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Invited Review
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A Systematic Review and Meta-Analysis of Attention, Memory, Learning, and Fluency Deficits Associated with Gambling Behavior

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WHAT IS ALREADY KNOWN ON THIS TOPIC?

- *The findings of studies assessing the effect of gambling on the domains of attention, memory, learning, verbal fluency, and figural fluency remain fragmented. These findings are yet to be systematically integrated, leading to difficulties in generating inferential data for further clinical and research purposes.*

WHAT THIS STUDY ADDS ON THIS TOPIC?

- *The study concludes that gambling behavior was not associated with significant deficits in the domains of attention, memory, learning, reading, verbal fluency, or figural fluency.*
- *Since these cognitive abilities remain intact in individuals with gambling issues, they can be utilized to support treatment efforts aimed at addressing other behavioral challenges experienced by this population.*

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ABSTRACT

Objective: The study aimed to systematically review and analyze the association of gambling behavior with deficits in attention, memory, learning, verbal fluency, and figural fluency.

Methods: A comprehensive search was conducted across 4 databases (PubMed, Scopus, Embase, and Web of Science) using a set of keywords related to cognitive impairment and gambling behavior. The selection process began with de-duplication, followed by a preliminary screening of titles and abstracts, and a subsequent full-text review of relevant articles. The risk of bias in the included studies was assessed using the Joanna Briggs Critical Appraisal Checklists. Studies were categorized based on the cognitive domains evaluated. Qualitative data were used for the systematic review, comparing gambling groups with controls or independently. For the meta-analysis, quantitative data from neuropsychological tests were analyzed using fixed or random-effects models, depending on heterogeneity. All analyses were conducted using Open Meta-Analyst software.

Results: Of the 12 488 records initially screened, 303 articles were selected for a full-text review. Of these, 14 studies with an average quality score of 80.38% met the eligibility criteria, and 7 of them provided sufficient quantitative data for the meta-analysis. The findings indicated no substantial cognitive deficits in individuals with gambling behavior across the domains of attention, memory, learning, verbal fluency, and figural fluency.

Conclusion: The cognitive domains of attention, memory, learning, verbal fluency, and figural fluency remain intact in gamblers. While these domains may not require direct intervention, their stability can provide a foundational framework for implementing treatments that target other, potentially weaker cognitive and behavioral domains.

Keywords: Attention, fluency, learning, memory, meta-analysis, reviews

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INTRODUCTION

While much of the research on gambling disorder focuses on its clinical features and treatment, there has been increasing emphasis on understanding the cognitive deficits associated with gambling behaviors within the last few decades. These impairments have frequently been reported in individuals engaging in gambling, with evidence suggesting that they may play a role in both the initiation,[1] and the persistence of gambling behaviors.[2]

Systematic review and meta-analytic studies have been conducted to assess the effect of gambling on the domains of compulsivity,[3] motor impulsivity,[4] working memory,[5] decision-making,[6] and impulsivity.[7] Similarly, a narrative review reporting upon the effects of gambling on social cognition[8] and on several other cognitive domains have also been published.[9] This has set off research focusing on the systematic assessment of these domains. This growing body of literature has helped with the subsequent delivery of treatment interventions focussed at improving these deficits in the context of gambling behavior.[10] Also, researchers have studied the implications of these cognitive deficits in the disorder progression and treatment outcomes.[11]

However, despite this the findings remain fragmented across studies for other areas of cognition such as attention,[12] memory,[13] learning,[14] and fluency.[15,16] These findings are yet to be systematically integrated, leading to difficulties in generating inferential data for further clinical and research purposes. This has limited the potential to make evidence-based decisions or develop targeted interventions and assessments for gambling. For instance, if gambling is associated with deficits in a specific cognitive domain, research should target these domains as targets for future interventions. Conversely, if it can be conclusively established that a particular domain is not impacted, then the focus may be shifted to alternate targets. Essentially, primary research serves as the foundation that drives subsequent investigations. Therefore, it is crucial to identify the specific cognitive domains affected by gambling disorder, recognizing that deficits may not be uniform across all domains. This can effectively guide future research and intervention strategies.

To explore these under-researched areas, a systematic review and metaanalysis was planned to investigate the cognitive deficits associated with gambling behavior. This study is in line with the 6 key domains of neurocognitive function according to the Diagnositc and Statistical Manual of Mental Disorders- 5 (DSM-5) approach, including, attention, divided attention, selective attention, and processing speed, learning and memory, executive function, language, perceptual-motor functioning, and social cognition.[17] This review paper will focus exclusively on the domains of attention, memory, learning, reading, and fluency in order to provide a more in-depth and comprehensive summary of the extant literature. The findings on other domains shall be presented elsewhere.

MATERIAL AND METHODS

This systematic review and meta-analysis was conducted and reported in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses for Protocols 2015 (PRISMA-P 2015) guidelines and has been registered in PROSPERO International Prospective Register of Systematic Reviews (Registration Number: CRD42024585796). The PRISMA for Protocols (PRISMA-P) checklist for the review is also included in Figure 1.

Databases and Search Strategy

An electronic literature search was conducted across Medline (PubMed), Scopus, Embase, and Web of Science databases to identify relevant original articles as per the pre-specified search strategy. The searches were conducted in September 2024.

The following keywords were incorporated in the search strategy entered on all databases: "cognition," "cognitive function," "cognitive deficit," "cognitive dysfunction," "cognitive impairment," "cognitive defect," "neurocognition," "neurocognitive function," "neurocognitive deficit," "neurocognitive dysfunction," "neurocognitive impairment," "executive function," "working memory," "memory impairment," "attention impairment," "concentration impairment," "cognitive flexibility," "cognitive inflexibility," "response inhibition," "inhibitory control," "impulse control," "decision making," "compulsivity," "set-shifting," "reward sensitivity," "reward processing," "interference control," "general cognitive functioning," "motor planning," "action planning," "verbal fluency," "visuomotor dysfunction," "feedback processing," "intellectual functioning," "language abilities," "visuospatial abilities," "visuo-constructional abilities," "perseveration," "planning," "response sensitivity," "delay discounting," "social cognition," ("gambling," "pathological gambling," "problem gambling," "gambling disorder," "gambling addiction," "compulsive gambling," "gambling behavior").

The search strategy for each database incorporated all the keywords mentioned above, with modifications made to match the available field options in each database. The following string combination was consistently used across all searches: ("Neurocognitive Domain" OR "Neurocognitive Domain" OR OR "Neurocognitive Domain") AND [("gambling," "pathological gambling," "problem gambling," "gambling disorder," "gambling addiction," "compulsive gambling," "gambling behavior")]. Detailed search strategies for each database are provided in the Supplementary File–I.

Eligibility Criteria

Selected studies had to incorporate the following inclusion criteria: observational research designs, such as case-control, cross-sectional, cohort, prospective, and longitudinal studies, that utilized objective methods to assess neurocognitive domains. There were no restrictions regarding publication date or geographical location.

Observational studies relying on subjective methods for assessing neurocognitive domains, as well as secondary studies, including reviews and meta-analyses, were excluded. Additionally, qualitative studies, case reports, case series, and editorials were not considered. Studies published in languages other than English and full-length articles that were not accessible to the authors were also excluded from this review.

Study Selection

Zotero was utilized for duplicate removal and Rayyan was employed for documenting decisions related to inclusion and exclusion of records. The titles and abstracts of the de-duplicated studies underwent an initial screening process to identify studies that align with the inclusion criteria. This was done independently by 2 blinded reviewers (Y.A. and P.S.N.). The Cohen's *d* of inter-rater agreement came out to be 0.84, which is considered to indicate a near perfect agreement. Any discrepancies between the reviewer's decisions were resolved by discussion until an agreement was reached (<1% of articles).

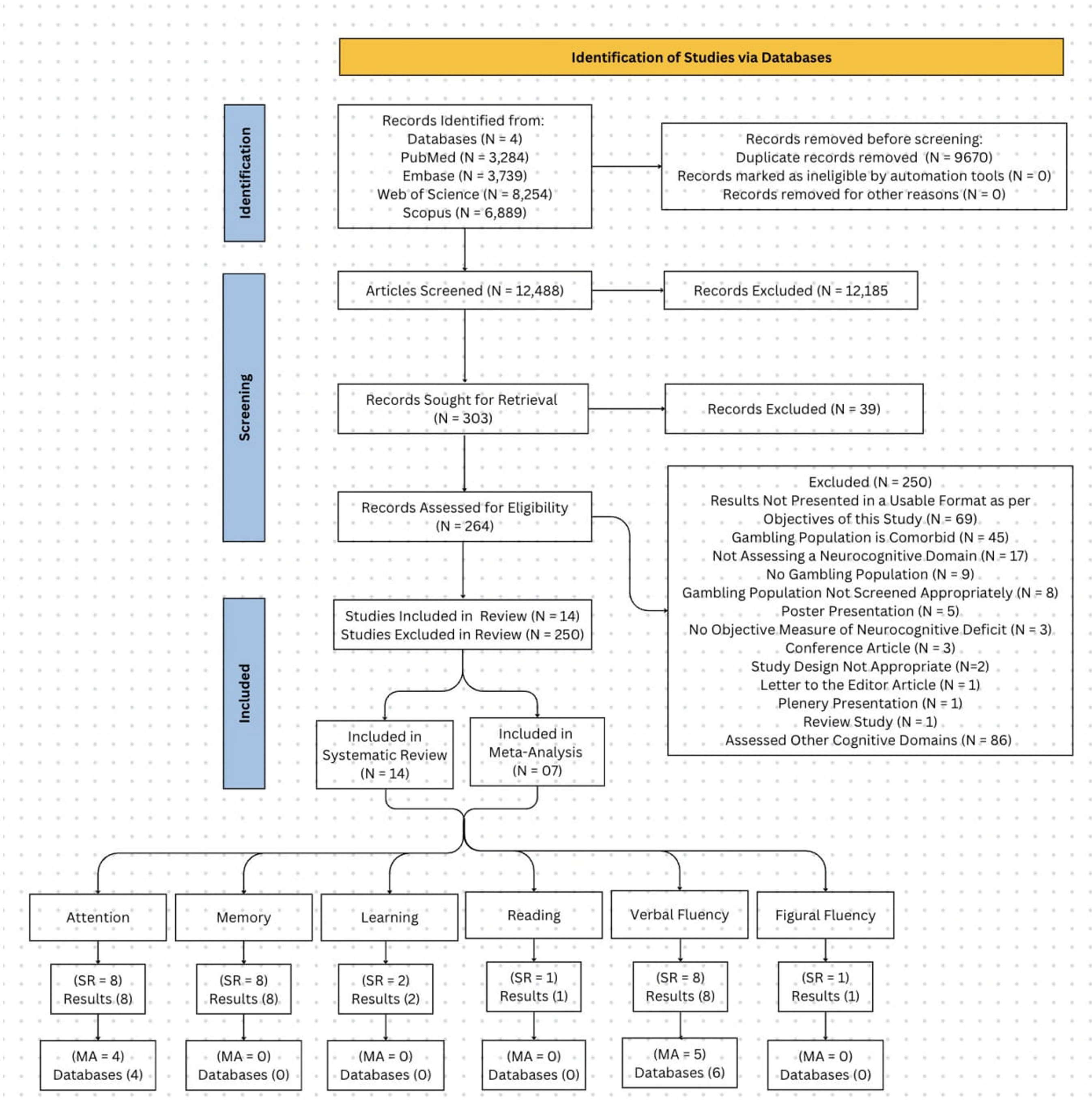

Figure 1. PRISMA flow chart depicting the study selection process.

The initially identified 303 studies underwent full-text screening in 2 sets by the 2 reviewers. The studies that were subsequently found eligible for inclusion in this review were taken up for data extraction by 2 independent reviewers. Out of 303 studies, a total of 14 studies met the eligibility criteria, from which 7 were included in the metanalysis.

Data Extraction and Study Quality

Data extraction from the included studies after full-text article evaluation encompassed details such as the identification number, author's name, publication year, sample size, demographic details of the sample, study setting, geographical location, cognitive domains(s) being tested, neuropsychological test(s) being used, average performance scores of individuals in the patient group and the control group (if any), and the concluding outcome of the study. If any studies included additional groups (e.g., eating disorder, bipolar disorder, obsessive-compulsive disorder), their results were noted but will not be included in the current study.

Two raters (Y.A. and P.S.N.) independently rated their set of the extracted studies for methodological quality on a validity scale assessing methodological rigor, selection and reporting bias for an overall risk of bias (RoB) assessment. The Joanna Briggs (JBI) critical appraisal checklists (e.g. JBI quality assessment tool) for each study design using the appropriate version (e.g., case-control studies, randomized controlled trials, cohort studies, cross-sectional studies) was employed. In the present review, all the studies utilized the 8-item cross-sectional format. A summary score was calculated for each study based on the percentage of applicable items positively rated on the checklist (i.e., higher scores indicate better quality/lower RoB). The included studies were also classified into the following 3 categories based on their sum total JBI score percentages: low RoB (at least 70%); moderate RoB (50%-69%); and high RoB (49% and below).[18]

Data Analysis and Synthesis

For the systematic review, a narrative synthesis of the qualitative data reported in the studies with the primary outcome being the results of the neuropsychological test for the gambling group, in comparison to the controls group was conducted.[19] However, 1 cross-sectional study did not have a control group,[20] and only the qualitative data for the gambling group was recorded for the systematic review.

For the meta-analysis, the mean scores and standard deviations for both the gambling and control groups on each neuropsychological task across different cognitive domains examined across various studies were recorded. Standardized mean differences in effect sizes (Hedge's g) were calculated using these statistics, with the meta-analysis effect size calculator (https://www.campbellcollaboration.org/calculator/d-means-sds). Negative values of Hedge's g indicated better performance in the control population compared to the gambling population. All effect sizes were computed using the original standard deviations.

Due to significant variation in test parameters across neuropsychological tasks, and the lack of correlations found in previous literature; meta-analyses were performed separately for each task score. A minimum of 3 studies per task were required for inclusion in the meta-analysis. For each cognitive task, the outcome measure was selected based on prior literature, established norms, prevalence of each parameter, and consensus among the study team.

Heterogeneity for each meta-analysis was assessed using the Higgin's I^2 statistic, which guided the decision to use fixed-effects or random-effects models for the overall between-group analyses. If the P-value for the I^2 statistic was significant ($P < .01$) in the fixed-effect model, a random-effects model was selected instead. Four meta-analyses were conducted: 2 for the attention domain, both using fixed-effects models, and 1 for verbal fluency, which initially used fixed-effects models but shifted to random-effects models after observing significant heterogeneity.

Three separate leave-one-out meta-analyses were conducted to assess the influence of each individual study on the overall pooled effect estimate. Additionally, subgroup analyses were performed based on RoB and geographical location to explore potential effect modifiers, if feasible. The groups were categorized based on RoB into low risk and moderate-to-high risk, and by geographical regions into the Americas, Europe, and the Western Pacific regions. These analyses were conducted using Open Meta-Analyst software.

RESULTS

The initial search identified 12 488 unique studies, of which 14 could be included in this review. For the domain of attention, 4 studies were included in both the systematic review and the meta-analysis. In memory, 8 studies were included in the systematic review. The domain of learning had 2 studies in the systematic review and none in the meta-analysis. Verbal fluency was represented by 3 studies in the systematic review and 5 in the meta-analysis while figural fluency had 1 study in both the systematic review and the meta-analysis. Figure 1 shows a PRISMA Flow Diagram illustrating the study selection process.

The aim was to review all cognitive deficits mentioned in the search strategy; however, due to the extensive literature, the findings were divided into separate publications. This is the first article focusing on the domains of attention, memory, learning, verbal fluency, and figural fluency.

Quality Score of the Included Studies

The average quality score of the included 14 studies was 6.43, as shown in Figure 2. Out of the total studies, 11 were categorized as having a low RoB,[13-16,21-27] 3 studies with a moderate RoB,[12,20,28] and 0 studies with a high RoB.

Attention

The cognitive domain of attention in individuals with gambling behavior has been assessed in 8 studies, with 7 of them including a control group. A total of 406 individuals with gambling behavior and 246 controls were assessed in them. The individuals with gambling behavior have an average age of 39.05 years (SD = 2.94) and 12.31 years of education. This group consisted of 303 males and 102 females. The control group, with an average age of 37.25 years (SD = 3.63) and 14.46 years of education (SD = 1.64), included 198 males and 59 females. Out of them, 4 studies were included in the meta-analysis and the remaining 4 were included in the systematic review only (see Table 1).

Four studies, all conducted in European regions, comprising a total of 159 individuals with gambling behavior and 127 controls were included in the meta-analysis for the domain of attention. All of them used the digit span task (DST) for cognitive assessment, which has also been included as a measure of attention in the mental status examination.[29] Thus, it was considered as a measure of attention in the review. Across these studies, the average age of the gambling group was 39.68 years (SD = 3.23) with 13.74 years of education (SD = 1.89), and a gender-wise distribution of 135 males and 24 females. The control group had an average age of 40.94 years (SD = 3.41) and 14.20 years of education (SD = 3.56), with a gender-wise distribution of 106 males and 21 females.

All 4 studies reported results for the forward version of the task,[12,16,22,28] while only 3 studies reported on the backward version.[12,16,22] Out of 4 studies employing the forward version of the task, only 1 indicated that the gambling group performed better than the control group.[16] The studies employing the backward version of the task all indicated non-significant results with the gambling population preforming similar to the control population.

The I^2 statistic for the studies employing the forward version of the DST was 0%, indicating no significant heterogeneity ($P = .091$). A

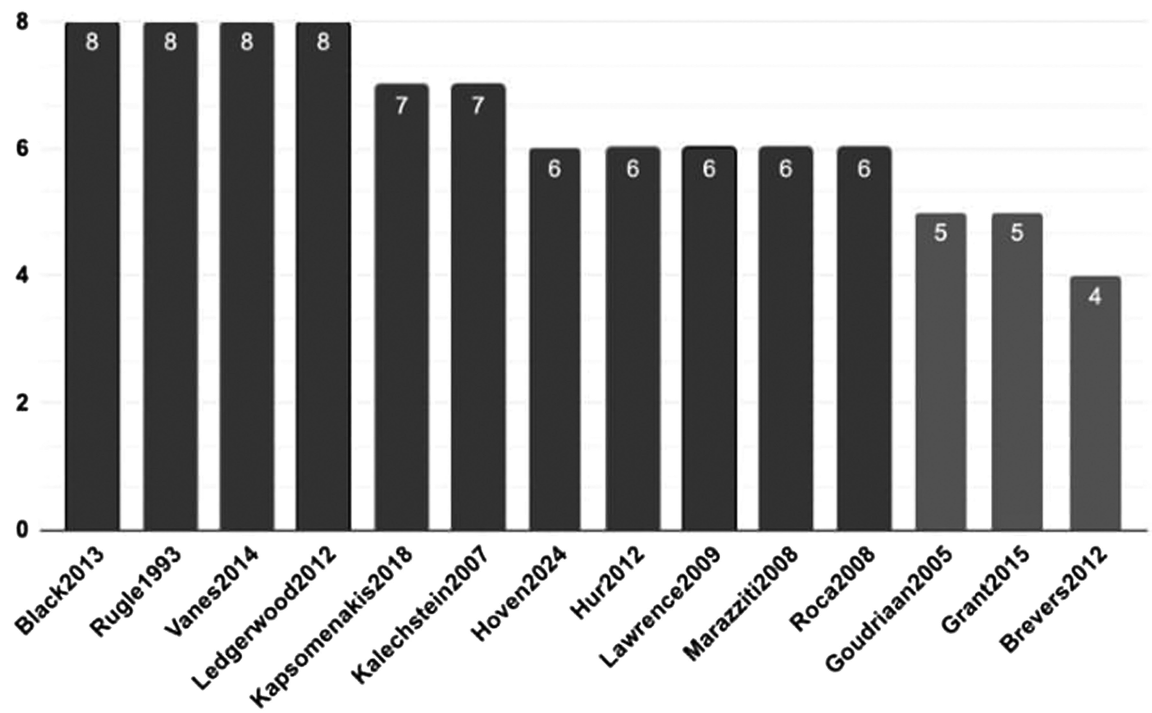

Figure 2. Risk of bias (RoB) scores for the included studies.

fixed-effects model was applied to the data, giving the overall Hedge's *g* estimate of −0.060 (95% CI: −0.297 to 0.177), with a *P*-value of .618, suggesting that the result was not statistically significant. The forest plot for this meta-analysis can be found in Figure 3. The leave-one-out sensitivity analysis confirmed that the results remained non-significant regardless of which study was excluded (see Supplementary Figure 2 for forest plot). In the subgroup analysis conducted for RoB, there was no significant difference in cognitive deficits across the studies ($P > .05$) (see Supplementary File–II for forest plot).

The I^2 statistic for the studies employing the backward version of the DST was 0%, indicating no significant heterogeneity ($P = .206$). A fixed-effects model was applied to the data, giving the overall Hedge's *g* estimate of 0.068 (95% CI: −0.203 to 0.375), with a *P*-value of .559, suggesting that the result was not statistically significant. The forest plot for this meta-analysis can be found in Figure 4. The leave-one-out sensitivity analysis demonstrated that excluding any single study did not alter the non-significance of the results (see Supplementary File–II for forest plot). In the subgroup analysis conducted for RoB, there was no significant difference in cognitive deficits across the studies ($P > .05$) (see Supplementary File–II for forest plot).

As shown in Table 1, the remaining 4 studies in the domain of attention were only systematically reviewed. They incorporated 247 individuals with gambling behavior and 119 controls. The gambling group had an average age of 38.43 years (SD = 2.73) and 11.60 years of education (SD = 1.25), with 168 males and 78 females. The control group's average age was 32.33 years (SD = 3.85) and 14.63 years of education (SD = 3.85), comprising 92 males and 38 females.

Each study in this review used a different neuropsychological task to assess attention. Black et al (2013)[21] and Kapsomenakis et al (2018)[16] found no substantial difference in sustained attention between the groups. Grant et al (2015)[20] employed the rapid visual information processing test, showing no specific comparison with controls, but reported scores of 0.93 for target detection and 0.88 for response tendency in gamblers. Rugle and Melamed (1993)[26] employed 6 neuropsychological tasks to assess attention. Among these, only the embedded figures test (EFT) revealed that gamblers outperformed controls, while the remaining tests showed similar performance between the 2 groups.

Memory

The cognitive domain of memory in individuals with gambling behavior has been assessed in 8 studies, as shown in Table 2. These studies were conducted on a total of 252 individuals with gambling behavior and 297 control participants. The individuals with gambling behavior had an average age of 38.59 years (SD = 3.31) and 14.52 years of education (SD = 1.55), consisting of 168 males and 83 females. The control group, with an average age of 37.83 years (SD = 3.50) and 14.47 years of education (SD = 1.52), included 190 males and 165 females. Two of these studies were conducted in the European region, 2 in the Western Pacific region, and 2 in the Americas.

Each study in this review used a different neuropsychological task to assess memory, using the Wechsler memory scale-III,[23] Wechsler memory scale-revised,[24] Hopkins verbal learning test-revised, Brief visuospatial memory test-revised,[21] Benton visual retention test,[12] California verbal learning test,[13] Memory impairment screen[16] Addenbrooke's cognitive examination (ACE) memory subscale,[25] and list learning.[26] None of these studies found significant differences in the performance of gamblers and controls. Hur et al (2012)[13] found significant differences between the groups across the parameters of fragmentation and orientation, with the control group being better

Table 1. Studies Included in the Meta-Analysis and Systematic Review of the Attentional Domain

Study	Population	Criteria	Age	Education	Gender	Location	Task	Description of Task	Outcome	Scores	Results	Conclusion
Brevers[28MA]	Problem gamblers (n = 65)	SOGS ≥ 3	38.93 (11.35)	N/S	50 ♂ 15 ♀	European Region (Belgium)	Digit span task (forward)	N/S	Forward score	10.10 (2.30)	N.S.	TPG ≈ CPG
	Normal controls (n = 35)	N/A	43.24 (10.69)	N/S	29 ♂ 6 ♀					10.69 (1.53)		
Goudriaan et al[12MA]	Pathological gamblers (n = 49)	DIS-DV (T) SOGS-DV = 11.6 (0.58)	37.3 (9.5)	N/S	40 ♂ 9 ♀	European Region (Netherlands)	Digit span (forwards/backward) from the Wechsler adult intelligence scale	In forward version, participants recall a progressively longer list of numbers immediately after presentation In digit span backward, they recall the list in reverse order	Forward score Backward score	7.19 (2.1) −0.08 (2.34)	N.S. N.S.	TPG ≈ CPG TPG ≈ CPG
	Normal controls (n = 50)	N/A	35.6 (11.4)	N/S	35 ♂ 15 ♀					7.38 (2.2) 0.26 (2.08)		
Lawrence et al[22MA]	Problem gamblers (n = 21)	SOGS ≥ 3	37 (9.6)	12.9 (2.9)	21 ♂	European Region (Cambridge)	Digit span (forwards/backwards) from the Wechsler adult intelligence scale	N/S	Forward score Backward score	9.7 (1.8) 8.6 (3.0)	N.S. N.S.	TPG ≈ CPG TPG ≈ GG
	Healthy controls (n = 21)	SOGS ≤ 2	40.2 (13.6)	13.5 (2.4)	21 ♂					10.1 (1.8) 7.8 (2.5)		
Kapsomenakis et al[16MA]	Gamblers (n = 24)	SOGS > 4	45.5 (10.6)	14.58 (4.17)	24 ♂	European Region (Greece)	Digit span task from Simos et al, 2011	N/S	Forward score Backward score	18.83 (2.62) 15.00 (3.38)	0.037 0.144	TPG > CPG TPG ≈ CPG
	Healthy controls (n = 21)	SOGS = 0	44.7 (11.8)	14.9 (3.95)	21 ♂					16.86 (3.54) 13.38 (3.93)		
Black et al[21]	Pathological gamblers (n = 54)	DSM-IV PG SOGS ≥ 5	45.3 (15.2)	14.6 (1.9)	19 ♂ 35 ♀	Regions of the Americas (Washington)	Letter-number sequencing subtest from the Wechsler adult intelligence scale (WAIS-III) (Wechsler, 1997)	To assess sustained and selective attention, cognitive inhibition, and working memory	Score	11.7 (3.3)	$P = .372$	TPG ≈ CPG
	Controls (n = 65)	N/A	47.5 (18.3)	15.0 (2.3)	27 ♂ 38 ♀					11.2 (2.6)		
Kapsomenakis et al[16]	Gamblers (n = 24)	SOGS > 4	45.5 (10.6)	14.58 (4.17)	24 ♂	European Region (Greece)	Continuous performance task (CPT)	Experimental task for assessing sustained attention	Score	49.38 (8.85)	$P = .071$	TPG ≈ CPG
	Control group (n = 21)	SOGS = 0	44.7 (11.8)	14.9 (3.95)	21 ♂					44.19 (9.96)		
Grant et al[20]	Pathological gamblers (n = 136)	SCI-PG = 1.5 (0.7)	21.5 (3.4)	3.2 (0.8)	92 ♂ 44 ♀	Regions of the Americas (Minnesota)	Rapid visual information processing (RVP) test	Tests sustained attention, sensitive to dysfunction in the parietal and frontal lobes Digits appeared on the screen at 100 per minute, and participants had to distinguish between targets and non-targets	RVP A0 RVP B0	0.93 (0.05) 0.88 (0.24)		

(*Continued*)

Table 1. Studies Included in the Meta-Analysis and Systematic Review of the Attentional Domain (*Continued*)

Study	Population	Criteria	Age	Education	Gender	Location	Task	Description of Task	Outcome	Scores	Results	Conclusion
Rugle and Melamed[26]	Gamblers (n = 33)	SOGS > 5	41.4 (9.5)	14 (2.3)	33 ♂	Regions of the Americas (Ohio)	Embedded figures test (EFT; Douglas, 1984)	A nonverbal visual/ perceptual test that invokes discriminative frontally mediated aspects of attention	Total time score	983.73 (474.17) 629.85 (392.78)	$P < .002$	TPG > CPG
	Matched controls (n = 33)	SOGS = 0-2	40.8 (10.0)	14 (2.1)	33 ♂		Porteus maze test, forms XII-adult (Porteus, 1965)	A visual, nonverbal test measuring the capacity to focus attention while engaged in sequential problem-solving	Error score	15.33 (2.16) 16.16 (0.86)	$P < .06$	TPG ≈ CPG
							Seashore rhythm test (Reitan, 1986)	A measure of alertness and focused attention al a basic level. Total correct was scored	Total correct score	26.27 (2.50) 27.12 (2.56)	$P < .178$	TPG ≈ CPG
							Symbol digit substitution test (SDST; Royer et al, 1981)	A visual, nonverbal measure of sustained attention, requiring encoding, memory storage, and visual search among alternatives	Total score (form I-III)	126.51 (21.66) 131.58 (26.58)	$P < .472$	TPG ≈ CPG
							Knox cube test (Stone and Wright, 1980)	A visual, nonverbal attention span measure	Total correct score	12.67 (3.39) 13.27 (2.76)	$P < .429$	TPG ≈ CPG
							Primary memory with interference test (Peterson and Peterson, 1959)	A distraction task which is a visual-verbal task measuring the ability to inhibit distracting sensory and mental input and the capacity to engage and maintain attention	Total correct score	35.76 (8.14) 37.09 (6.78)	$P < .400$	TPG ≈ CPG

♂, males; ♀, females; CPG, control population group; DIS-DV (T), Dutch version of section t of the diagnostic interview schedule; DSM-IV PG, diagnostic and statistical manual of mental disorders-iv pathological gambling criteria; [MA], included in meta-analysis; N/A, not applicable; N/S, not specified; N.S., not significant; SCI-PG, modified structured clinical interview for pathological gambling; SOGS, South Oaks gambling screen; SOGS-DV, South Oaks gambling screen-Dutch version; TPG, target population group.

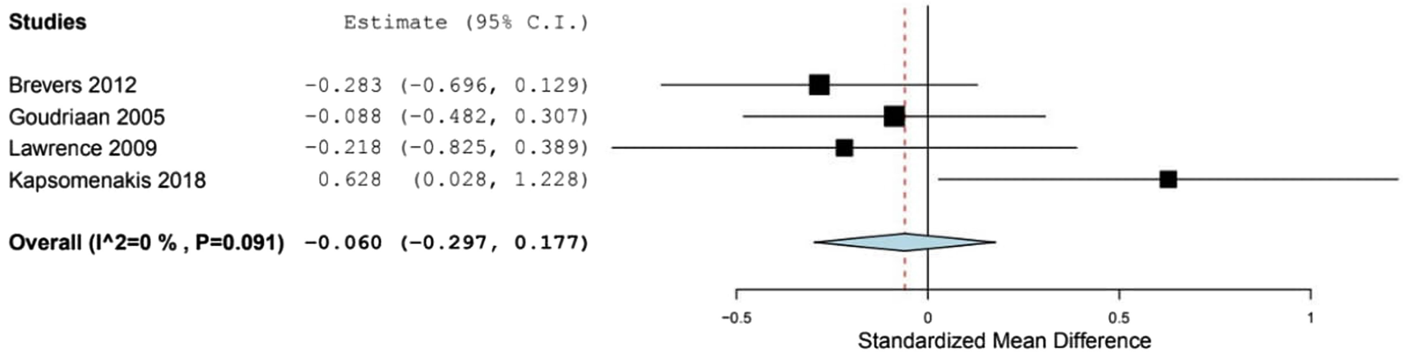

Figure 3. Forest plot of studies using digit span test—forward version using fixed-effects models.

at the task. Similarly, Roca et al (2008)[25] found that gamblers scored significantly lower than controls, indicating memory deficits.

Learning

The cognitive domain of learning in individuals with gambling behavior has been assessed in 2 studies, with both of them having control groups, as shown in Table 3. These studies were conducted on a total of 55 individuals with gambling behavior and 48 control participants. The individuals with gambling behavior had an average age of 34.70 years (SD = 17.39) and 3.12 years of education (SD = 0.90), consisting of 51 males and 4 females. The control group, with an average age of 37.35 years (SD = 16.10) and 3.23 years of education (SD = 1.20), included 42 males and 6 females.

The studies by Hoven et al (2024)[14] and Vanes et al (2014)[27] assessed learning in the gambling population. Hoven's study used the predictive inference task to test error-driven learning which indicated that the gambling group had a significantly lower learning rate as compared to the control group. In contrast, Vanes' study[14] used 3 learning tasks: discrimination learning, reversal learning, and extinction learning for evaluation of this cognitive domain.[27] The findings indicated no significant differences between gamblers and controls.

Verbal Fluency

Verbal fluency in individuals with gambling behavior has been assessed in 8 studies, with all of them including control groups (see Table 4). A total of 273 individuals with gambling behavior and 329 controls participated in these studies. The individuals with gambling behavior had an average age of 39.14 years (SD = 3.47) and 14.57 years of education (SD = 1.52), consisting of 154 males and 118 females. The control group, with an average age of 38.79 years (SD = 3.70) and 14.73 years of education (SD = 1.52), included 182 males and 134 females.

Five studies comprising a total of 188 individuals with gambling behavior and 233 controls were included in the meta-analysis. These studies assessed verbal fluency through the controlled oral word association test (COWAT),[12,13,16,21,23] as shown in Table 4.

Across these studies, the average age of the gambling group was 40.50 years (SD = 3.45) with 14.57 years of education (SD = 1.57), and comprised 120 males and 68 females. The control group had an average age of 39.75 years (SD = 3.64) and 14.66 years of education (SD = 1.52), with 142 males and 91 females.

With the fixed-effects models, the I^2 statistic for the studies employing the controlled word association test was 0%, indicating significant heterogeneity ($P < .01$). The Hedge's g estimate of −203 (95% CI: −390 to −0.015), with a P-value for this estimate being less than .034, suggested that the result was statistically significant. The forest plot of this meta-analysis has been given in Figure 5. However, since significant heterogeneity was indicated, a random-effects model was also applied, the I^2 statistic of which was 68.91 ($P = .007$). The Hedge's g estimate came out to be (95% CI: −0.488 to 0.205), with a P-value of less than .425, suggesting that the result was not statistically significant (see Figure 6). The leave-one-out sensitivity analysis, along with subgroup analyses based on RoB and geographical location, all indicated non-significant results ($P > .05$) (see Supplementary File–II for forest plots).

Individually, most studies found no significant differences in performance.[13,21,23] However, Kapsomenakis et al (2018)[16] suggested that

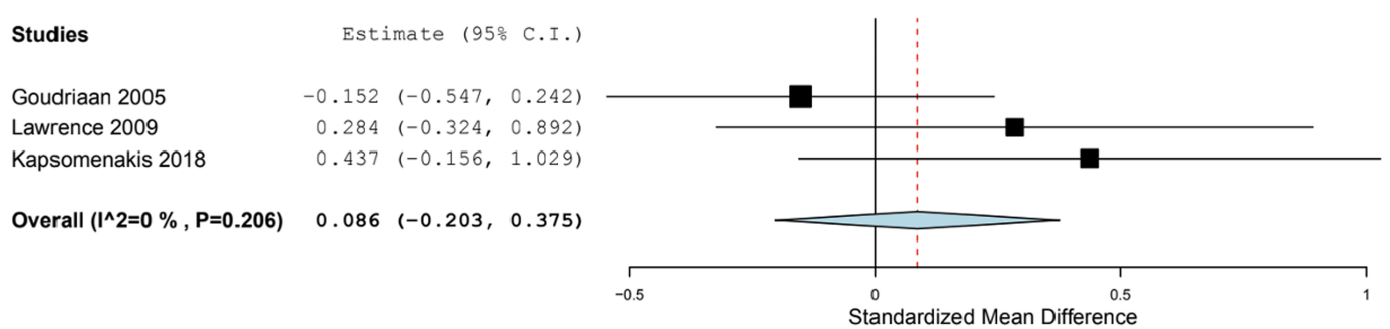

Figure 4. Forest plot of studies using digit span test—backward version using fixed-effects models.

the control group performed worse than the gamblers, whereas Goudriaan et al (2006)[12] reported the opposite in the semantic subscale of the task.

The systematic review involves 85 individuals with gambling behavior and 96 controls. The gambling group has an average age of 35.75 years (SD = 3.51) and 14.60 years of education (SD = 1.90), with 34 males and 50 females. The control group's average age is 36.40 years (SD = 3.92) and 15.00 years of education (SD = 2.30), comprising 42 males and 43 females. One study is from the European region and one from the Americas.

While Black et al (2013)[21] and Marazziti et al (2008)[24] reported no significant difference in verbal fluency between gamblers and controls, Roca et al (2008)[25] found that gamblers performed significantly worse than controls.

Figural Fluency

Only 1 study was found for the domain of figural fluency (Table 5).

Kalechstein (2007)[15] investigated cognitive performance in gamblers compared to a control group. The study included 10 gamblers with an average age of 53.7 years (SD = 9.6) and 13.7 years of education (SD = 1.4) and 19 comparison subjects with an average age of 32.5 (SD = 7.6) and 13.7 years of education (SD = 1.8). Both groups were assessed using the Ruff figural fluency test. The results showed that gamblers had significantly lower scores (104.0, SD = 21.4) compared to the control group (75.4, SD = 22.1, $P > .01$), indicating that gamblers performed worse on this cognitive task.

DISCUSSION

This systematic review and meta-analysis aimed to investigate potential cognitive deficits in individuals engaged in gambling behavior, with a particular focus on the domains of attention, memory, learning, verbal fluency, and figural fluency. To the best of knowledge, this is the first review study to focus on examining deficits in these particular cognitive domains in the context of gambling. For each cognitive domain, neuropsychological tests having 3 or more quantitative datasets were included in the meta-analysis, while the remaining studies were reviewed qualitatively. Some studies contributed to multiple domains within both the systematic review and the meta-analysis. Also, heterogeneity was observed across studies examining various cognitive domains. This variation was evident in terms of sample size, participant characteristics, methods used to screen the gambling group, types of neuropsychological tests administered, outcome measures reported, and the gender distribution of participants.

Attention

In the domain of attention, 4 studies were included in the meta-analysis, which employed the digit span test–forward version. The results were not statistically significant in the metaanalysis, indicating no consensus across studies regarding the presence of attention-related deficits in gambling behavior. Three of these studies[12,22,28] found no significant difference between gambling and control groups in terms of attentional performance. Only Kapsomenakis et al (2018)[16] reported that gamblers performed better on the forward version of the task than the control group, a result that the authors stated could be explained as gradual development of strategies through their gambling activity. For the backward version of the task, all 3 studies reported that the control groups performed similar to the gambling group[12,16,22] and the meta-analysis also indicated non-significant results. The systematic review of the attentional domain revealed 3 studies reporting no significant deficits for attention domain in the gambling group.[16,20,21] Only Rugle and Melamed (1993),[26] who used 6 different attention tests, found that the gambling group took significantly longer to complete the EFT, suggesting associated attentional delays.

Memory

In the memory domain, 6 out of 8 studies[12,16,21,23,24,26] concluded that gamblers did not differ significantly from control groups on a variety of memory tests. Only 1 study by Kapsomenkais (2018)[16] found that the controls performed significantly better on the ACE (memory subscale) than the gamblers, suggesting a potential link with cognitive strategies and skills developed during gambling. Hur et al (2012),[13] in contrast, found significant deficits in the gambling group, specifically in the domains of fragmentation and organization, which suggests that gamblers may experience impairments in the structure of memory processes.

Learning

Regarding learning, only 2 studies were found. Hoven et al (2024)[14] indicated that the control group demonstrated superior learning rates on a predictive inference task than the gambling group. In contrast, Vanes et al (2014)[27] reported no significant differences between gambling and control groups in terms of discriminative learning, reversal learning, or extinction learning, suggesting mixed findings in this domain. However, more studies are required to draw definitive conclusions.

Verbal Fluency

For verbal fluency, an initial meta-analysis was conducted using a fixed-effects model, which showed high heterogeneity. This was followed by a random-effects model analysis, which revealed no consensus across studies. Five studies and 6 databases were included in the analysis, but only 1 study[12] showed that controls performed better than gamblers on the semantic subscale of the COWAT. Conversely, another study[16] reported that gamblers performed better than controls on the semantic subscale of the same task. Other studies using the same test[13,21,23] did not find any significant differences. Studies using other verbal fluency tests found no significant differences between gambling and control groups,[21,24] although 1 study[25] did show that the gambling group performed worse on the verbal fluency subscale of the ACE.

Figural Fluency

In the figural fluency domain, only 1 study[15] was identified, which indicated that controls performed significantly better than gamblers on the Ruff figural fluency test, suggesting that gamblers may experience deficits in nonverbal fluency tasks. However, a single study is insufficient to draw definitive conclusions.

The review findings suggest no significant cognitive deficits in the domains of attention, memory, learning, reading, verbal fluency, and figural fluency among people with problematic or disordered gambling. This represents that these cognitive domains may not be central to the neuropsychology of gambling behaviors. As a result of which, these domains may not be amenable to direct intervention, and efforts should instead be focused on other cognitive areas that have shown deficits. One meta-analyses revealed significant deficits in individuals with gambling disorder, particularly cognitive flexibility, attentional set-shifting, attentional bias,[3]

Table 2. Studies Included in the Systematic Review of the Memory Domain

Study	Population	Criteria	Age	Education	Gender	Location	Task	Description of Task	Outcome	Scores	Results	Conclusion
Ledgerwood et al[23]	Pathological gamblers (n = 45)	NODS–L: 8.0 (1.7) NODS–PY: 7.5 (1.8)	46.1 (13.9)	14.2 (2.5)	21 ♂ 24 ♀	Regions of the Americas (Ontario)	Wechsler memory scale, 3rd Edition (WMS-III)	It consists of 7 primary memory indexes, including auditory immediate, visual immediate, immediate memory, auditory delayed, visual delayed, auditory reception delayed, and general memory	Score	101.0 (14.2)	N.S.	TPG ≈ CPG
	Control group (n = 45)	NODS < 1	45.8 (17.3)	14.4 (2.5)	23 ♂ 22 ♀					105.8 (15.1)		
Marazziti et al[24]	Pathological gamblers (n = 20)	DSM-IV-R PG	26.2 (4.4)	N/S	15 ♂ 15 ♀	European region (Italy)	Wechsler memory scale-revised (WMS-R)	Global values are assessed for general, verbal, and visual short- and long-term memory, as well as attention and concentration. Specific areas of evaluation include verbal functions such as logical memory and associative learning with verbal pairings, both immediate and delayed. For visual memory, assessment covers image recall, learning with visual stimuli, and visual reproduction of pictures, all measured immediately and delayed	Score	97 (11)	N.S.	TPG ≈ CPG
	Healthy controls (n = 20)	N/A	25.3 (5.6)	N/S	15 ♂ 5 ♀					95 (10)		
Black et al[21]	Pathological gambling (n = 54)	NODS = 13.7 (4.3) SOGS ≥ 5	45.3 (15.2)	14.6 (1.9)	19 ♂ 35 ♀	Regions of the Americas (Washington)	Hopkins verbal learning test-revised (HVLT-R; Brandt and Benedict, 2004)	For the assessment of verbal learning and memory	Total recall (raw score) Delayed recall (raw score)	27.0 (4.8) 9.5 (2.3) 26.3 (3.6) 9.3 (2.1)	0.340 0.685	TPG ≈ CPG TPG ≈ CPG
	Control group (n = 65)	NODS = 0 SOGS = 0	47.5 (18.3)	15.0 (2.3)	27 ♂ 38 ♀		Brief visuospatial memory test-revised (BVMT-R; Benedict, 1997)	For the assessment of visual learning and memory	Total recall (Raw score) Delayed recall (Raw score)	23.0 (7.4) 9.1 (2.2) 23.3 (6.7) 9.5 (2.1)	0.793 0.257	TPG ≈ CPG TPG ≈ CPG
Goudriaan et al[12]	Pathological gamblers (n = 49)	DIS-DV (T) SOGS-DV = 11.6 (0.58)	37.3 (9.5)	N/S	40 ♂ 9 ♀	European Region (Netherlands)	Benton visual retention test (BVRT; Sivan, 1992)	This test was included to control for immediate visual short-term memory abilities Form C was administered consisting of 10 abstract designs, which are presented for 10 seconds. After each presentation, subjects have to draw the design by heart	Correct designs	7.23 (1.6)	N.S.	TPG ≈ CPG
	Normal controls (n = 50)	N/A	35.6 (11.4)	N/S	35 ♂ 15 ♀					7.54 (1.3)		

(*Continued*)

Table 2. Studies Included in the Systematic Review of the Memory Domain (***Continued***)

Study	Population	Criteria	Age	Education	Gender	Location	Task	Description of Task	Outcome	Scores	Results	Conclusion
Hur et al[13]	Pathological gamblers (n = 16)	DSM-IV PG SOGS = 15.79 (1.53)	28.31 (3.79)	14.88 (1.67)	16 ♂	Western Pacific Region (Korea)	California verbal learning test-Korean (K-CVLT; Kang and Kim, 1997)	To assess verbal learning and memory. This test yields recall for 16 target nouns, recall for 16 intervening nouns, immediate and delayed recall of 16 nouns learned verbally, and word recognition	First trial for target list Trial for intervention list Immediate recall (IR) Delayed recall (DR) Recognition (%)	6.75 (2.35) 6.19 (2.64) 12.13 (2.83) 12.00 (2.73) 93.77 (6.85) 7.94 (1.96) 6.65 (2.20) 12.58 (2.44) 13.48 (2.07) 94.76 (7.20)	N.S. N.S. N.S. N.S. N.S.	TPG ≈ CPG TPG ≈ CPG TPG ≈ CPG TPG ≈ CPG TPG ≈ CPG
	Healthy controls (n = 52)	SCID-NP for Axis I or Axis II disorders	25.13 (5.00)	14.35 (1.53)	36 ♂ 16 ♀	Western Pacific Region (Korea)	Rey–Osterrieth complex figure test (ROCF; Shin et al, 2006)	To test for visual organization and memory, including measures of copying, immediate and delayed recall, as well as a series of subscales such as planning, fragmentation, and organization	BQSS score–copy BQSS score–IR BQSS score–DR IR-retention DR-retention Fragmentation Planning Organization	18.25 (1.29) 13.19 (2.26) 12.81 (2.59) 227.46 (12.89) 22.50 (13.85) 2.81 (1.11) 3.13 (0.72) 5.94 (1.69) 18.73 (1.14) 13.85 (2.74) 13.83 (2.73) 226.01 (14.14) 2.15 (26.28) 3.52 (0.58) 3.42 (0.64) 6.94 (0.94)	N.S. N.S. N.S. N.S. N.S. – N.S. ––	TPG ≈ CPG TPG ≈ CPG TPG ≈ CPG TPG ≈ CPG TPG ≈ CPG TPG < CPG TPG ≈ CPG TPG < CPG
Kapsomenakis et al[16]	Gamblers (n = 24)	SOGS > 4	45.5 (10.6)	14.58 (4.17)	24 ♂	European Region (Greece)	Memory impairment screen (Buschke et al, 1999)	N/S	Score	7.13 (1.15)	$P = .427$	TPG ≈ CPG
	Healthy controls (n = 21)	SOGS = 0	44.7 (11.8)	14.9 (3.95)	21 ♂					6.86 (1.24)		
Roca et al[25]	Pathological gamblers (n = 11)	DSM-IV PG SOGS > 5	N/S	N/S	N/S	Region of the Americas (Argentina)	Addenbrooke's cognitive examination (memory subscale; Mathuranath et al, 2000)	N/S	Memory score	7.82 (0.4)	, $P = .008$	TPG < CPG
	Control (n = 11)	No psychiatric disorder	N/S	N/S	N/S					8.0 (0.0)		
Rugle and Melamed[26]	Gamblers (n = 33)	SOGS > 5	41.4 (9.5)	14 (2.3)	33 ♂	Regions of the Americas (Ohio)	List learning with categorical clustering (list; Buschke and Fuld, 1971)	A selective reminding task based on verbal learning is enhanced by spontaneous use of frontally mediated organization strategies	List learning	20.97 (2.26)	$P < .436$	TPG ≈ CPG
	Matched controls (n = 33)	SOGS = 0-2	40.8 (10.0)	14 (2.1)	33 ♂					21.42 (2.45)		

♂, males; ♀, females; CPG, control population group; DIS-DV (T), Dutch version of section t of the diagnostic interview schedule; DSM-IV PG, diagnostic and statistical manual of mental disorders-iv pathological gambling criteria; DSM-IV-R, diagnostic and statistical manual of mental disorders-iv-revised for pathological gambling; N/A, not applicable; N/S, not specified; N.S., not significant; NODS, NORC DSM screen for gambling problems; NODS–L, NORC DSM screen for gambling problems–lifetime; NODS–PY, NORC DSM screen for gambling problems–past year; SCID-NP, structured clinical interview for DSM-IV-TR, non-patient edition; SOGS, South Oaks gambling screen; SOGS-DV, South Oaks gambling screen-Dutch version; TPG, target population group.

Table 3. Studies Included in the Systematic Review of the Learning Domain

Study	Population	Criteria	Age	Education	Gender	Location	Task	Description of Task	Outcome	Scores	Results	Conclusion
Hoven et al[14]	Gambling disorder (n = 27)	PGSI = 15.1 (4.2)	36.8 (11.4)	3.12 (0.9)	23 ♂ 4 ♀	European Region (Netherlands)	Predictive inference task (Adapted from Vaghi et al, 2017)	This task allows for the investigation of the relationship between error-driven learning and confidence, by letting participants infer the landing location of a particle based on its previous landing locations	Learning rate	0.37 (0.14)	*P* = .021	TPG < CPG
	Control group (n = 30)	N/A	35.6 (8.8)	3.23 (1.2)	24 ♂ 6 ♀					0.47 (0.21)		
Vanes et al[27]	Pathological gamblers (n = 28)	DIS (T) SOGS ≥ 5	36.6 (12.0)	N/S	28 ♂	European Region (Netherlands)	Discrimination learning	Participants learned to distinguish between 2 patterns that required a response and 2 that did not. The phase aimed for participants to make 9 correct responses in 10 consecutive trials. If the participant failed to reach this criterion within 120 trials, the phase would automatically end. All participants reached the criterion before the trial limit	Commission errors trials until criterion	5.3 (6.3) 26.1 (21.0) 4.7 (5.4) 25.6 (23.3)	*P* = .32 *P* = .27	TPG ≈ CPG TPG ≈ CPG
	Healthy controls (n = 18)	N/A	39.1 (10.5)	N/S	18 ♂		Reversal learning	After the discrimination phase, the reward contingencies were reversed unexpectedly. Previously correct responses were now penalized, while previously incorrect responses were rewarded. Participants were required to reach the criterion of 9 correct trials within 10 consecutive trials. If they failed to do so within 120 trials, the phase ended automatically for some participants	Commission errors trials until criterion	10.3 (11.8) 42.2 (37.4) 6.2 (6.8) 28.2 (20.7)	*P* = .74 *P* = .6	TPG ≈ CPG TPG ≈ CPG
							Extinction learning	Following a 10-minute break, participants entered a second discrimination phase where the contingencies learned in reversal were applied again. In this phase, no stimuli required a response, and pressing the space bar on any stimulus resulted in a penalty. The task ended once participants successfully completed 15 consecutive correct extinction trials. All participants reached this criterion within 120 trials	Commission errors trials until criterion	6.1 (4.4) 31.3 (11.1) 5.6 (3.0) 31.8 (8.2)	*P* = .62 *P* = .67	TPG ≈ CPG TPG ≈ CPG

♂, males; ♀, females; CPG, control population group; DIS (T), diagnostic interview schedule; N/A, not applicable; N.S., not significant ; N/S, not specified; PGSI, problem gambling severity index; TPG, target population group.

Table 4. Studies Included in the Meta-Analysis and Systematic Review of the Verbal Fluency Domain

Study	Population	Criteria	Age	Education	Gender	Location	Task	Description of Task	Outcome	Scores	Results	Conclusion
Black et al[21]	Pathological gambling (n = 54)	NODS = 13.7 (4.3) SOGS ≥ 5	45.3 (15.2)	14.6 (1.9)	19 ♂ 35 ♀	Regions of the Americas (Washington)	Controlled oral word association test (COWAT; Benton, 1969)	To assess verbal fluency	Score	44.9 (10.3)	*P* = .232	TPG ≈ CPG
	Control group (n = 65)	N/A	47.5 (18.3)	15.0 (2.3)	27 ♂ 38 ♀					47.2 99.6)		
Hur et al[13 MA]	Pathological gamblers (n = 16)	DSM-IV PG SOGS = 15.79 (1.53)	28.31 (3.79)	14.88 (1.67)	16 ♂	Western Pacific Region (Korea)	Controlled oral word association test (COWAT; Benton, 1969)	N/S	Score	36.56 (13.25)	N.S.	TPG ≈ CPG
	Healthy controls (n = 52)	SCID (SCID-NP) for Axis I or Axis II Disorders	25.13 (5.00)	14.35 (1.53)	36 ♂ 16 ♀					41.87 (11.23)		
Goudriaan et al[12 MA]	Pathological gamblers (n = 49)	DIS-DV (T) SOGS-DV = 11.6 (0.58)	37.3 (9.5)	N/S	40 ♂ 9 ♀	European Region (Netherlands)	Controlled oral word association test (COWAT; Benton and Hamsher, 1989)	To assess phonemic and semantic fluency	Fluency n correct Fluency n perseverations	71.6 (18.2) 1.49 (1.53)	– N.S.	TPG < CPG TPG ≈ CPG
	Normal controls (n = 50)	N/A	35.6 (11.4)	N/S	35 ♂ 15 ♀					83.7 (16.4) 1.25 (1.28)		
Kapsomenakis et al ([2018]MA)	Gamblers (n = 24)	SOGS > 4	45.5 (10.6)	14.58 (4.17)	24 ♂	European Region (Greece)	Controlled Oral Word Fluency (Kosmidis et al 2004)	In the semantic condition, subjects had to name as many animals or professions as possible in 1 minute	Sematic subscale	65.54 10.45 58.75 (10.76)	*P* = .021	TPG > CPG
	Healthy controls (n = 21)	SOGS = 0	44.7 (11.8)	14.9 (3.95)	21 ♂			In the phonological condition subjects were asked to name as many words as possible in 1 minute starting with the letters N, A or K, and were not allowed to give proper names or to repeat words starting with the same word stem (e.g. table, tablecloth)	Phoenomic subscale	39.67 (7.92) 37.30 (10.95)	*P* = .153	TPG ≈ CPG

(*Continued*)

Table 4. Studies Included in the Meta-Analysis and Systematic Review of the Verbal Fluency Domain (*Continued*)

Study	Population	Criteria	Age	Education	Gender	Location	Task	Description of Task	Outcome	Scores	Results	Conclusion
Ledgerwood et al ([23])[MA]	Pathological gamblers (n = 45)	NODS–L: 8.0 (1.7) NODS–PY: 7.5 (1.8)	46.1 (13.9)	14.2 (2.5)	21 ♂ 24 ♀	Regions of the Americas (Ontario)	Controlled oral word association test (COWAT; Strauss, Sherman and Spreen, 1998)	Participants are given 1 minute each to list as many words as possible that begin with the letters F, A, and S. Proper names and multiple words beginning with the same word stem (e.g., fond and fondly) are not allowed	Total correct rule break	37.9 (9.9) 1.8 (1.6)	N.S. N.S.	TPG ≈ CPG TPG ≈ CPG
	Control group (n = 45)	NODS < 1	45.8 (17.3)	14.4 (2.5)	23 ♂ 22 ♀					39.3 (9.5) 1.5 (1.6)		
Black et al ([21])	Pathological gambling (n = 54)	NODS = 13.7 (4.3) SOGS ≥ 5	45.3 (15.2)	14.6 (1.9)	19 ♂ 35 ♀	Regions of the Americas (Washington)	Boston diagnostic aphasia examination (BDAE) Animal naming test (Goodglass and Kaplan, 1983)	To assess verbal fluency	Score	21.4 (5.1)	*P* = .213	TPG ≈ CPG
	Control group (n = 65)	N/A	47.5 (18.3)	15.0 (2.3)	27 ♂ 38 ♀					22.2 (5.0)		
Marazziti et al ([24])	Pathological gamblers (n = 20)	DSM-IV-R PG	26.2 (4.4)	N/S	15 ♂ 15 ♀	European Region (Italy)	Verbal associative fluency test (FAS; Benton and Hamsher, 1989)	N/S	Score	27 ± 3	N.S.	TPG ≈ CPG
	Healthy controls (n = 20)	N/A	25.3 (5.6)	N/S	15 ♂ 5 ♀					28 ± 6		
Roca et al ([25])	Pathological gamblers (n = 11)	DSM-IV PG SOGS > 5	N/S	N/S	N/S	Region of the Americas (Argentina)	Addenbrooke's cognitive examination (verbal fluency subscale; Mathuranath et al, 2000)	N/S	Score	10.36 (1.63)	PGs subjects had significantly worse performance in word fluency (*P* = .024).	GB < CPG
	Control (n = 11)	No psychiatric disorder	N/S	N/S	N/S					12.18 (1.72)		

♂, males; ♀, females; CPG, control population group; DIS-DV (T), Dutch version of section t of the diagnostic interview schedule; DSM-IV PG, diagnostic and statistical manual of mental disorders-iv pathological gambling criteria; DSM-IV-R PG, diagnostic and statistical manual of mental disorders-iv-revised for pathological gambling; [MA], included in meta-analysis; N/A, not applicable; N.S., not significant; N/S, not specified; NODS, NORC DSM screen for gambling problems; NODS–L, NORC DSM screen for gambling problems–lifetime; NODS–PY, NORC DSM screen for gambling problems–past year; SCID-NP, structured clinical interview for DSM-IV-TR, non-patient edition; SOGS, South Oaks gambling screen; SOGS-DV, South Oaks gambling screen-Dutch version; TPG, target population group.

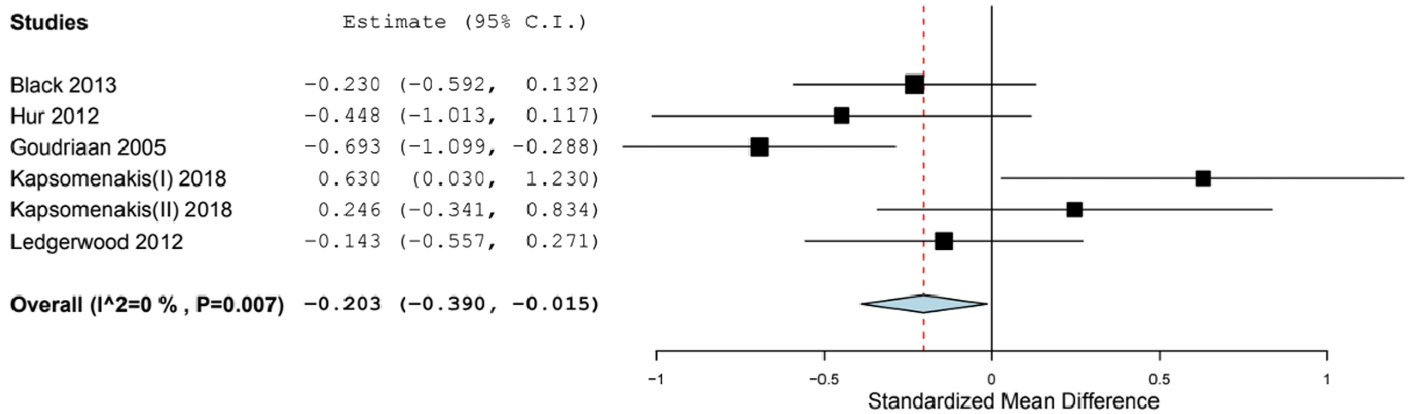

Figure 5. Forest plot of studies using controlled word association test using fixed-effects models.

working memory,[5] decision-making,[6] impulsivity,[4,7] and social cognition.[8]

Nonetheless, since the cognitive functions identified in the present review remain stable in individuals with gambling issues, their intact nature can be leveraged to improve other areas of functioning and address behavioral challenges faced by people with gambling disorder. For future treatment approaches, this information can serve as a foundation for targeting other behavioral issues more effectively. For instance, using well-preserved cognitive functions as a resource, psychotherapy can focus on enhancing self-monitoring, problem-solving, and goal-setting abilities to address gambling behaviors more directly. Attention can support sustained focus on treatment by aiding in self-regulation[30,31] and managing impulsivity.[32] Memory ensures the retention of coping strategies, personal insights, and the recall of consequences, thereby reinforcing motivation for recovery.[33] Learning enables the acquisition of new skills and behaviors essential for managing triggers.[34,35] Fluency, particularly verbal and cognitive fluency, can also play a crucial role in treatment and rehabilitation, by enabling emotional expression, articulation of challenges, processing of thoughts, effective communication, and engaging in treatment.[36]

Some limitations were also identified in this review study. The literature search did not specifically target studies focused only on the cognitive domains of attention, memory, learning, and fluency, but on a comprehensive set, potentially limiting the specificity of the findings. A limited search strategy focused on attention, memory, learning, and fluency could have provided more accurate results. The categorization of the neuropsychological tests to 1 cognitive domain was problematic, because most tests were targeting more than 1 cognitive ability. While the classification was based on prior research to address any ambiguities, this approach doesn't provide an accurate assessment of each domain. Tests were not repeated across domains, even if they measured more than 1 cognitive function. Further subgroup analysis of different gambling groups based on age, gender, education level, and gambling severity was not carried out because of unavailability of raw data; however, it could have presented more findings. Studies relying on self-reported data, rather than objective tests, were excluded, so the relationship between subjective and objective measures also remains unaddressed in the findings. Moreover, with the majority of studies having been conducted in European and American regions, it may not be entirely appropriate to generalize these findings to the global gambling population due to cultural, demographic, and regulatory differences.

The literature on the cognitive aspects of gambling is limited, particularly in areas such as learning, and figural fluency. There is a need for more primary studies exploring the above-mentioned cognitive domains from different parts of the world, before definitive conclusions can be made about whether the focus on them in the context of gambling should be reduced. This is because the existing studies are too limited to draw reliable conclusions. Some studies identifying that gamblers are better at some cognitive skills due to their gambling experience could be used as a potential rationale of a working hypothesis for future studies. Future research might also explore if these cognitive abilities can be used as a foundation structure for

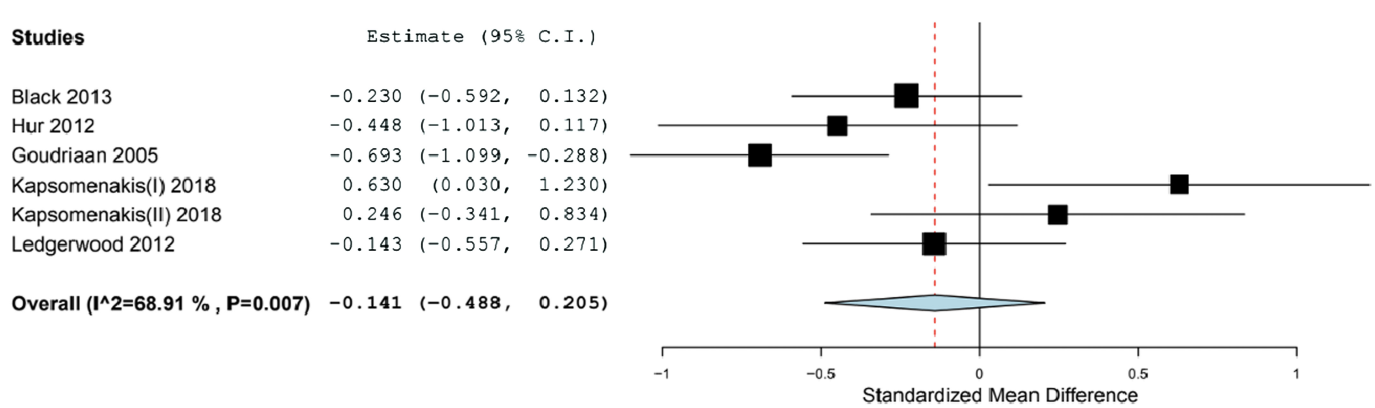

Figure 6. Forest plot of studies using controlled word association test using random-effects models.

Table 5. Studies Included in the Systematic Review of the Figural Fluency Domain

Study	Population	Criteria	Age	Education	Gender	Location	Task	Description of Task	Outcome	Scores	Results	Conclusion
Kalechstein[15]	Gamblers (n = 10)	DSM-IV PG, Gambling activity within 2 weeks of assessment.	53.7 (9.6)	13.7 (1.4)	9 ♂ 1 ♀	Regions of the Americas (California)	Ruff figural fluency test (Ruff, 1996)	N/S	Score	104.0 (21.4)	*P* > .01	GB < CPG
	Comparison subjects (n = 19)	N/A	32.5 (7.6)	13.7 (1.8)	15 ♂ 4 ♀					75.4 (22.1)		

♂, males; ♀, females; CPG, control population group; DSM-IV PG, diagnostic and statistical manual of mental disorders-iv pathological gambling criteria; N/A, not applicable; N.S., not significant; N/S, not specified; TPG, target population group.

assessments, interventions, or rehabilitation, and if so, how they can be effectively utilized.

The study concludes that gambling behavior was not associated with significant deficits in the domains of attention, memory, learning, reading, verbal fluency, or figural fluency. Since these cognitive abilities remain intact in individuals with gambling issues, they can be utilized to support treatment efforts aimed at addressing other behavioral challenges experienced by this population.

Data Availability Statement: The data that support the findings of this study are available on request from the corresponding author.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – Y.A., Y.P.S.B.; Design – Y.A., S.S., Y.P., C.B.; Supervision – S.S., Y.P.S.B.; Resources – S.S., Y.P.S.B.; Materials – Y.A., S.S., Y.P.S.B.; Data Collection and/or Processing – Y.A., P.S.N., S.S.; Analysis and/or Interpretation – Y.A., P.S.N., S.S.; Literature Search – Y.A., P.S.N.; Writing – Y.A., Y.P.S.B.; Critical Review – Y.A., P.S.N., S.S., S.S., Y.P.S.B.

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SUPPLEMENTARY FILE – I **https://drive.google.com/drive/folders/1GnyYvp6K7kdyUPmM36PxpOBMs_i2Brsn?usp=sharing**

PubMed – Search Strategy

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Scopus – Search Strategy

TITLE-ABS-KEY ("cognition") OR TITLE-ABS-KEY ("cognitive function") OR TITLE-ABS-KEY ("cognitive deficit") OR TITLE-ABS-KEY ("cognitive dysfunction") OR TITLE-ABS-KEY ("cognitive impairment") OR TITLE-ABS-KEY ("cognitive defect") OR TITLE-ABS-KEY ("neurocognition") OR TITLE-ABS-KEY ("neurocognitive function") OR TITLE-ABS-KEY ("neurocognitive deficit") OR TITLE-ABS-KEY ("neurocognitive dysfunction") OR TITLE-ABS-KEY ("neurocognitive impairment") OR TITLE-ABS-KEY ("executive function") OR TITLE-ABS-KEY ("working memory") OR TITLE-ABS-KEY ("memory impairment") OR TITLE-ABS-KEY ("attention impairment") OR TITLE-ABS-KEY ("concentration impairment") OR TITLE-ABS-KEY ("cognitive flexibility") OR TITLE-ABS-KEY ("cognitive inflexibility") OR TITLE-ABS-KEY ("response inhibition") OR TITLE-ABS-KEY ("inhibitory control") OR TITLE-ABS-KEY ("impulse control") OR TITLE-ABS-KEY ("decision making") OR TITLE-ABS-KEY ("compulsivity") OR TITLE-ABS-KEY ("set-shifting") OR TITLE-ABS-KEY ("reward sensitivity") OR TITLE-ABS-KEY ("reward processing") OR TITLE-ABS-KEY ("interference control") OR TITLE-ABS-KEY ("general cognitive functioning") OR TITLE-ABS-KEY ("motor planning") OR TITLE-ABS-KEY ("action planning") OR TITLE-ABS-KEY ("verbal fluency") OR TITLE-ABS-KEY ("visuomotor dysfunction") OR TITLE-ABS-KEY ("feedback processing") OR TITLE-ABS-KEY ("intellectual functioning") OR TITLE-ABS-KEY ("language abilities") OR TITLE-ABS-KEY ("visuospatial abilities") OR TITLE-ABS-KEY ("visuoconstructional abilities") OR TITLE-ABS-KEY ("perseveration") OR TITLE-ABS-KEY ("planning") OR TITLE-ABS-KEY ("response sensitivity") OR TITLE-ABS-KEY ("delay discounting") OR TITLE-ABS-KEY ("social cognition") AND (TITLE-ABS-KEY ("gambling") OR TITLE-ABS-KEY ("pathological gambling") OR TITLE-ABS-KEY ("problem gambling") OR TITLE-ABS-KEY ("gambling disorder") OR TITLE-ABS-KEY ("gambling addiction") OR TITLE-ABS-KEY ("compulsive gambling") OR TITLE-ABS-KEY ("gambling behaviour"))

Embase – Search Strategy

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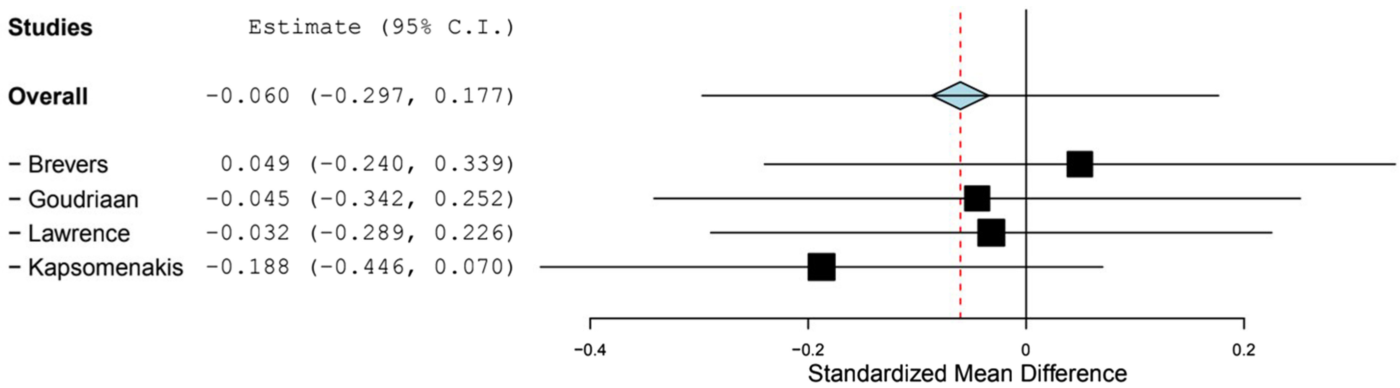
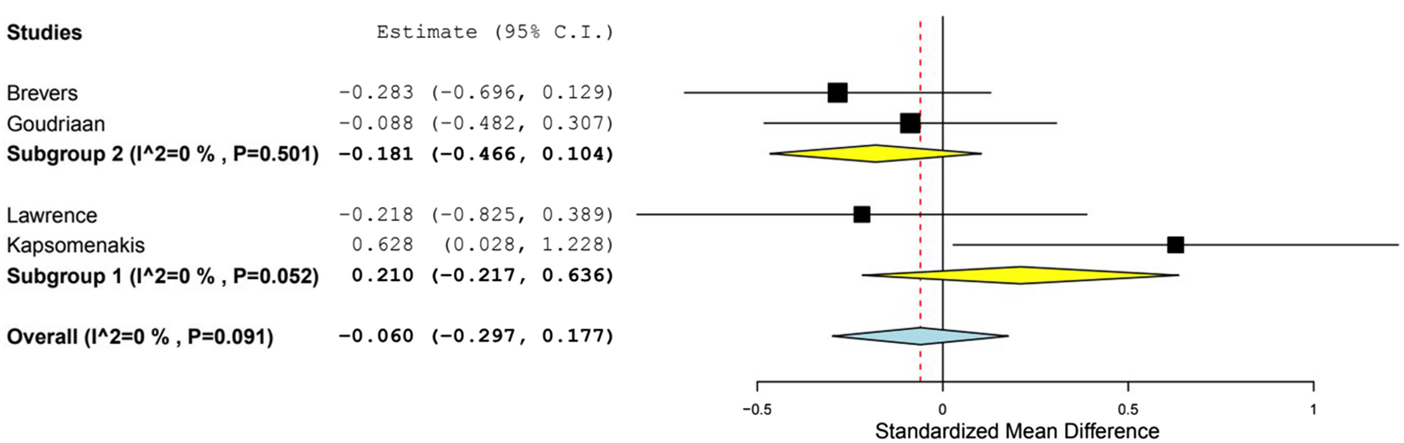
Web of Science – Search Strategy

((TS=(cognition)) OR TS=(cognitive function)) OR TS=(cognitive deficit)) OR TS=(cognitive dysfunction)) OR TS=(cognitive impairment)) OR TS=(cognitive defect)) OR TS=(neurocognition)) OR TS=(neurocognitive function)) OR TS=(neurocognitive deficit)) OR TS=(neurocognitive impairment)) OR TS=(neurocognitive dysfunction)) OR TS=(executive function)) OR TS=(working memory)) OR TS=(memory impairment)) OR TS=(attention impairment)) OR TS=(concentration impairment)) OR TS=(cognitive flexibility)) OR TS=(cognitive inflexibility)) OR TS=(cognitive inflexibility)) OR TS=(response inhibition)) OR TS=(inhibitory control)) OR TS=(impulse control)) OR TS=(decision making)) OR TS=(compulsivity)) OR TS=(set-shifting)) OR TS=(reward sensitivity)) OR TS=(reward processing)) OR TS=(interference control)) OR TS=(general cognitive functioning)) OR TS=(motor planning)) OR TS=(action planning)) OR TS=(verbal fluency)) OR TS=(visuomotor dysfunction)) OR TS=(feedback processing)) OR TS=(intellectual functioning)) OR TS=(language abilities)) OR TS=(visuospatial abilities)) OR TS=(visuoconstructional abilities)) OR TS=(perseveration)) OR TS=(planning)) OR TS=(response sensitivity)) OR TS=(delay discounting)) OR TS=(social cognition)) AND TS=(gambling)) OR TS=(pathological gambling)) OR TS=(problem gambling)) OR TS=(gambling disorder)) OR TS=(gambling addiction)) OR TS=(compulsive gambling)) OR TS=(gambling behaviour)

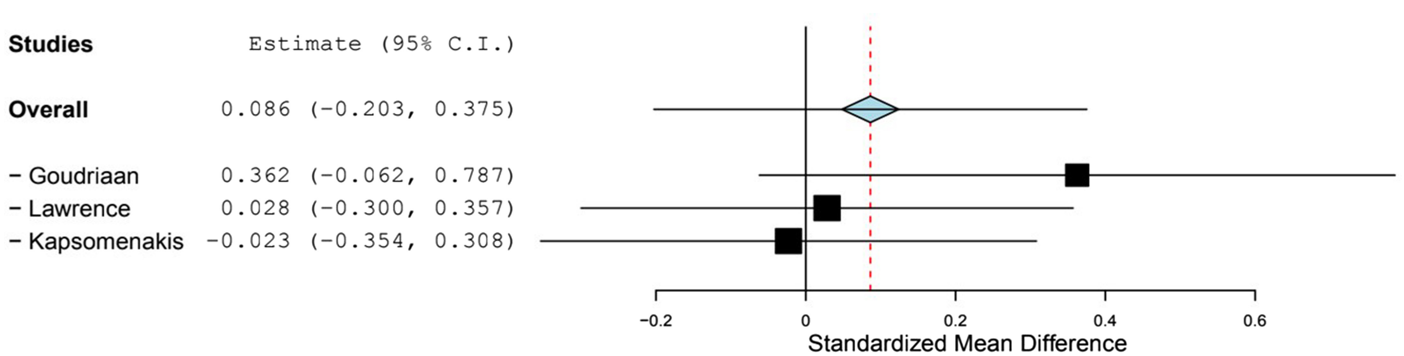
SUPPLEMENTARY FILE – II



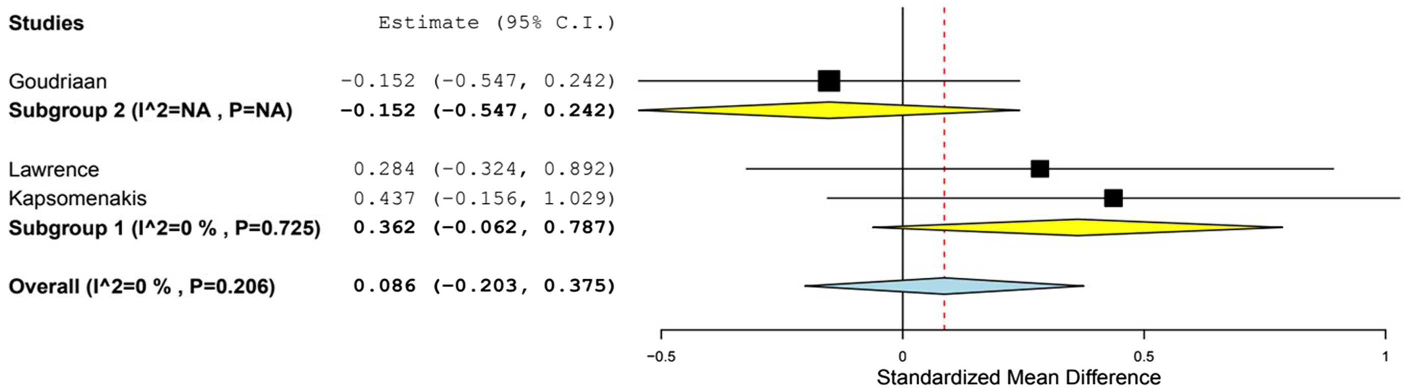
Supplementary Figure 1. Forest Plot of Studies using Digit Span Test – Forward Version using Leave-one-out Sensitivity Analysis



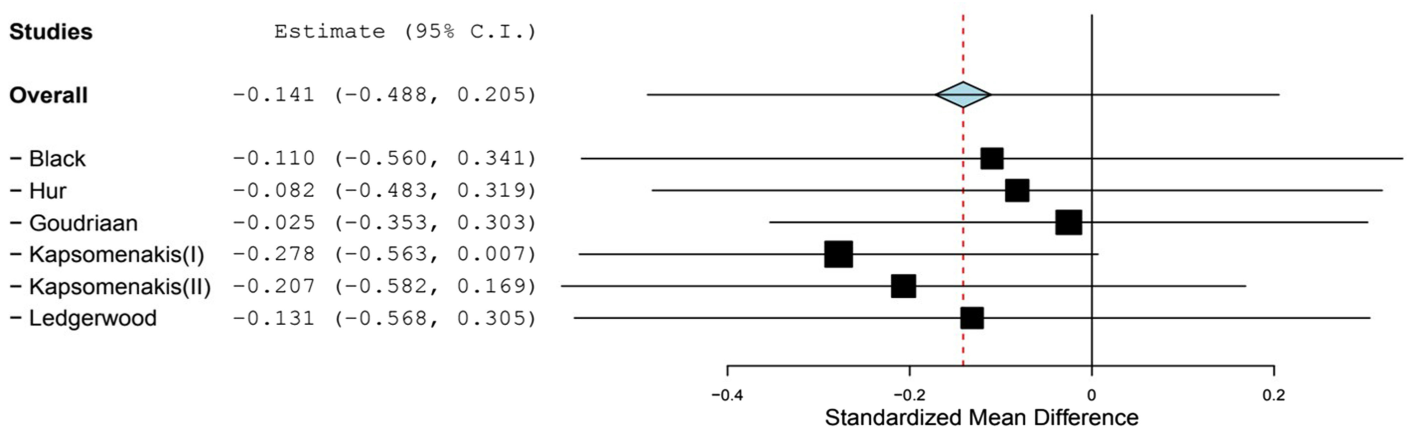
Supplementary Figure 2. Forest Plot of Studies using Digit Span Test – Forward Version using Subgroup Analysis in Terms of Risk of Bias (Subgroup 1: Low Risk of Bias; Subgroup 2: Moderate-to-High Risk of Bias).



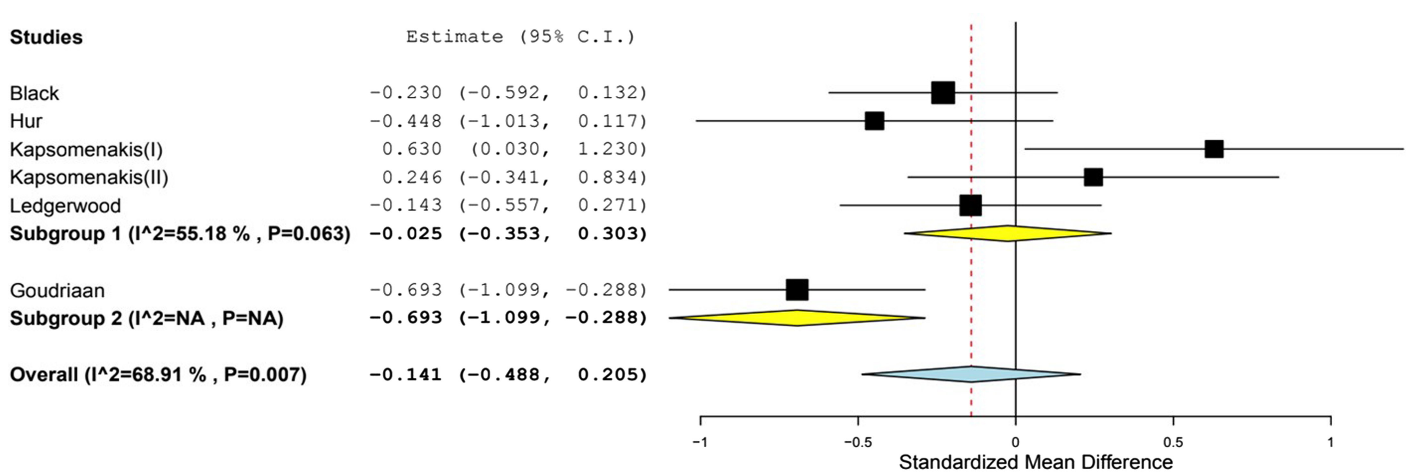
Supplementary Figure 3. Forest Plot of Studies using Digit Span Test – Backward Version using Leave-one-out Sensitivity Analysis.



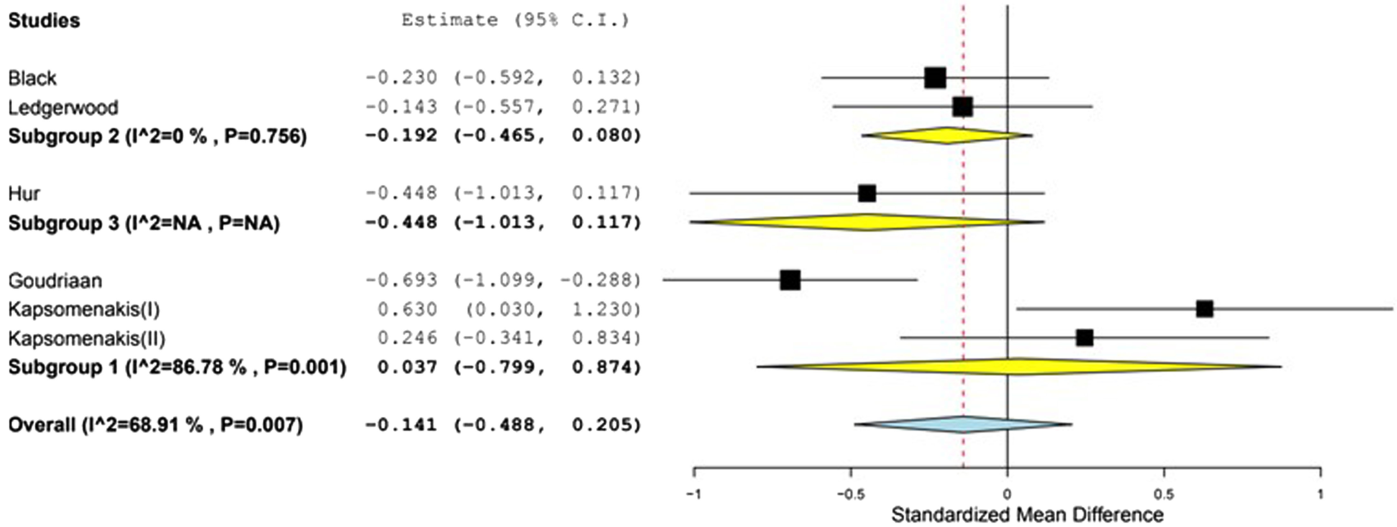
Supplementary Figure 4. Forest Plot of Studies using Digit Span Test – Backward Version using Subgroup Analysis in Terms of Risk of Bias (Subgroup 1: Low Risk of Bias; Subgroup 2: Moderate-to-High Risk of Bias).



Supplementary Figure 5. Forest Plot of Studies using Controlled Word Association Test using Leave-one-out Sensitivity Analysis



Supplementary Figure 6. Forest Plot of Studies using Digit Span Test – Backward Version using Subgroup Analysis in Terms of Risk of Bias (Subgroup 1: Low Risk of Bias; Subgroup 2: Moderate-to-High Risk of Bias).



Supplementary Figure 7. Forest Plot of Studies using Digit Span Test – Backward Version using Subgroup Analysis in Terms of Risk of Bias (Subgroup 1: European Regions 2: Regions of the Americas; Subgroup 3: Western Pacific Regions).