pairs CPT; $r = 0.31$, 95%CI 0.27 to 0.34.
- 1 study (N = 36 inpatients), reported a large association between increased individual measures of executive functioning (WCST, trails B) and increased scores on letter-number span, digit span, Gordon's CPT and letter fluency, $r = 0.44$, 95%CI 0.33 to 0.54.
- 1 study (N = 118 first or second episode), reported a medium association between increased individual measures of executive functioning (Stroop colour and word conditions combined) and increased scores on CVLT, Rey complex figure memory, category fluency, Gordon's CPT; $r = 0.30$, 95%CI 0.24 to 0.36.
- 1 study (N > 1,123 outpatients), reported a large association between increased individual measures of executive functioning (WCST) and increased measured of category and letter fluency, digit symbol, WISC mazes, HVL, visuospatial working memory, letter-number sequencing and identical pairs CPT; $r = 0.40$, 95%CI 0.37 to 0.44.
- 1 study (N = ~140 inpatients and outpatients), reported a medium association between increased



Executive functioning

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individual measures of executive functioning (Tower of London) and increased measures of verbal list learning, digit sequencing, category and letter fluency and symbol digit coding; $r = 0.33$, 95%CI 0.24 to 0.41.

1 study (N = 32 outpatients), reported a large association between increased individual measures of executive functioning (WCST perseverative errors) and increased measures of Penn conditional exclusion test and letter fluency, trails A, trails B, digit symbol, and HVLT; $r = 0.40$, 95%CI 0.28 to 0.50.

1 study (N = 53 inpatients), reported a large association between increased individual measures of executive functioning (WCST and Stroop colour-word) and increased measures of letter fluency, verbal series CPT, trails B, symbol digit, HVLT (immediate) and digit span; $r = 0.43$, 95%CI 0.38 to 0.47.

1 study (N = 30 inpatients), reported a medium association between increased individual measures of executive functioning (WCST and trails B) and increased measures of symbol digit with Rey AVLT, identical pairs CPT, letter number sequencing and trails A; $r = 0.30$, 95%CI 0.18 to 0.41.

1 study (N = 30 inpatients), reported a medium association between increased individual measures of executive functioning (WCST perseverative errors) and increased measures of visuospatial working memory, digit span (backwards) and digit symbol; $r = 0.24$, 95%CI 0.01 to 0.46.

1 study (N = 27 patients), reported a medium association between increased individual measures of executive functioning (WCST perseverative errors) and increased measures of dot working memory test, letter-number sequencing, spatial working memory test and HVLT; $r = 0.27$, 95%CI 0.12 to 0.40.

Consistency	Unable to assess; no measure of consistency is reported.
Precision	Precise
Directness	Direct

Doughty OJ, Done DJ

Is semantic memory impaired in schizophrenia? A systematic review and meta-analysis of 91 studies

Cognitive Neuropsychiatry 2009; 14(6): 473-509

[View review abstract online](#)

Comparison	Semantic memory involving executive functioning in people with schizophrenia and symptom dimensions.
Summary of evidence	Moderate to low quality evidence (unclear sample size, direct, imprecise, unable to assess consistency) suggests more



Executive functioning

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	impaired performance in people with schizophrenia with formal thought disorder or negative symptoms compared with people with schizophrenia without thought disorder or negative symptoms on verbal fluency tasks.
Executive functioning	
More impairment in people with thought disorder compared with people without thought disorder for verbal fluency; 3 studies reported a difference, $d = -1.12$, 95%CI -1.72 to -0.72, p not reported More impairment in people with negative symptoms compared with people without negative symptoms in verbal fluency; 2 studies, $d = -1.006$, 95%CI -1.43 to -0.58, p not reported	
Consistency	Unable to assess; no measure of consistency is reported.
Precision	Imprecise
Directness	Direct

Fatouros-Bergman H, Cervenka S, Flyckt L, Edman G, Farde L

Meta-analysis of cognitive performance in drug-naïve patients with schizophrenia

Schizophrenia Research 2014; 158: 156-162

[View review abstract online](#)

Comparison	Cognitive performance in people with schizophrenia who have never been medicated vs. controls.
Summary of evidence	High quality evidence (large sample, direct, consistent, precise) shows poorer performance on executive functioning tasks in never-medicated people with schizophrenia compared with controls.
Executive functioning	
Significant, medium to large effect of poorer executive functioning in never-medicated patients compared with controls; 11 studies, $N = 966$, SMD -0.74, 95%CI -0.85 to -0.62, $p < 0.001$, $I^2 = 29.7\%$, $p = 0.09$	



Executive functioning

Tests used were; CANTAB (total errors adjusted, problems solved in minimum moves, mean moves, Tower of London (frames completed), Trail Making Test B (time), Wisconsin Card Sorting Test (categories completed, total number of errors, perseverative errors).

Consistency	Consistent
Precision	Precise
Directness	Direct

Fioravanti M, Bianchi V, Cinti ME

Cognitive deficits in schizophrenia: an updated meta-analysis of the scientific evidence

BMC Psychiatry 2012; 12: 64

[View review abstract online](#)

Comparison	Executive functioning in people with schizophrenia vs. controls.
Summary of evidence	Moderate to high quality evidence (large sample, inconsistent, precise, direct) suggests people with schizophrenia showed lower cognitive flexibility than controls.
Executive functioning	
<i>Authors reported a large effect of lower cognitive flexibility on the Wisconsin Card Sorting test in people with schizophrenia compared with controls;</i> 67 studies, N = 5,257, SMD = -1.10, 95%CI -1.27 to -0.92, $p < 0.0001$, $I^2 = 88\%$	
Consistency	Inconsistent
Precision	Precise
Directness	Direct

Forbes NF, Carrick LA, McIntosh AM, Lawrie SM

Working memory in schizophrenia: a meta-analysis

Executive functioning

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Psychological Medicine 2009; 39: 889-905

[View review abstract online](#)

Comparison	Executive working memory in people with schizophrenia vs. controls.
Summary of evidence	Moderate to high quality evidence (unclear sample size, direct, consistent, mostly precise) suggests a medium to large effect showing poorer performance in people with schizophrenia compared with controls on executive working memory tasks, including CANTAB SWM strategy score and random letter/number generation, executive golf and self-order pointing tasks.
Executive working memory	
<i>A significant medium to large effect size suggests poorer performance on the following executive working memory tests in people with schizophrenia compared with controls;</i> CANTAB SWM strategy score: 6 studies, $d = 0.92$, 95%CI 0.69 to 1.16, $p < 0.001$, $I^2 = 44.1$, $p = 0.111$ Random letter/number generation: 3 studies, $d = 0.81$, 95%CI 0.28 to 1.34, $p = 0.003$, $I^2 = 49.3$, $p = 0.139$ Executive golf task: 4 studies, $d = 0.73$, 95%CI 0.50 to 0.96, $p < 0.001$, $I^2 = 0.0$, $p = 0.488$ Self-ordered pointing: 3 studies, $d = 0.75$, 95%CI 0.3 to 1.2, $p = 0.001$, $I^2 = 47.8$, $p = 0.147$	
Consistency	Consistent
Precision	Precise for all except random letter/number generation.
Directness	Direct

Henry JD, Crawford JR

A meta-analytic review of verbal fluency deficits in schizophrenia relative to other neurocognitive deficits

Cognitive Neuropsychiatry 2005; 10(1): 1-33

[View review abstract online](#)

Comparison	Association between phonemic and semantic fluency (thought
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Executive functioning

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	to impose demands on executive functioning) in people with schizophrenia vs. controls.
Summary of evidence	High quality evidence (large samples, direct, consistent, precise) suggests a medium to large effect of poorer semantic fluency (WCST) in schizophrenia vs. controls. Moderate to high quality evidence (inconsistent) suggests a medium to large effect of poorer phonemic fluency (WCST and Stroop) and poorer semantic fluency (Stroop).
Phonemic fluency (generation of words beginning with a specified letter)	
<i>A medium to large effect suggests a significant association between poorer executive functioning and impaired phonemic fluency in people with schizophrenia compared with controls;</i> WCST Categories completed: 40 studies, $N = 2,295$, $r = 0.47$, SE 0.023, 95%CI 0.42 to 0.51, p not reported, $Q = 84.0$, $p < 0.05$ WCST Perseverative errors: 43 studies, $N = 2,525$, $r = 0.44$, SE 0.021, 95%CI 0.39 to 0.48, $Q = 78.6$, $p < 0.05$ Stroop interference: 20 studies, $N = 1,132$, $r = 0.44$, SE 0.046, 95%CI 0.35 to 0.53, $Q = 74.8$, $p < 0.05$ Authors report that these effects are moderated by IQ.	
Semantic fluency (generation of words constrained by a specific category)	
<i>A medium to large effect suggests a significant association between poorer cognition and impaired semantic fluency in people with schizophrenia compared with controls;</i> WCST Categories Completed: 13 studies, $N = 653$, $r = 0.53$, SE 0.034, 95%CI 0.46 to 0.59, $Q = 18.2$, $p > 0.05$ WCST Perseverative Errors: 14 studies, $N = 748$, $r = 0.46$, SE 0.036, 95%CI 0.39 to 0.53, $Q = 19.1$, $p > 0.05$ Stroop Interference: 13 studies, $N = 610$, $r = 0.48$, SE 0.044, 95%CI 0.40 to 0.57, $Q = 27.3$, $p < 0.05$ Authors report that these effects are moderated by IQ.	
Consistency	Inconsistent for phonemic fluency and semantic fluency - stroop interference.
Precision	Precise
Directness	Direct



Executive functioning

Irani F, Kalkstein S, Moberg E, Moberg P

Neuropsychological performance in older patients with schizophrenia: A meta-analysis of cross-sectional and longitudinal studies

Schizophrenia Bulletin 2011; 37(6): 1318-1326

[View review abstract online](#)

Comparison	Executive functioning in older people with schizophrenia (mean age 64 years).
Summary of evidence	Moderate quality evidence (unclear sample size, direct, inconsistent, precise or unable to assess) suggests older people with schizophrenia may have poorer global cognition and executive functioning than age-matched controls.
Executive functioning	
<i>A large effect suggests global cognition was significantly more impaired in older people with schizophrenia compared with the age-matched control group;</i> 21 observational studies (cross-sectional), $d = -1.19$, 95%CI -1.29 to -1.11, p value not reported, $Q = 325.96$, $p < 0.01$ <i>A large effect size suggesting poorer executive functioning in older people with schizophrenia compared with the age-matched control group;</i> $d = -1.14$, Q and p-values are not reported Subgroup analysis suggests global cognition may be associated with age, sex, education, ethnicity, diagnosis, living status, age of onset/duration of illness and clinical symptoms.	
Consistency	Inconsistent for overall global cognition, unable to assess for executive functioning.
Precision	Precise for overall global cognition. Unable to assess for executive functioning.
Directness	Direct

Jameson KG, Nasrallah HA, Northern TG, Welge JA

Executive function impairment in first-degree relatives of persons with



Executive functioning

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schizophrenia: A meta-analysis of controlled studies

Asian Journal of Psychiatry 2011; 4: 96

[View review abstract online](#)

Comparison	Executive functioning in first-degree relatives of people with schizophrenia vs. controls.
Summary of evidence	Moderate to high quality evidence (large samples, inconsistent or imprecise, direct) suggests poorer executive functioning in first-degree relatives of people with schizophrenia compared to controls.
Executive functioning	
<i>A small to medium effect suggests significantly less categories achieved and significantly more perseverative errors on the WCST in relatives of people with schizophrenia compared to controls;</i> Categories achieved: 17 studies, N = 1,602, $d = -0.34$, 95%CI -0.50 to 0.18, p value not reported Authors report no heterogeneity ($p = 0.273$), but potential publication bias ($p = 0.08$) Perseverative errors: 23 studies, N = 2,173, $d = 0.26$, 95%CI 0.06 to 0.46, p value not reported Authors report significant heterogeneity ($p < 0.001$) and potential publication bias ($p = 0.06$)	
Consistency	Consistent for categories, inconsistent for perseverative errors.
Precision	Precise for perseverative errors, imprecise for categories.
Directness	Direct

Johnson-Selfridge M, Zalewski C

Moderator variables of executive functioning in schizophrenia: meta-analytic findings

Schizophrenia Bulletin 2001; 27(2): 305-316

[View review abstract online](#)

Comparison	Executive functioning in people with schizophrenia vs. controls.
Summary of evidence	Moderate quality evidence (large samples, direct, unable to assess consistency or precision) suggests that people with schizophrenia (medicated or unmedicated) may show impaired



Executive functioning

	performance on executive functioning tasks compared with controls. The evidence also suggests that poorer performance may be associated with greater symptom severity.
Executive functioning	
<i>Significantly impaired executive functioning in people with schizophrenia compared with controls on:</i> All measures: 64 studies, N = 4,524, weighted ES = -1.45 WCST and HCT combined: N = 2,140, weighted ES = -1.42 Verbal fluency, TMT-B and Stroop combined: N = 3,173, weighted ES = -1.58 <i>Impaired executive functioning in people with schizophrenia who are medicated or unmedicated;</i> Medicated: 37 studies, N = 2,904, weighted ES = -1.30 Unmedicated: 9 studies, N = 706, weighted ES = -1.99 A significant association between increased effect sizes and higher symptom ratings on SANS (10 studies, $r = -0.69$) and SAPS (9 studies, $r = -0.67$) as well as greater number of hospitalisations (20 studies, $r = -0.68$); $p < 0.05$. No significant association was reported between effect sizes and BPRS scores (15 studies, $r = -0.11$), chlorpromazine equivalents (24 studies, $r = 0.04$) or duration of illness (34 studies, $r = -0.25$); $p > 0.05$.	
Consistency	Unable to assess; no measure of consistency is reported.
Precision	Unable to assess; no measure of precision is reported.
Directness	Direct
Comparison 2	Executive functioning in people with schizophrenia vs. people with other psychiatric disorders.
Summary of evidence	Moderate quality evidence (large samples, direct, unable to assess consistency or precision) suggests that people with schizophrenia may show impaired performance on executive functioning tasks compared with people with other psychiatric disorders.
Executive functioning	
<i>Impaired executive functioning in people with schizophrenia compared with people with other psychiatric disorders on:</i> All measures: 20 studies, N = 1,104, weighted ES = 0.40 WCST and HCT combined: N = 527, weighted ES = 0.38 Verbal fluency, trail making B and Stroop test combined: N = 703, weighted ES = 0.36	

Executive functioning

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Consistency	Unable to assess; no measure of consistency is reported.
Precision	Unable to assess; no measure of precision is reported.
Directness	Direct

Knapp F, Viechtbauer W, Leonhart R, Nitschke K, Kaller CP

Planning performance in schizophrenia patients: a meta-analysis of the influence of task difficulty and clinical and sociodemographic variables

Psychological Medicine 2017; 47: 2002-16

[View review abstract online](#)

Comparison	Executive functioning in people with schizophrenia vs. controls.
Summary of evidence	Moderate to high quality evidence (large sample, direct, inconsistent, precise) suggests people with schizophrenia show impaired planning compared to controls.

Executive functioning

Significant, medium-sized effect of poorer planning in people with schizophrenia;

31 studies, N = 2,854, SMD = 0.67, 95%CI 0.56 to 0.78, $p < 0.05$, $Qp < 0.0001$

Meta-regression found increased effect size with increased task difficulty in terms of the minimum number of moves required for a solution.

Consistency	Inconsistent
Precision	Precise
Directness	Direct

Knowles E, David A, Reichenberg A

Processing speed deficits in schizophrenia: Reexamining the evidence

American Journal of Psychiatry 2010; 167: 828-835



Executive functioning

[View review abstract online](#)

Comparison	Executive functioning in people with schizophrenia vs. controls.
Summary of evidence	Moderate to high quality evidence (large samples, direct, inconsistent, precise) suggests people with schizophrenia show impaired executive functioning compared with controls.
Executive functioning	
<i>A large effect size suggests impaired performance on executive functioning tasks in people with schizophrenia compared with controls;</i> TMT-A: 24 studies, N = 3,224, $g = 0.85$, 95%CI 0.74 to 0.97, $I^2 = 49.92$, $Q = 45.92$, $p < 0.001$ TMT-B: 24 studies, N = 3,194, $g = 0.93$, 95%CI 0.82 to 1.04, $I^2 = 46.70$, $Q = 43.15$, $p < 0.01$ WCST categories completed: 22 studies, N = 3,572, $g = -1.03$, 95%CI -1.19 to -0.87, $I^2 = 64.3$, $Q = 56.05$, $p < 0.001$ WCST perseverative errors: 24 studies, N = 2,284, $g = 0.75$, 95%CI 0.63 to 0.87, $I^2 = 34.33$, $Q = 35.03$, $p > 0.05$	
Consistency	Inconsistent for all measures except WCST perseverative errors.
Precision	Precise
Directness	Direct

Krabbendam L, Arts B, van Os J, Aleman A

Cognitive functioning in patients with schizophrenia and bipolar disorder: A quantitative review

Schizophrenia Research 2005; 80: 137-149

[View review abstract online](#)

Comparison	Cognitive performance in people with schizophrenia vs. people with bipolar disorder.
Summary of evidence	High quality evidence (large samples, direct, consistent, precise) shows a medium effect of lower performance on verbal fluency and executive control tasks in studies that have matched samples on remission status, duration of disorder / number of admissions, and age / education variables. Moderate

Executive functioning

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	quality evidence (inconsistent) suggests this finding may also be applicable to concept formation with evidence from matched or unmatched studies.
Executive functioning	
<i>A significant, medium effect suggests people with schizophrenia showed impaired performance on executive functioning tasks compared with people with bipolar disorder;</i> Verbal fluency: 11 studies, N = 823, $d = 0.63$, 95%CI 0.40 to 0.85, $p < 0.0001$, $Q_w = 22.3$, $p = 0.01$ Executive control: 11 studies, N = 801, $d = 0.55$, 95%CI 0.19 to 0.91, $p = 0.002$, $Q_w = 52.5$, $p < 0.001$ Concept formation: 17 studies, N = 1,158, $d = 0.34$, 95%CI 0.11 to 0.57, $p = 0.004$, $Q_w = 51.0$, $p < 0.0001$ <i>Results were similar and across study heterogeneity was reduced in subgroup analyses of studies matched for remission status, duration of disorder / number of admissions, and age / education on fluency and executive control;</i> In remission: 10 studies, N = 646, $d = 0.49$, 95%CI 0.28 to 0.70, $p = 0.0001$, $Q_w = 14.3$, $p = 0.11$ Duration of disorder / number of admissions: 10 studies, N = 832, $d = 0.49$, 95%CI 0.31 to 0.67, $p < 0.0001$, $Q_w = 12.6$, $p = 0.19$ Age / education: 10 studies, N = 702, $d = 0.50$, 95%CI 0.29 to 0.71, $p = 0.0001$, $Q_w = 14.8$, $p = 0.10$	
Consistency	Inconsistent for all except subgroup analyses.
Precision	Precise
Directness	Direct

Li CSR

Do schizophrenia patients make more perseverative errors than non-perseverative errors on the Wisconsin Card Sorting Test? A meta-analytic study

Psychiatry Research 2004; 129: 179-190

[View review abstract online](#)

Comparison	Perseverative and non-perseverative errors on WCST in people with schizophrenia vs. controls.
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Executive functioning

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Summary of evidence	Moderate quality evidence (large sample, direct, unable to assess consistency or precision) suggests no difference in the ratio of perseverative to non-perseverative errors on the WCST between people with schizophrenia and controls.
Executive functioning	
<i>No difference in the ratio of perseverative errors to non-perseverative errors in people with schizophrenia compared with controls;</i> 59 studies, $N = 3,990$, $t(116) = -1.303$, $p = 0.195$	
Consistency	Unable to assess; no measure of consistency is reported.
Precision	Unable to assess; no measure of precision is reported.
Directness	Direct

Lipszyc J, Schachar R

Inhibitory control and psychopathology: A meta-analysis of studies using the stop signal task

Journal of the International Neuropsychological Society 2010; 16: 1064–1076

[View review abstract online](#)

Comparison	Inhibitory control in people with schizophrenia vs. controls.
Summary of evidence	Moderate to high quality evidence (unclear sample size, direct, consistent, precise) suggests a medium effect of deficient inhibition in patients with schizophrenia.
Inhibition	
<i>Medium effect of deficient inhibition and more response variability in patients with schizophrenia;</i> Stop signal task: 4 studies, $g = 0.69$, 95%CI 0.40 to 0.98, $p < 0.001$, $Q = 1.85$, $p = 0.60$ Mean reaction time: 6 studies, $g = 0.47$, 95%CI 0.12 to 0.81, $p = 0.008$, $Q = 8.94$, $p = 0.11$	
Consistency	Consistent
Precision	Precise
Directness	Direct



Executive functioning

Lynham AJ, Cleaver SL, Jones IR, Walters JTR

A meta-analysis comparing cognitive function across the mood/psychosis diagnostic spectrum

Psychological Medicine 2020; 52(2): 323-331

[View review abstract online](#)

Comparison 1	Executive functioning in people with schizoaffective disorder vs. bipolar disorder.
Summary of evidence	High quality evidence (large sample, consistent, precise, direct) finds a small to medium-sized effect suggesting people with schizoaffective disorder show impaired performance on executive functioning tasks compared to people with bipolar disorder.
Executive functioning	
<i>A significant, small to medium-sized effect suggests people with schizoaffective disorder showed impaired performance on executive functioning tasks compared to people with bipolar disorder;</i> 10 studies, N = 1,678, $g = -0.30$, 95%CI -0.41 to -0.20, $p < 0.00001$, $Qp = 0.24$	
Consistency	Consistent
Precision	Precise
Directness	Direct
Comparison 2	Executive functioning in people with schizophrenia vs. schizoaffective disorder.
Summary of evidence	Moderate to high quality evidence (large sample, inconsistent, precise, direct) finds no significant difference in executive functioning between people with schizophrenia and people with schizoaffective disorder.
Executive functioning	
<i>No significant difference in executive functioning between people with schizophrenia and people with schizoaffective disorder;</i> 21 studies, N = 4,111, $g = 0.10$, 95%CI -0.02 to 0.22, $p = 0.10$, $Qp < 0.00001$	

Executive functioning

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Consistency	Inconsistent
Precision	Precise
Directness	Direct

Mesholam-Gately R, Giuliano A, Goff K, Faraone S, Seidman L

Neurocognition in first-episode schizophrenia: a meta analytic review

Neuropsychology 2009; 23(3): 315-335

[View review abstract online](#)

Comparison	Executive functioning in people with first-episode schizophrenia vs. controls. Note: participants defined as 'first-episode' had either a first presentation of psychosis, initial psychiatric hospitalisation, or a minimal duration of illness/treatment.
Summary of evidence	Moderate to high quality evidence (large sample, direct, inconsistent, precise) suggests a large effect showing poorer executive functioning in people with first-episode schizophrenia compared with controls.

Executive functioning

Large effect size suggests people with first-episode schizophrenia showed significantly poorer executive functioning than controls;

17 studies, N = 2,246, $d = -0.83$, 95%CI -0.95 to -0.72, $p < 0.001$, $Q = 64.58$, $p < 0.001$

A smaller effect was associated with a higher proportion of first-episode patients on antipsychotic medication, recency of studies, and studies published outside the United States.

Consistency	Inconsistent
Precision	Precise
Directness	Direct

Nair A, Palmer EC, Aleman A, David AS



Executive functioning

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Relationship between cognition, clinical and cognitive insight in psychotic disorders: A review and meta-analysis

Schizophrenia Research 2014; 152: 191-200

[View review abstract online](#)

Comparison	Associations between clinical and cognitive insight and cognitive functioning in people with schizophrenia.
Summary of evidence	High quality evidence (medium to large samples, precise, consistent, direct) suggests small associations between increased clinical insight and increased executive functioning, and between increased cognitive insight and increased executive functioning, with no associations between cognitive insight and self-certainty or self-reflectiveness.
Associations between clinical insight (ability to identify symptoms as being a mental disorder) and executive functioning	
<i>Significant, small association between increased clinical insight and increased executive functioning;</i> Overall executive functioning: 25 studies, $N = 1,333$, $r = 0.14$, 95%CI 0.08 to 0.20, $p < 0.001$, $Q_w = 26.74$, $p = 0.32$, $I^2 = 10.25\%$ Wisconsin Card Sorting Test: 13 studies, $N = 792$, $r = 0.15$, 95%CI 0.05 to 0.25, $p < 0.001$, $Q_w = 21.29$, $p = 0.05$, $I^2 = 43.64\%$ Authors report no publication bias.	
Relationship between cognitive insight (ability to evaluate symptoms as measured by the Beck Cognitive Insight Scale) and executive functioning	
<i>Significant, small association between increased cognitive insight and increased executive functioning;</i> 4 studies, $N = 227$, $r = 0.16$, 95%CI 0.02 to 0.29, $p = 0.03$, $Q_w = 3.22$, $p = 0.36$, $I^2 = 6.90\%$ <i>No significant associations were found for self-certainty or self-reflectiveness;</i> Self-certainty: 5 studies, $N = 363$, $r = -0.02$, 95%CI -0.17 to 0.14, $p = 0.85$, $Q_w = 8.92$, $p = 0.06$, $I^2 = 55.16\%$ Self-reflectiveness: 5 studies, $N = 363$, $r = -0.03$, 95%CI -0.14 to 0.07, $p = 0.53$, $Q_w = 1.85$, $p = 0.76$, $I^2 = 0\%$	
Consistency	Consistent
Precision	Precise



Executive functioning

Directness	Direct
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Nieto R, Castellanos F

A Meta-Analysis of Neuropsychological Functioning in Patients with Early Onset Schizophrenia and Paediatric Bipolar Disorder

Journal of Clinical Child & Adolescent Psychology 2012; 40:2, 266-280

[View review abstract online](#)

Comparison	Cognitive performance in patients with early onset schizophrenia (EOS: mean age 15.8 years) and in paediatric bipolar disorder (PBD: mean age 13.6 years) vs. controls.
Summary of evidence	Moderate to high quality evidence (large samples, consistent, imprecise, direct) suggests a large effect of poor executive control in EOS than controls. High quality evidence (precise) suggests a medium effect of poor executive control in PBD.
Executive control	
<i>Large effect in EOS and a medium effect in PBD of poorer executive control vs. controls;</i> EOS: 11 studies, N = 758, $g = -0.95$, 95%CI -1.72 to -0.63, $p < 0.005$, $Q = 13.54$, $p = 0.19$ PBD: 9 studies, N = 605, $g = -0.66$, 95%CI -0.97 to -0.35, $p < 0.005$, $Q = 5.46$, $p = 0.71$ Executive control was significantly lower in EOS vs. PBD ($p < 0.001$). Moderator analyses revealed significantly smaller effect sizes in PBD studies with a lower percentage of patients taking medication, and in EOS studies with a higher percentage of patients taking antipsychotics. Smaller effect sizes were reported in studies with a lower percentage of patients with acute psychotic symptoms or a lower percentage of manic patients. Authors report no publication bias.	
Consistency	Consistent
Precision	Imprecise (EOS only)
Directness	Direct, apart from EOS vs. PBD



Executive functioning

Nieuwenstein M, Aleman A, de Haan E

Relationship between symptom dimensions and neurocognitive functioning in schizophrenia: a meta-analysis of WCST and CPT studies

Journal of Psychiatric Research 2001; 35: 119-125

[View review abstract online](#)

Comparison	Association between executive functioning and symptom dimensions in people with schizophrenia.
Summary of evidence	High quality evidence (medium to large samples, direct, consistent, precise) shows a medium association between increased negative or disorganised symptoms and impaired executive functioning. No significant association is reported with positive symptoms or reality distortion.
Negative symptoms	
<i>A medium positive association suggests that as negative symptoms increase in patients with schizophrenia, they may demonstrate more perseveration errors on the WCST-PE;</i> 15 studies, N = 699, $r = 0.27$, 95%CI 0.13 to 0.40, $p < 0.01$, $Q = 18.9$, $p > 0.10$	
Disorganised symptoms	
<i>A medium positive association suggests that as disorganised symptoms increase in patients with schizophrenia, they may demonstrate more perseveration errors on the WCST-PE;</i> 6 studies, N = 273, $r = 0.25$, 95%CI 0.24 to 0.26, $p < 0.01$, $Q = 6.0$, $p > 0.10$	
Positive symptoms	
<i>No association was reported between positive symptoms and executive functioning on the WCST-PE;</i> 9 studies, N = 487, $r = 0.06$, 95%CI -0.15 to 0.27, $p > 0.05$, $Q = 13.3$, $p > 0.10$	
Reality distortion	
<i>No significant association reported between reality distortion symptoms and executive functioning assessed through performance on the WCST;</i> 4 studies, N = 194, $r = 0.04$, 95%CI -0.22 to 0.30, $p > 0.05$, $Q = 7.4$, $p > 0.10$	



Executive functioning

Consistency	Consistent
Precision	Precise
Directness	Direct

Palmer BW, Savla GN

The association of specific neuropsychological deficits with capacity to consent to research or treatment

Journal of the International Neuropsychological Society 2007; 13: 1047-1059

[View review abstract online](#)

Comparison	Association between executive functioning and capacity to consent to treatment and research in people with schizophrenia spectrum disorders, in terms of their <i>understanding</i> of the information; <i>appreciation</i> of the context; and <i>reasoning</i> of the consequences of their decision.
Summary of evidence	Moderate to low quality evidence (mixed sample size, direct, unable to assess precision or consistency) suggests that impaired understanding, appreciation and reasoning were associated with poorer executive function (small to medium effect) in people with schizophrenia.
Executive functioning	
Three studies (N = 1,625) examined the association between an individual's capacity to consent, and their executive functioning. 3 of 3 studies reported a significant association between impaired executive functioning and poorer understanding, and 2 of 3 studies reported a significant association between impaired executive functioning and poorer appreciation and reasoning; Understanding: 3 studies reporting on executive composite scores, N = 1,625, $r = 0.15$ to 0.41, $p < 0.05$; 1 study (N = 108) also reporting on DRS conceptualisation ($r = 0.30$) and initiation ($r = 0.35$), $p < 0.05$. Appreciation: 2 studies reporting on executive composite scores, N = 1,517, $r = 0.16$ to 0.35, $p < 0.05$. Reasoning: 2 studies reporting on executive composite scores, N = 1,555, $r = 0.19$ to 0.39, $p < 0.05$, and 1 study (N = 108) reporting on DRS conceptualisation ($r = 0.45$), $p < 0.01$.	
Consistency	Unable to assess; no measure of consistency is reported.

Executive functioning

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Precision	Unable to assess; no measure of precision is reported.
Directness	Direct

Pickup GJ

Relationship between Theory of Mind and executive functioning in schizophrenia: A systematic review

Psychopathology 2008; 41: 206-213

[View review abstract online](#)

Comparison	The association between Theory of Mind and executive functioning in people with schizophrenia vs. controls (healthy and various control groups).
Summary of evidence	Moderate to low quality evidence (small samples, unable to assess consistency or precision, direct) suggests impaired performance on various executive functioning tasks in people with schizophrenia compared with controls. Poorer performance may be associated with increased negative thought disorder, but not overall symptoms. The evidence also suggests that executive functioning tasks may be correlated with Theory of Mind tasks.

Executive functioning tasks

Authors reported poorer performance in people with schizophrenia compared with controls on;
Tower of London (3 studies, N = 153), the WCST (2 studies, N = 108), capture picture-sequencing (5 studies, N = 264), BADS zoo map test (2 studies, N = 108), BADS key search (1 study, N = 41), verbal fluency (1 study, N = 127), classical Weigl set shifting (1 study, N = 60), SCWT and concept shifting test (1 study, N = 127), trails B (1 study, N = 93).

Authors reported no difference between people with schizophrenia and controls on verbal fluency (3 studies, N = 238), capture picture-sequencing performance (1 study, N = 40) and trails B (1 study, N = 50).

Executive functioning association with Theory of Mind

Authors reported that six studies (N = 227) suggest overall ToM performance was associated with executive functioning tasks, including capture (N = 56), Weigl (N = 60), key search and zoo map (N = 41) and trails B (N = 50). 4 studies reported no association with ToL (N = 56), WCST (N = 41),

Executive functioning

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capture (N = 63) or SCWT (N = 50). 3 studies (N = 148) suggest FB scores were associated with executive functioning tasks, including capture (2 studies, N = 90), ToL (1 study, N = 45) and WCST (1 study, N = 58). 1 study (N = 128) reported that hinting scores correlated negatively with Trails B and positively with the WCST task.	
Executive functioning association with symptoms	
Increased negative thought disorder (1 study, N = 45) was associated with poorer performance on executive functioning tasks. No association between executive functioning and symptom severity (2 studies, N = 93).	
Consistency	Unable to assess; no measure of consistency is reported.
Precision	Unable to assess; no measure of precision is reported.
Directness	Direct

<i>Quraishi S, Frangou S</i> Neuropsychology of bipolar disorder: a review Journal of Affective Disorders 2002; 72: 209-225 View review abstract online	
Comparison	Cognitive performance in people with schizophrenia vs. bipolar disorder.
Summary of evidence	Moderate to low quality evidence (small to medium-sized samples, unable to assess consistency or precision, direct) suggests poorer executive functioning in people with schizophrenia.
Executive functioning	
5 studies reported lower executive functioning performance in people with schizophrenia compared with people with bipolar disorder (some samples also include unipolar depression), however 3 studies (N = 344) reported no differences between groups. 1 study (N = 81) reported impaired executive functioning in people with psychotic bipolar but not people with schizophrenia.	
Consistency	Unable to assess; no measure of consistency is reported.

Executive functioning

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Precision	Unable to assess; no measure of precision is reported.
Directness	Direct

Rabin RA, Zakzanis KK, George TP

The effects of cannabis use on neurocognition in schizophrenia: a meta-analysis

Schizophrenia Research 2011; 128: 111-116

[View review abstract online](#)

Comparison	Relationship between current cannabis use and cognitive ability in people with schizophrenia.
Summary of evidence	Moderate to low quality evidence (unclear sample sizes, unable to assess consistency or precision, direct) suggests no differences between groups.
Executive functioning	
<i>No differences in executive functioning between patients with and without current cannabis use; 7 studies, $d = 0.14$ SD = 0.49</i>	
Consistency in results	Unable to assess; no measure of consistency is reported.
Precision in results	Unable to assess; no measure of precision is reported.
Directness of results	Direct

Rajji TK, Mulsant BH

Nature and course of cognitive function in late-life schizophrenia: a systematic review

Schizophrenia Research 2008; 102: 122-140

[View review abstract online](#)



Executive functioning

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Comparison	Executive functioning in people with schizophrenia aged over 50 years (late-life schizophrenia, LLS).
Summary of evidence	Moderate to low quality evidence (mostly large samples, direct, unable to assess consistency or precision) suggests people with late-life schizophrenia are impaired on global cognition and executive functioning.
Global cognitive score	
Seventeen studies reported the total score of a cognitive screening test (Mini-Mental Status Examination; Dementia Rating Scale) or a comprehensive battery (Repeatable Battery for the Assessment of Neuropsychological Status). People with LLS were consistently found to be impaired relative to age-matched controls. 10 studies (N = 1,417) found lower MMSE scores in LLS; 7 studies (N = 1,068) found lower DRS scores in LLS; 1 study (N = 157) found lower RBANS scores in LLS.	
Executive function	
Executive function was consistently found to be impaired in nine studies in LLS. Six studies (N = 766) reported LLS were impaired in composite measures of executive function; three further studies (N = 399) reported LLS impairments in individual tests of executive function, such as Wisconsin Card Sorting Test, letter fluency, Tower of London. This dysfunction was maintained regardless of early or late illness onset in nine LLS studies (N = 895). One study (N = 75) additionally reported poorer executive performance in hospitalised patients compared with ambulatory patients, after controlling for illness severity and medication.	
Consistency	Unable to assess; no measure of consistency is reported.
Precision	Unable to assess; no measure of precision is reported.
Directness	Direct

Rajji TK, Ismail Z, Mulsant BH

Age at onset and cognition in schizophrenia: meta-analysis

The British Journal of Psychiatry 2009; 195: 286-293

[View review abstract online](#)

Executive functioning

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Comparison	Executive functioning in people with schizophrenia with different age of onset (first-episode schizophrenia, youth-onset schizophrenia and late-onset schizophrenia) vs. controls. Note: maximum age for youth-onset was 19 years; minimum age for late-onset was 40 years; people with any other age at onset were classified as first-episode schizophrenia.
Summary of evidence	Moderate to low quality evidence (unclear sample size, direct, unable to assess consistency or precision) suggests poorer performance in executive functioning in people with first-episode, youth-onset and late-onset schizophrenia compared with controls.
Executive functioning	
<i>A medium to large effect of impaired executive functioning in all groups compared with controls;</i> N = 5010 (4057 first-episode schizophrenia, 692 youth-onset, 261 late-onset) <i>Tower of London test</i> First-episode schizophrenia: 13 studies, $d = 0.78$, SE 0.05 Youth-onset schizophrenia: 10 studies, $d = 0.57$, SE 0.08 Late-onset schizophrenia: 3 studies, $d = 0.97$, SE 0.15 <i>Stroop test</i> First-episode schizophrenia: 21 studies, N = 4057, $d = 0.86$, SE 0.04 Youth-onset schizophrenia: 4 studies, N = 692, $d = 1.14$, SE 0.13 Late-onset schizophrenia: 1 studies, N = 261, $d = 1.76$, SE 0.27 <i>WCST</i> First-episode schizophrenia: 45 studies, N = 4057, $d = 0.76$, SE 0.03 Youth-onset schizophrenia: 13 studies, N = 692, $d = 2.00$, SE 0.08 Late-onset schizophrenia: 5 studies, N = 261, $d = 1.13$, SE 0.12 <i>TMT-B</i> First-episode schizophrenia: 17 studies, N = 4057, $d = 0.77$, SE 0.05 Youth-onset schizophrenia: 6 studies, N = 692, $d = 1.12$, SE 0.10	
Consistency	Unable to assess; no measure of consistency is reported.
Precision	Unable to assess; no measure of precision is reported.
Directness	Direct

Executive functioning

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Schug R, Raine A

Comparative meta-analyses of neuropsychological functioning in antisocial schizophrenic persons

Clinical Psychological Review 2009; 29: 230-242

[View review abstract online](#)

Comparison	Executive functioning in people with schizophrenia and antisocial traits vs. people with schizophrenia without antisocial traits. Note: Authors state that antisocial behaviour was broadly defined as assaultive, criminal, psychopathic, or violent behaviours and included individuals who had committed specific crimes (i.e., homicide, assault) or who had specific mental disorder diagnoses (i.e., antisocial personality disorder, psychopathy).
Summary of evidence	Moderate to high quality evidence (unclear sample sizes, direct, consistent, precise) suggests a medium-sized effect of more perseverative errors on the WCST in people with schizophrenia and antisocial traits, with no differences on other tasks reflecting broad or narrowly defined executive functioning.
Executive functioning	
<i>No difference on broadly or narrowly defined executive functioning;</i> Broad: 13 studies, $g = -0.078$, $p > 0.05$, 95%CI -0.251 to 0.096, $Q = 21.228$, $p < 0.05$ Narrow: 8 studies, $g = -0.079$, $p > 0.05$, 95%CI -0.305 to 0.147, $Q = 12.807$, $p > 0.05$ <i>Significant, medium effect size of more perseverative errors on WCST in people with schizophrenia and antisocial traits compared with people with schizophrenia without antisocial traits;</i> WCST perseverative errors: 5 studies, $g = -0.517$, 95%CI -0.794 to -0.240, $p < 0.001$, $Q = 1.504$, $p > 0.05$	
Consistency	Consistent for all measures except broadly defined executive functioning.
Precision	Precise
Directness	Direct



Executive functioning

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Comparison	Executive functioning in people with schizophrenia and antisocial traits vs. people without schizophrenia with antisocial traits.
Summary of evidence	Moderate to high quality evidence (unclear sample size, direct, consistent, precise) suggests a small effect of poorer performance on broadly defined, but not narrowly defined, executive functioning tasks in people with schizophrenia and antisocial traits. Moderate quality evidence (inconsistent) suggests a medium effect size for more perseverative errors on the WCST in people with schizophrenia and antisocial traits.
Executive function	
<i>Significant small effect size of poorer performance on broadly defined, but not narrowly defined executive functioning tasks in people with schizophrenia and antisocial traits;</i> <i>Broad: 9 studies, $g = -0.284$, 95%CI -0.525 to -0.043, $p < 0.05$, $Q = 4.990$, $p > 0.05$</i> <i>Narrow: 7 studies, $g = -0.246$, 95%CI -0.556 to 0.063, $p > 0.05$, $Q = 7.547$, $p > 0.05$</i> <i>Significant, medium effect size of poorer performance on WCST (perseverative errors) in people with schizophrenia and antisocial traits;</i> <i>WCST perseverative errors: 3 studies, $g = -0.637$, 95%CI -1.039 to -0.235, $p < 0.01$, $Q = 9.741$, $p < 0.01$</i>	
Consistency	Consistent for all measures except WCST.
Precision	Precise
Directness	Direct

Sedgwick O, Young S, Baumeister D, Greer B, Das M, Kumari V

Neuropsychology and emotion processing in violent individuals with antisocial personality disorder or schizophrenia: The same or different? A systematic review and meta-analysis

Australian and New Zealand Journal of Psychiatry 2017; 51: 1178-97

[View review abstract online](#)

Comparison	Executive functioning in people with schizophrenia or antisocial
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Executive functioning

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	personality disorder and violent behaviours vs. controls.
Summary of evidence	Moderate to high quality evidence (unclear sample size, some inconsistency, precise, direct) shows a large effect of poorer executive functioning in people with schizophrenia and a small to medium effect in people with antisocial personality disorder.
Executive functioning	
<i>A large effect of poorer executive functioning in people with schizophrenia than controls;</i> 8 studies, $g = -0.82$, 95%CI -1.10 to -0.54, $p < 0.001$, $I^2 = 58\%$, $p < 0.019$ <i>A small-to-medium effect of poorer executive functioning in people with antisocial personality disorder than controls;</i> 9 studies, $g = -0.38$, 95%CI -0.55 to -0.20, $p = 0.006$, $I^2 = 0\%$, $p = 0.531$	
Consistency in results	Inconsistent for schizophrenia, consistent for antisocial personality disorders.
Precision in results	Precise
Directness of results	Direct

Sitskoorn M, Aleman A, Ebishe S, Appels M, Kahn R

Cognitive deficits in relatives of patients with schizophrenia: a meta-analysis

Schizophrenia Research 2004; 17: 285-295

[View review abstract online](#)

Comparison	Cognitive functioning in first-degree relatives of people with schizophrenia vs. controls.
Summary of evidence	High quality evidence (large samples, direct, consistent, precise) shows a small to medium effect of poorer executive functioning as measured by TMT-B, attention as measured by Stroop and TMT-A, and visual and verbal memory in first-degree relatives. Moderate to high quality evidence (inconsistent) also suggests poorer performance on executive functioning as measured by WCST, attention as measured by CPT, and verbal fluency.



Executive functioning

Executive functioning	
<i>Small to medium effect sizes suggest first-degree relatives performed significantly worse than controls on;</i> TMT-B: 12 studies, N = 1,424, $d = 0.51$, 95%CI 0.36 to 0.67, $p < 0.0001$, $Q = 12.9$, $p > 0.05$ WCST: 19 studies, N = 860, $d = 0.29$ 95%CI 0.14 to 0.43 $p = 0.0001$, $Q = 33.2$, $p < 0.05$	
Attention	
<i>Small effect sizes suggest first degree relatives performed significantly worse than controls on;</i> CPT: 11 studies, N = 951, $d = 0.33$, 95%CI 0.09 to 0.57, $p = 0.006$, $Q = 27.6$, $p < 0.01$ Stroop: 8 studies, N = 1,689, $d = 0.28$, 95%CI 0.06 to 0.50, $p = 0.01$, $Q = 11.8$, $p > 0.05$ TMT-A: 10 studies, N = 843, $d = 0.38$, 95%CI 0.23 to 0.53, $p < 0.0001$, $Q = 9.3$, $p > 0.05$	
Language function	
<i>A small effect size suggests first degree relatives performed significantly worse than controls on;</i> Verbal fluency: 13 studies, N = 887, $d = 0.35$, 95%CI 0.14 to 0.56, $p = 0.001$, $Q = 30.6$, $p < 0.01$	
Memory	
<i>Small to medium effect sizes suggest first-degree relatives performed significantly worse than controls on;</i> CVLT/WMS verbal memory: 15 studies, N = 997, $d = 0.54$, 95%CI 0.43 to 0.66, $p < 0.0001$, $Q = 12.3$, $p > 0.05$ WMS visual reproduction: 8 studies, N = 1,148, $d = 0.30$, 95%CI 0.10 to 0.50, $p = 0.003$, $Q = 11.2$, $p > 0.05$ Digit Span: 10 studies, N = 630, $d = 0.35$, 95%CI 0.19 to 0.50, $p < 0.0001$, $Q = 4.4$, $p > 0.05$	
Consistency	Consistent apart from language, CPT and WCST.
Precision	Precise
Directness	Direct

Stefanopoulou E, Manoharan A, Landau S, Geddes J, Goodwin G, Frangou S

Cognitive functioning in patients with affective disorders and



Executive functioning

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schizophrenia: A meta-analysis

International Review of Psychiatry 2009; 21(4): 336-356

[View review abstract online](#)

Comparison	Executive functioning in people with schizophrenia vs. bipolar disorder.
Summary of evidence	Moderate to high quality evidence (unclear sample sizes, direct, consistent, precise) shows a small effect of lower performance on TMT-A, TMT-B, and WCST categories, but not on WCST perseverative errors or the STROOP test in patients with schizophrenia compared with patients with bipolar disorder.
Executive functioning	
<i>A significant, small effect suggests people with schizophrenia were more impaired on the following executive functioning tests than people with bipolar disorder;</i> WCST Categories achieved: SMD = 0.37, 95%CI 0.22 to 0.51, $p < 0.0001$, I^2 = not reported, $p = 0.30$ TMT-A: (number of studies not reported) SMD = -0.23, 95%CI -0.44 to 0.03, $p = 0.02$, I^2 = not reported, $p = 0.06$ TMT-B: SMD = -0.42, 95%CI -0.63 to 0.21, $p < 0.0001$, I^2 = not reported, $p = 0.08$ No differences were reported for the following tests; WCST perseverative errors: SMD = -0.14, 95%CI -0.33 to 0.03, $p = 0.10$, I^2 = not reported, $p = 0.14$ Stroop Colour Word Test: SMD = 0.18, 95%CI -0.16 to 0.58, $p = 0.34$, I^2 = not reported, $p = 0.21$	
Consistency	Consistent
Precision	Precise
Directness	Direct

Szöke A, Tranfafir A, Dunpont ME, Méary A, Schürhoff F

Longitudinal studies of cognition in schizophrenia: meta-analysis

The British Journal of Psychiatry 2008; 192: 248-257

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Executive functioning

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Comparison	Executive functioning in people with schizophrenia tested on two separate occasions more than 1 month apart, with no training in between.
Summary of evidence	Moderate to high quality evidence (mostly large samples, precise, direct, unable to assess consistency) suggested that people with schizophrenia may show improved performance in verbal fluency (letters), TMT-B (time), Stroop, and WCST (total errors, number and percentage of perseverative errors, number of categories completed), but the degree of improvement was smaller than that of controls for the WCST (number of categories).
Executive functioning	
<i>Significant, small effect size suggests that people with schizophrenia showed improvement in the following executive functioning tasks at retest compared with baseline;</i> Verbal fluency (letters): 25 studies, $N = 1,186$, $g = 0.20$, 95%CI 0.12 to 0.28, $p < 0.05$ Stroop task (coloured words): 8 studies, $N = 358$, $g = 0.28$, 95%CI 0.02 to 0.53, $p < 0.05$ TMT- B (time): 27 studies, $N = 1,191$, $g = 0.23$, 95%CI 0.14 to 0.31, $p < 0.05$ WCST (total errors): 5 studies, $N = 287$, $g = 0.17$, 95%CI 0.01 to 0.34, $p < 0.05$ WCST (% perseverative errors): 8 studies, $N = 297$, $g = 0.21$, 95%CI 0.04 to 0.37, $p < 0.05$ WCST (# perseverative errors): 14 studies, $N = 637$, $g = 0.16$, 95%CI 0.05 to 0.28, $p < 0.05$ WCST (categories): 22 studies, $N = 1,013$, $g = 0.12$, 95%CI 0.03 to 0.21, $p < 0.05$ <i>No significant difference between test and retest in patients with schizophrenia on;</i> Verbal fluency (categories): 7 studies, $N = 601$, $g = 0.02$, 95%CI -0.10 to 0.14, $p > 0.05$ TMT-B (errors): 3 studies, $N = 71$, $g = 0.28$, 95%CI -0.06 to 0.61, $p > 0.05$ WCST (perseverative responses): 5 studies, $N = 144$, $g = 0.13$, 95%CI -0.11 to 0.36, $p > 0.05$ <i>Compared with controls, improvement was significantly greater for controls in;</i> WCST (categories): 3 studies, $N = 89$, $g = 0.24$, 95%CI -0.06 to 0.54, $p < 0.05$ <i>But not for:</i> TMT-B (time): 5 studies, $N = 126$, $g = 0.15$, 95%CI -0.12 to 0.42, $p > 0.05$ WCST (perseverative errors): 4 studies, $N = 61$, $g = 0.43$, 95%CI 0.05 to 0.82, $p > 0.05$	
Consistency	Unable to assess; no measure of consistency is reported.
Precision	Precise
Directness	Direct



Executive functioning

Thai ML, Andreassen AK, Bliksted V

A meta-analysis of executive dysfunction in patients with schizophrenia: Different degree of impairment in the ecological subdomains of the Behavioural Assessment of the Dysexecutive Syndrome

Psychiatry Research 2019; 272: 230-6

[View review abstract online](#)

Comparison	Executive functioning in people with schizophrenia vs controls.
Summary of evidence	Moderate to high quality evidence (large sample, inconsistent, precise, direct) shows people with schizophrenia have poorer performance on The Behavioural Assessment of the Dysexecutive Syndrome test.
Executive functioning The Behavioural Assessment of the Dysexecutive Syndrome	
<i>Large effect of lower total scores in people with schizophrenia;</i> 10 studies, N = 916, SMD = -1.70, 95%CI -2.17 to -1.24, $p < 0.001$, $I^2 = 86\%$ The results were similar on all subtests (rule shift cards, action program, key search, temporal judgement, zoo map, and modified six elements test).	
Consistency	Inconsistent
Precision	Precise
Directness	Direct

Wang K, Song LL, Cheung EFC, Lui SSY, Shum DHK, Chan RCK

Bipolar disorder and schizophrenia share a similar deficit in semantic inhibition: A meta-analysis based on hayling sentence completion test performance

Progress in Neuro-Psychopharmacology and Biological Psychiatry 2013; 46: 153-60

[View review abstract online](#)



Executive functioning

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Comparison	Semantic inhibition in people with bipolar disorder vs. controls compared to people with schizophrenia vs. controls
Summary of evidence	Moderate quality evidence (medium-sized samples, mostly consistent and precise, direct) suggests similar, medium to large effects of poor semantic inhibition in people with bipolar disorder and schizophrenia when compared to controls.
Semantic inhibition	
<i>Significant, medium to large effects of poor semantic inhibition in both bipolar disorder and schizophrenia compared to controls on the following tasks;</i> <u>Total Latency of Task A</u> Bipolar disorder: 6 studies, $N = 341$, $d = 0.719$, 95%CI 0.231 to 1.207, $p < 0.05$, $Qp < 0.01$ Schizophrenia: 7 studies, $N = 405$, $d = 0.749$, 95%CI 0.367 to 1.132, $p < 0.05$, $Qp < 0.01$ <u>Total Latency of Task B</u> Bipolar disorder: 5 studies, $N = 253$, $d = 0.930$, 95%CI 0.403 to 1.457, $p < 0.05$, $Qp < 0.05$ Schizophrenia: 4 studies, $N = 245$, $d = 0.840$, 95%CI 0.566 to 1.113, $p < 0.05$, $Qp > 0.05$ <u>Total Error of Task B</u> Bipolar disorder: 5 studies, $N = 253$, $d = 0.866$, 95%CI 0.402 to 1.330, $p < 0.05$, $Qp < 0.05$ Schizophrenia: 8 studies, $N = 447$, $d = 0.944$, 95%CI 0.698 to 1.190, $p < 0.05$, $Qp > 0.05$ <u>Type A Error of Task B</u> Bipolar disorder: 2 studies, $N = 146$, $d = 0.678$, 95%CI 0.336 to 1.021, $p < 0.05$, $Qp < 0.05$ Schizophrenia: 6 studies, $N = 395$, $d = 0.639$, 95%CI 0.431 to 0.847, $p < 0.05$, $Qp > 0.05$ <i>Significant, small effect of poor task performance in schizophrenia vs. controls only;</i> <u>Type B Error of Task B</u> Bipolar disorder: 2 studies, $N = 146$, $d = 0.869$, 95%CI -0.472 to 2.211, $p > 0.05$, $Qp < 0.05$ Schizophrenia: 6 studies, $N = 395$, $d = 0.170$, 95%CI 0.578 to 0.247, 0.912, $p < 0.05$, $Qp < 0.05$ <i>No significant differences between bipolar disorder or schizophrenia vs. controls;</i> <u>Suppression Time</u> Bipolar disorder: 4 studies, $N = 218$, $d = 0.156$, 95%CI 0.240 to -0.313, $p > 0.05$, $Qp < 0.05$ Schizophrenia: 5 studies, $N = 285$, $d = 0.325$, 95%CI -0.065 to 0.549, $p > 0.05$, $Qp < 0.05$	
Consistency in results	Inconsistent, apart from Total Latency of Task B, Total Error of Task B, and Type A Error of Task B in schizophrenia.
Precision in results	Precise, apart from Type B Error of Task B in bipolar disorder.



Executive functioning

Directness of results	Direct
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Wang YY, Wang S, Zheng W, Zhong B-L, Ng CH, Ungvari GS, Wang CX, Xiang YT, Li XH

Cognitive functions in smoking and non-smoking patients with schizophrenia: A systematic review and meta-analysis of comparative studies

Psychiatry Research 2019; 272: 155-63

[View review abstract online](#)

Comparison	Executive functioning in people with schizophrenia who smoke vs. people with schizophrenia who don't smoke.
Summary of evidence	Moderate to high quality evidence (large sample, inconsistent, precise, direct) suggests no differences in executive functioning.
Executive functioning WCST – categories completed	
No significant difference between groups; 3 studies, N = 201, SMD = -0.05, 95%CI -0.41 to 0.31, $p = 0.79$, $I^2 = 26\%$	
Consistency	Consistent
Precision	Precise
Directness	Direct

Woodward ND, Purdon SE, Meltzer HY, Zald DH

A meta-analysis of neuropsychological change to clozapine, olanzapine, quetiapine, and risperidone in schizophrenia

International Journal of Neuropsychopharmacology 2005; 8: 457-472

[View review abstract online](#)



Executive functioning

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Comparison	Executive functioning in people with schizophrenia receiving second-generation antipsychotics (clozapine, olanzapine, risperidone and quetiapine) vs. first-generation antipsychotics (various) or pre- to post-treatment comparison with second generation antipsychotics.
Summary of evidence	Moderate to high quality evidence (small to medium-sized samples, consistent, precise, direct) shows greater improvements in verbal fluency in patients receiving second-generation antipsychotics compared with first-generation antipsychotics, with no differences in cognitive flexibility and abstraction. Moderate quality evidence (unable to assess precision) suggests patients receiving quetiapine, olanzapine, or clozapine may show improvements on verbal fluency post-treatment, however patients receiving risperidone may show no improvement on verbal fluency. No improvements are reported for cognitive flexibility and abstraction.
Cognitive flexibility and abstraction	
<i>No difference was reported between patients receiving second-generation antipsychotics compared with patients receiving first-generation antipsychotics;</i> 14 studies, N= 405, $g = 0.04$, 95%CI -0.10 to 0.18, $p = 0.581$, $Q p > 0.05$ <i>Post-treatment, patients receiving the following second-generation antipsychotics showed no improved performance;</i> Clozapine: 12 studies, N = 227, $g = 0.25$, (CI not reported), $p > 0.05$, $Q p > 0.05$ Olanzapine: 10 studies, N = 471, $g = 0.15$, (CI not reported), $p > 0.05$, $Q p > 0.05$ Risperidone: 4 studies, N = 189, $g = 0.10$, (CI not reported), $p > 0.05$, $Q p > 0.05$ Quetiapine: 3 studies, N = 50, $g = 0.33$, (CI not reported), $p > 0.05$, $Q p > 0.05$	
Verbal fluency	
<i>Greater improvements in verbal fluency were reported for patients receiving second-generation antipsychotics compared with patients receiving first-generation antipsychotics;</i> 15 studies, N= 449, $g = 0.16$, 95%CI 0.02 to 0.30, $p = 0.024$, $Q p > 0.05$ <i>Post-treatment, patients receiving olanzapine, clozapine or quetiapine showed improved performance;</i> Quetiapine: 6 studies, N = 107, $g = 0.63$, (CI not reported), $p < 0.006$, $Q p > 0.05$ Clozapine: 15 studies, N = 319, $g = 0.44$, (CI not reported), $p < 0.006$, $Q p > 0.05$	



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Olanzapine: 11 studies, N = 651, $g = 0.25$, (CI not reported), $p < 0.006$, $Q p > 0.05$ <i>Patients receiving risperidone showed no significant improvement post-treatment;</i> Risperidone: 5 studies, N = 207, $g = 0.06$, (CI not reported), $p > 0.05$, $Q p > 0.05$	
Consistency	Consistent
Precision	Precise for first vs. second generation antipsychotics, unable to assess pre-post comparison
Directness	Direct

Woodward ND, Purdon SE, Meltzer HY, Zald DH

A meta-analysis of cognitive changes with haloperidol in clinical trials of atypical antipsychotics: Dose effects and comparison to practice effects

Schizophrenia Research 2007; 89: 211-224

[View review abstract online](#)

Comparison	Executive functioning in people with schizophrenia receiving haloperidol to assess pre-post treatment effects.
Summary of evidence	Moderate to high quality evidence (medium-sized samples, consistent, precise, direct) suggests no improvement on the WCST or verbal fluency tasks post-treatment with haloperidol.
Executive functioning	
<i>No improvement in WCST performance post-treatment;</i> All studies: 10 studies, N = 491, $g = 0.02$, 95%CI -0.10 to 0.14, $p > 0.05$ Low dose: 6 studies, N = 359, $g = -0.01$, 95%CI -0.16 to 0.13, $p > 0.05$ High dose: 4 studies, N = 132, $g = 0.12$, 95%CI -0.11 to 0.33, $p > 0.05$	
Verbal fluency	
<i>No improvements on COWA or CIGT post-treatment;</i> No difference in performance in people with schizophrenia receiving haloperidol ($p > 0.05$) COWA All studies: 12 studies, N = 553, $g = 0.05$, 95%CI -0.07 to 0.17, $p < 0.05$ Low dose: 6 studies, N = 372, $g = 0.04$, 95%CI -0.10 to 0.18, $p < 0.05$	



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High dose: 5 studies, $N = 154$, $g = 0.00$, 95%CI -0.21 to 0.21, $p < 0.05$ CIGT All studies: 5 studies, $N = 349$, $g = -0.09$, 95%CI -0.24 to 0.06, $p < 0.05$ Low dose: 4 studies, $N = 330$, $g = -0.06$, 95%CI -0.21 to 0.09, $p < 0.05$ High dose: 1 study, $N = 19$, $g = -0.68$, 95%CI -1.33 to 0.05, $p < 0.05$	
Consistency	Authors report all results are consistent (using fixed effects model)
Precision	Imprecise for CIGT high dose only
Directness	Direct

Wright L, Lipszyc J, Dupuis A, Thayapararajah SW, Schachar R

Response Inhibition and Psychopathology: A Meta-Analysis of Go/No-Go Task Performance

Journal of Abnormal Psychology 2014; 123(2): 429-439

[View review abstract online](#)

Comparison	Response inhibition in people with schizophrenia vs. controls.
Summary of evidence	Moderate to high quality evidence (unclear sample size, direct, consistent, precise) suggests a medium effect of increased commission and omission errors in people with schizophrenia compared with controls. Moderate quality evidence (inconsistent) also suggests increased response time.
Response inhibition	
Medium size effects of increased commission errors (responses that are not successfully withheld), omission errors (failure to respond), and response time in people with schizophrenia; Commission errors: 26 studies, $g = 0.33$, 95%CI 0.20 to 0.47, $p < 0.001$, $Q = 34.72$, $p = 0.09$ Omission errors: 11 studies, $g = 0.54$, 95%CI 0.36 to 0.73, $p < 0.001$, $Q = 14.74$, $p = 0.14$ Mean response time: 29 studies, $g = 0.76$, 95%CI 0.60 to 0.92, $p < 0.001$, $Q = 56.95$, $p = 0.001$ No differences in the ability to differentiate a target from a non-target; 3 studies, $g = 0.04$, 95%CI -0.42 to 0.50, $p = 0.86$, $Q = 5.18$, $p = 0.08$	
Consistency	Inconsistent for response time only.
Precision	Imprecise for target differentiation only.

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Directness	Direct
Yücel M, Bora E, Lubman DI, Solowij N, Brewer WJ, Cotton SM, Conus P, Takagi MJ, Fornito A, Wood SJ, McGorry PD, Pantelis C The impact of cannabis use on cognitive functioning in patients with schizophrenia: a meta-analysis of existing findings and new data in first-episode sample Schizophrenia Bulletin 2012; 38(2): 316-330 View review abstract online	
Comparison	Cognition in people with schizophrenia with comorbid cannabis use vs. people with schizophrenia without cannabis use.
Summary of evidence	Moderate to high quality evidence (small sample, direct, consistent, precise) suggests a medium effect of better planning ability in people with schizophrenia with a history of cannabis use compared with people with schizophrenia without a history of cannabis use.
Planning <i>People with schizophrenia with a history of cannabis use showed better planning ability than people with schizophrenia without any comorbid substance use;</i> 3 studies, N = 132, $d = 0.67$, 95%CI 0.31 to 1.03, $p = 0.001$, $Q = 1.20$, $p > 0.05$	
Consistency	Consistent
Precision	Precise
Directness	Direct

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Explanation of acronyms

AVLT = Auditory Verbal Learning Test, B = estimated regression coefficient, BADS = Behavioural Assessment of Dysexecutive Syndrome, BPRS = Brief Psychiatric Rating Scale, CANTAB SWM = Cambridge Neuropsychological Test Automated Battery, Spatial Working Memory, CI = Confidence Interval, CPT = Continuous Performance Test, CVLT = California Verbal Learning Test, d = Cohen's d and g = Hedges' g = standardised mean differences (see below for interpretation of effect size), DRS = Mattis Dementia Rating Scale, ES = effect size, FB = false belief, HCT = Halstead Category Test, HVLT = Hopkins Verbal Learning Test, I^2 = the percentage of the variability in effect estimates that is due to heterogeneity rather than sampling error (chance), IQ = Intelligence Quotient, LLS = Late-Life Schizophrenia, MMSE = Mini-Mental Status Examination, N = number of participants, NS = non-significant, p = statistical probability of obtaining that result ($p < 0.05$ generally regarded as significant), Q = Q statistic (chi-square) for the test of heterogeneity, Q_w = test for within group differences (heterogeneity in study results within a group of studies – measure of study consistency), Q_B = test for between group differences (heterogeneity between groups of studies for an outcome of interest), r = correlation coefficient, RBANS = Repeatable Battery for the Assessment of Neuropsychological Status, SAI = Schedule for the Assessment of Insight, SANS = Scale for Assessment of Negative Symptoms, SAPS = Scale for Assessment of Positive Symptoms, SCWT = Stroop Colour-Word Test, SE = Standard error, SMD = standard mean difference, SUMD = Scale to Assess Unawareness of Mental Disorders, t = independent-samples t-test, TMT = Trail Making Test, ToM = Theory of Mind, vs = versus, WCST = Wisconsin Card Sorting Task, WISC = Wechsler Intelligence Scale for Children, μ_p = estimated average correlation in the population

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Explanation of technical terms

* Bias has the potential to affect reviews of both RCT and observational studies. Forms of bias include; reporting bias – selective reporting of results; publication bias - trials that are not formally published tend to show less effect than published trials, further if there are statistically significant differences between groups in a trial, these trial results tend to get published before those of trials without significant differences; language bias – only including English language reports; funding bias - source of funding for the primary research with selective reporting of results within primary studies; outcome variable selection bias; database bias - including reports from some databases and not others; citation bias - preferential citation of authors. Trials can also be subject to bias when evaluators are not blind to treatment condition and selection bias of participants if trial samples are small⁵⁰.

† Different effect measures are reported by different reviews.

Prevalence refers to how many existing cases there are at a particular point in time. Incidence refers to how many new cases there are per population in a specified time period. Incidence is usually reported as the number of new cases per 100,000 people per year. Alternatively some studies present the number of new cases that have accumulated over several years against a person-years denominator. This denominator is the sum of individual units of time that the persons in the population are at risk of becoming a case. It takes into account the size of the underlying population sample and its age structure over the duration of observation.

Reliability and validity refers to how accurate the instrument is. Sensitivity is the proportion of actual positives that are correctly identified (100% sensitivity = correct identification of all actual positives) and specificity is the proportion of negatives that are correctly identified (100% specificity = not identifying anyone as positive if they are truly not).

Weighted mean difference scores refer to mean differences between treatment and comparison groups after treatment (or occasionally pre- to post-treatment) and in a randomised trial there is an assumption that both groups are comparable on this measure prior to treatment. Standardised mean differences are divided by the pooled standard deviation (or the standard deviation of one group when groups are homogenous) that allows results from different scales to be combined and compared. Each study's mean difference is then given a weighting depending on the size of the sample and the variability in the data. 0.2 represents a small effect, 0.5 a medium effect, and 0.8 and over represents a large effect⁵⁰.

Odds ratio (OR) or relative risk (RR) refers to the probability of a reduction (< 1) or an increase (> 1) in a particular outcome in a treatment group, or a group exposed to a risk factor, relative to the comparison group. For example, a RR of 0.75 translates to a reduction in risk of an outcome of 25% relative to those not receiving the treatment or not exposed to the risk factor. Conversely, a RR of 1.25 translates to an increased risk of 25% relative to those not receiving treatment or not having been exposed to a risk factor. A RR or OR of 1.00 means there is no difference between groups. A medium effect is considered if $RR > 2$ or < 0.5 and a large effect if $RR > 5$ or < 0.2 ⁵¹. InOR stands for logarithmic OR where a InOR of 0 shows no difference between groups. Hazard ratios

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measure the effect of an explanatory variable on the hazard or risk of an event.

Correlation coefficients (eg, r) indicate the strength of association or relationship between variables. They are an indication of prediction, but do not confirm causality due to possible and often unforeseen confounding variables. An r of 0.10 represents a weak association, 0.25 a medium association and 0.40 and over represents a strong association. Unstandardised (b) regression coefficients indicate the average change in the dependent variable associated with a 1 unit change in the independent variable, statistically controlling for the other independent variables. Standardised regression coefficients represent the change being in units of standard deviations to allow comparison across different scales.

‡ Inconsistency refers to differing estimates of effect across studies (i.e. heterogeneity or variability in results) that is not explained by subgroup analyses and therefore reduces confidence in the effect estimate. I^2 is the percentage of the variability in effect estimates that is due to heterogeneity rather than sampling error (chance) - 0% to 40%: heterogeneity might not be important, 30% to 60%: may represent moderate heterogeneity, 50% to 90%: may represent considerable heterogeneity and over this is considerable heterogeneity. I^2 can be calculated from Q (chi-square) for the test of heterogeneity with the following formula⁵⁰;

$$I^2 = \left(\frac{Q - df}{Q} \right) \times 100\%$$

§ Imprecision refers to wide confidence intervals indicating a lack of confidence in the effect estimate. Based on GRADE recommendations, a result for continuous data (standardised mean differences, not weighted mean differences) is considered imprecise if the upper or lower confidence limit crosses an effect size of 0.5 in either direction, and for binary and correlation data, an effect size of 0.25. GRADE also recommends downgrading the evidence when sample size is smaller than 300 (for binary data) and 400 (for continuous data), although for some topics, these criteria should be relaxed⁵².

|| Indirectness of comparison occurs when a comparison of intervention A versus B is not available but A was compared with C and B was compared with C that allows indirect comparisons of the magnitude of effect of A versus B. Indirectness of population, comparator and/or outcome can also occur when the available evidence regarding a particular population, intervention, comparator, or outcome is not available and is therefore inferred from available evidence. These inferred treatment effect sizes are of lower quality than those gained from head-to-head comparisons of A and B.



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