

The association between video game play and cognitive ability: A systematic review and meta-analysis[☆]

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ABSTRACT

As video games become increasingly prevalent in modern society, numerous studies have investigated their impact on cognitive abilities, yielding substantial yet inconsistent evidence. To systematically examine the association between video game play and cognitive ability, we conducted three meta-analyses (correlational studies, between-group comparison studies, and controlled trials) of 133 studies published between January 2005 and August 2025 (searched in September 2025), yielding 269 effect sizes from a total sample of 14,245 participants. The quality of the included studies was assessed using the Joanna Briggs Institute Critical Appraisal Checklist, with the majority rated as medium (69.93%), followed by high (25.56%) and low (4.51%). The results of the random effects model revealed a statistically significant but small correlation between video game play and cognitive ability in the domains of memory, spatial ability, visual attention, cognitive control, and intelligence across all three study designs. Moderator analyses indicated that factors such as gender, age group, health condition, game type, intervention duration, and cultural context did not significantly influence the findings. These findings suggest that playing video games may play a role in enhancing cognitive ability and provides reasonable suggestions for the better utilization of video games.

1. Introduction

Cognitive ability refers to the capacity to receive, process, store, and retrieve information, encompassing functions such as perception, memory, attention, thinking, and imagination (Solso et al., 2005). It is one of the most important psychological capacities for solving problems or navigating situations in daily life. Numerous studies have shown that cognitive abilities predict a broad spectrum of important life outcomes, behaviors, and performances (e.g., health-related behaviors, social outcomes, academic achievement, and job performance) (Hao et al., 2021; Nye et al., 2022; Stichter et al., 2018; Waters et al., 2025). However, cognitive ability declines with age (Salthouse, 2012). Some studies have shown that cognitive decline predicts higher levels of

depression, poorer decision making, and lower happiness and life satisfaction (Fechner et al., 2019; Ma et al., 2025; Mohamed Ismail et al., 2024). Given these significant implications, identifying effective methods to maintain and enhance cognitive function has become a central focus of psychological research. Cognitive training has emerged as a widely studied intervention strategy. It refers to the systematic and repeated practice of standardized tasks designed to enhance specific core cognitive abilities, with the goal of transferring these improvements to everyday functioning (Kelly et al., 2014). Such training is often delivered through structured tasks. Video games, due to their structured tasks, adjustable difficulty, immediate feedback, and engaging nature, are considered an ideal medium for implementing cognitive training (Bavelier & Davidson, 2013; Boyle et al., 2016). Recently, computer-

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based video games have increasingly attracted researchers' interest as a training tool for promoting cognitive development in children and adolescents, mitigating age-related cognitive decline in older adults, and aiding rehabilitation in clinical populations (Neugnot-Cerrioli et al., 2015).

A video game refers to an electronic game that involves human interaction with electronic devices (e.g., computer, mobile phone, and game console) through a user interface that generates visual and auditory feedback (Toril et al., 2014). This potential positive association between video game play and cognitive ability in different populations could be explained through various theories and some psychological processes. From a developmental perspective, the theory of neuroplasticity provides a critical framework for understanding how video games may enhance cognitive development in children and adolescents. Specifically, long-term gaming can trigger the remodeling of brain structure and function due to high neural plasticity of developing populations (Clemenson et al., 2018). For example, a systematic review reported that for school children and adolescents, video game play had a positive effect on executive functions (López-Serrano et al., 2021). Furthermore, the "Learning to learn" theory posits that older players can improve the ability of "meta-learning" (i.e., learn how to learn) by playing video games, and these general cognitive skills such as attention control and information processing speed can be transferred to other cognitive tasks (Bavelier et al., 2012). Indeed, several meta-analyses focusing on the elderly population suggested that video game training could enhance selective attention, memory, and executive function (Toril et al., 2016; Wang et al., 2021). In the field of clinical rehabilitation, the "common demands" theory provides valuable explanatory insights. When training tasks share similar requirements and common demands with the target functions in cognitive processing, the training effects are more likely to transfer effectively (Oei & Patterson, 2014). Video games tailored for specific clinical populations can deliver highly targeted and quantifiable rehabilitation training by simulating real-world cognitive challenges. For example, a meta-analysis showed that digital game-based training could enhance the core cognitive abilities of children with neurodevelopmental disorders (Ren et al., 2023).

Nevertheless, playing video games frequently has traditionally been considered an unfavorable form of entertainment because it can easily lead to addiction and affect physical and mental health (Leung et al., 2024). Some researchers remain skeptical about the positive cognitive effects of playing video games, arguing that video game play typically produces only "near-transfer" effects (Sala et al., 2019). This means improvements are largely confined to the video game itself or highly similar contexts, with limited evidence supporting the enhancement of "far-transfer" cognitive abilities applicable to everyday life.

Previous meta-analyses have analyzed the association between video game play and cognitive ability, involving various game genres (e.g., action video games; Bediou et al., 2018, 2023), different study designs (e.g., cross-sectional and intervention; Powers et al., 2013; Sala et al., 2018), specific age group (e.g., older adults; Toril et al., 2014), or particular cognitive skills (e.g., information processing; Wang et al., 2016). For example, meta-analyses only focusing on the action video game genre indicated that frequent players consistently outperform individuals who seldom play video games in a number of cognitive skills, while meta-analyses of interventions showed that training with an action video game results in smaller (in comparison to cross-sectional differences), but still significant improvements in cognitive skills (Bediou et al., 2018, 2023; Wang et al., 2016). Powers et al. (2013) coded game genre as a moderator using 5 categories (i.e., action/violent, mimetic, nonaction, puzzle, nonspecific) and reported that video game play led to improved information processing in both the quasi-experimental studies and the true experiments. However, Sala et al.'s (2018) meta-analyses have questioned the positive role of video games. The application of more precise effect size calculations and processing methods revealed small or null effects in their three meta-analyses on the association between video game play and cognitive ability.

These conflicting conclusions across meta-analyses might be attributed to a confluence of methodological, demographic, and game-related factors that moderate the true effect of gaming on cognition. For example, the discrepant conclusions can be partly explained by the differing inclusion criteria regarding intervention types. This is exemplified by the inclusive approach of Toril et al. (2014), who incorporated exergaming and brain-training studies, contrasting with the narrower focus of Sala et al. (2018), who excluded them. Additionally, differences in the classification of game types might also lead to confusion in their results. Only first- and third- person shooter games were included in action video games in meta-analyses of Bediou et al. (2018). While action video games contain a wider range of video games such as sport games in the meta-analyses of other authors (Powers et al., 2013; Wang et al., 2016).

The present meta-analyses aim to evaluate the impact of commercial video games on multidimensional cognitive abilities (memory, spatial ability, visual attention, cognitive control, and intelligence) and to examine potential moderators across correlational, between-group comparison, and controlled trials designs. To enhance the precision and generalizability of our findings, we introduced a more fine-grained game classification system and recruited an inclusive population that covers all age ranges from children to older adults, including both clinical and non-clinical participants. These strategies collectively enable this study to offer evidence-based guidance for designing targeted video game interventions tailored to the needs of specific populations.

2. Methods

The methodology of this meta-analysis adheres to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) (Page et al., 2021), and its protocol has been officially registered in PROSPERO under the identifier CRD420250656505. The PRISMA 2020 checklist is available in Table S1 in the Supplementary Materials.

2.1. Eligibility criteria

Studies were incorporated into this meta-analysis based on the following inclusion criteria: (1) Only empirical studies published in English or Chinese were included. (2) Population: studies involving human participants, including both healthy groups and groups with clinical conditions. (3) Exposure: commercially available, for-profit video games. "Serious games" designed primarily for cognitive enhancement (e.g., Lumosity) were excluded. In controlled trials, the video game intervention had to be administered as a standalone treatment. Studies combining the video game with another discrete intervention (e.g., video game and conventional exercise) within the same group were excluded. (4) Outcome: Research focusing on the relationship between video game exposure and five domains of cognitive ability (i.e., memory, spatial ability, visual attention, cognitive control, and intelligence; other cognitive domains were excluded) based on established frameworks in prior meta-analyses (Sala et al., 2018), whether as primary or secondary outcomes, was considered for inclusion. (5) Study design: Correlational studies, between-group comparison studies (comparing the differences in cognitive abilities between video game players and non-video game players), and controlled trials (comparing experimental groups that receive the video game intervention with control groups that receive an alternative intervention or no intervention), were considered for inclusion. (6) Data: Studies providing data or statistical information that allowed for effect size calculation, were considered for inclusion. If multiple studies used the same dataset, we prioritized the one with the most comprehensive data.

2.2. Search strategy

We conducted a comprehensive literature search in the electronic databases PubMed, Web of Science, Wiley, EBSCO, Scopus, CNKI, and Wanfang, using terms combined in the following Boolean expression (“video game” OR “video games” OR “video-game” OR “videogame” OR “computer game” OR “computer games” OR “arcade game” OR “arcade games” OR “digital game” OR “digital games”) AND (“intelligen*” OR “IQ” OR “executive function” OR “percept*” OR “cognit*” OR “attention” OR “visual” OR “vision” OR “inhibition” OR “memory” OR “motor” OR “dual task” OR “switching task” OR “flanker” OR “object tracking” OR “spatial”). Search syntax and strategies were tailored to each search engine to ensure all search terms, and their variations were considered. The literature search covered the period from January 1, 2005 and August 31, 2025. The search was conducted in September 2025. All retrieved records were imported into EndNote X9.1 software for reference management. Grey literature involving materials published outside of traditional publication channels such as dissertations and conference proceedings, was included. Further, the forward and backward citations of all eligible papers were hand-searched for relevant studies.

2.3. Selection process

Two independent reviewers performed the initial screening of titles and abstracts. Discrepancies regarding which studies required full-text review were resolved through discussion, with a third reviewer consulted for arbitration if needed. Following this, five trained reviewers independently evaluated the full-text articles for eligibility. Any disagreements arising during either stage were settled by consensus through group discussion.

2.4. Data extraction

Data extraction was performed by five researchers following the established criteria. The data extraction included: (1) Bibliographic details, specifically authors and publication dates. (2) Participants characteristics, incorporating age (M/SD), sample size, gender distribution, health condition, and country. (3) Study design. (4) Video game characteristics, incorporating game type and specific video game name. (5) Intervention details (only for controlled trials), incorporating total duration (hours), program length (weeks), the weekly frequency (sessions per week), and the time per session. (6) Effect size. (7) Outcome, specifically cognitive domains and measurement.

We categorized the computed effect sizes into five cognitive ability domains based on the specific tasks and conditions employed (Sala et al., 2018). The domains are as follows: (1) Memory, including tests such as dot matrix and recall tasks. (2) Spatial ability, including tests such as mental rotation and folding tasks. (3) Visual attention, including tests such as visual search, flanker, and useful field of view. (4) Cognitive control, including tests such as Go/No-Go, Simon, and Stroop tasks. (5) Intelligence, including tests of fluid intelligence/ reasoning (e.g., Raven's matrices) and creativity. The details of both standardized and non-standardized cognitive assessment tools and their mapping to the relevant cognitive domains are presented in Table S2 of the Supplementary Materials.

Of note, the cognitive domain was coded as the main moderator in the meta-analyses. To examine the effects of other moderators, effect sizes were first sorted by cognitive domain, and then the relative overall meta-analytic means were computed within each domain. Other six factors (gender, age group, health condition, cultural context, intervention duration, and game type) were also coded as moderators. Gender (percentage of the study sample that was female) and intervention duration (total hours; only for controlled trials) were coded as a continuous moderator. The age group was coded as children (3–11 years), adolescents (12–17 years), adults (18–54 years), and older adults (over 55 years) (Powers et al., 2013). The health condition was coded as

healthy or clinical. Cultural context was coded as Eastern or Western. Game type was coded as Multiplayer Online Battle Arena (MOBA; e.g., *League of Legends*), Real Time Strategy (RTS; e.g., *Starcraft*), Simulations (SIM; e.g., *Flight Simulator*), Shooting Game (STG; e.g., *Playerunknown's Battlegrounds*), Motion Sensing Game (MSG; e.g., *Wii Games*), Sport Game (SPG; e.g., *Riders Republic*), and Puzzle Game (PUZ; e.g., *Tetris*) (Boldi & Rapp, 2022; Homer et al., 2012).

2.5. Study quality assessment

To assess the quality of the included studies, we applied the Joanna Briggs Institute (JBI) Critical Appraisal Checklist, tailoring the tool to each study design. For correlational studies and between-group comparison studies, the JBI Checklist for Analytical Cross-Sectional Studies was used (Moola et al., 2020), which comprises eight items (e.g., “Were the study subjects and the setting described in detail”). For controlled trials, we applied the JBI Checklist for Quasi-Experimental Studies, which contains nine items (e.g., “Was there a control group”; Barker et al., 2024) and the JBI Critical Appraisal Tool for controlled trials, which consists of 13 items (e.g., “Was true randomization used for assignment of participants to treatment groups”; Barker et al., 2023). Each checklist item was rated as “Yes,” “No,” “Unclear,” or “Not applicable.” Affirmative responses were assigned 1 point, and the rest of the answers were given 0 points. Study quality assessment was completed independently by two reviewers. Discrepancies in assessments were resolved through deliberative discussion, and unresolved cases were referred to a third reviewer for final adjudication.

2.6. Effect measures

Effect sizes were calculated for each dependent variable reported in all included studies. For each independent sample, we aggregated effect sizes that measured the same construct (e.g., RTs) and came from the same test (e.g., different stimulus onset asynchronies in the UFOV task) into a single effect size. When effect sizes were statistically dependent but reflected different constructs or originated from different tests, we corrected for this dependency using the method described by Cheung and Chan (2004). The method works by calculating an adjusted N (i.e., a smaller sample size), which in turn reduces the weight assigned to dependent samples in the analysis. This approach decreases the weight assigned to dependent samples in the analysis. For studies that included multiple-group comparisons, we calculated effect sizes for each comparison separately.

2.7. Statistical data analysis

Comprehensive Meta Analysis 2.0 (CMA) was used to examine the main effects and moderating effects. The correlation coefficient r was used as our main measure of effect sizes. First, for between-group comparison studies, we converted the available statistics (i.e., M , SD , and N for each group, or t -values) into correlation coefficients r using CMA. For controlled trials, the standardized mean difference Cohen's d between the two groups was calculated with the following formula: $d = (M_{g-e} - M_{g-c}) / SD_{\text{pooled-pre}}$, where $SD_{\text{pooled-pre}}$ is the pooled standard deviation of the two pretest standard deviations, and M_{g-e} and M_{g-c} are the gain of the experimental group and the control group, respectively (Schmidt & Hunter, 2015). Cohen's d was then converted to the correlation coefficient r for the meta-analysis. During the meta-analysis, correlation coefficients were transformed to Z -scores using the Fisher's Z transformation, then meta-analyzed to obtain both a point estimate and its 95% confidence interval (CI). To facilitate interpretation of the results, Fisher's Z scores were then back-transformed to a correlation using the Fisher Z -to- r transformation.

Next, heterogeneity was evaluated using I^2 statistics, with thresholds of <25%, 25–50%, and > 75% representing low, moderate, and high heterogeneity, respectively. To investigate heterogeneity, subgroup

analyses, and meta-regression were performed. Publication bias was evaluated using Funnel plots and Egger's regression test. To reduce the analytical error, we only conducted moderator analyses for outcomes with the number of effect sizes $k > 5$ for each categorical comparison (Borenstein et al., 2009). Additionally, we implemented the Bonferroni correction across our moderator tests. Specifically, the significance level ($\alpha = 0.05$) was adjusted by dividing it by the number of moderator tests conducted. To evaluate the robustness of the findings, sensitivity analyses were performed by excluding studies with lower quality and by conducting a leave-one-out analysis.

Finally, since many studies reported both accuracy and reaction time (RT) data for the same tasks in controlled trials, we included both measures to provide a comprehensive assessment of cognitive performance.

3. Results

3.1. Study selection process

A systematic database search identified 46,340 records,

supplemented by 5 records from manual searches. After deduplication, 32,357 records were screened by title and abstract, resulting in 203 full-text articles assessed. Following evaluation, 85 articles were excluded, leaving 118 articles comprising 133 studies for final inclusion. The selection process is detailed in the PRISMA flow diagram (see Fig. 1).

3.2. Study characteristics

A total of 118 articles ($n = 118$) comprising 133 independent studies ($m = 133$) were included in the meta-analysis, with an overall sample size of 14,245 participants ($N = 14,245$). The included studies consisted of 17 correlational studies, 94 between-group comparison studies, and 22 controlled trials.

All correlational studies ($m = 17$, $N = 6263$, 2958 males, age range 4.64–34.2 years) were conducted with healthy populations, which comprised children ($m = 5$, $N = 1990$, 1045 males), adolescents ($m = 7$, $N = 2591$, 1135 males), and adults ($m = 5$, $N = 1682$, 778 males). A diverse age range was observed in the quasi-experimental studies ($m = 94$, $N = 6970$, 4163 males, age range 9–38 years). The vast majority recruited adults ($m = 83$, $N = 5222$, 3248 males), followed by

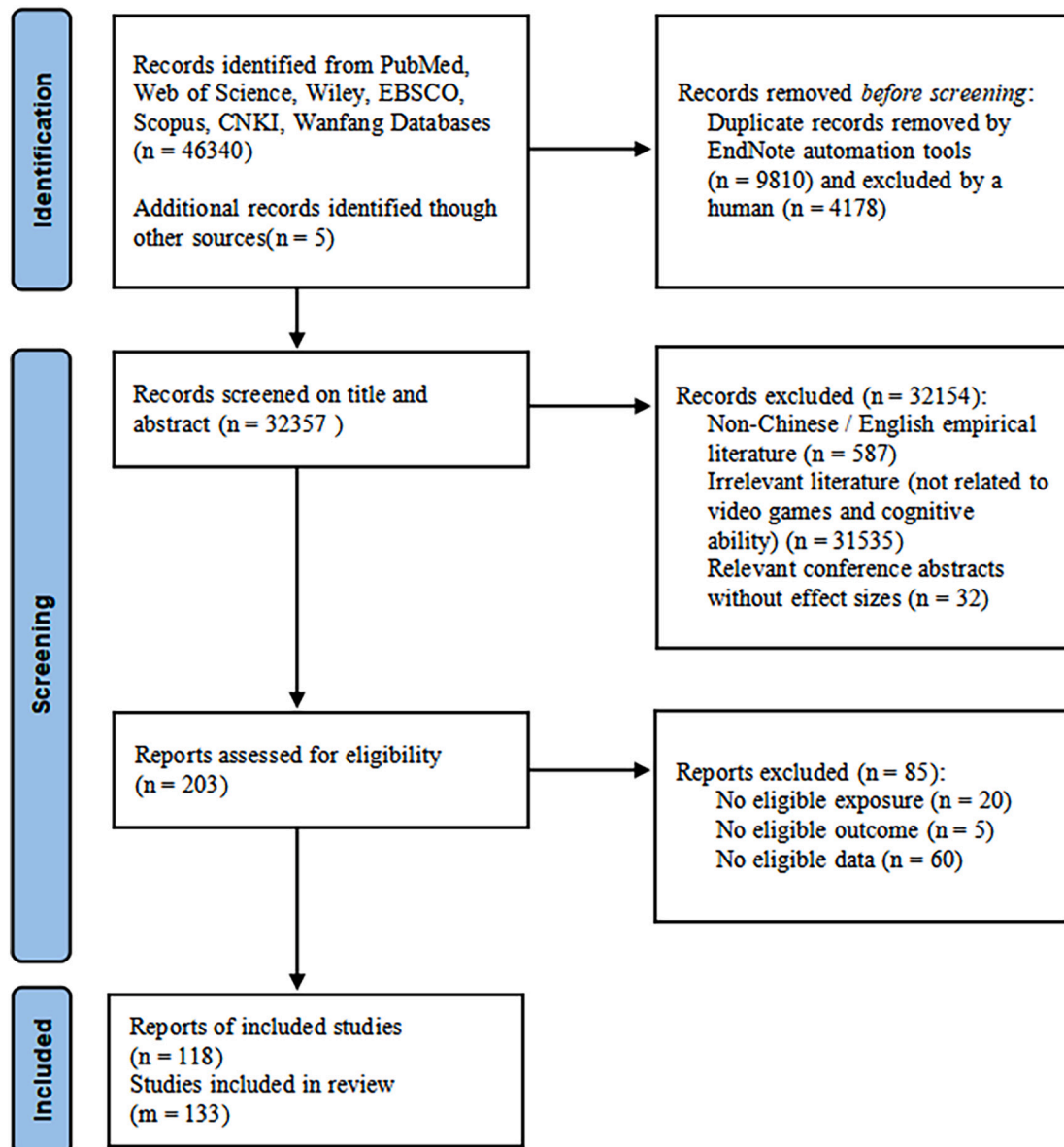


Fig. 1. PRISMA flowchart of study selection process.

adolescents ($m = 10$, $N = 1643$, 851 males) and children ($m = 1$, $N = 105$, 64 males). In terms of health condition, most studies ($m = 89$) focused on healthy samples, while a minority ($m = 5$) involved clinical participants diagnosed with internet gaming disorder. Regarding the controlled trials ($m = 22$, $N = 1012$, 431 males, age range 4.52–74.82 years), the samples included older adults ($m = 11$, $N = 478$, 139 males), adults ($m = 9$, $N = 398$, 224 males), and children ($m = 2$, $N = 136$, 68 males). Five studies enrolled clinical participants diagnosed with depression, schizophrenia, chronic schizophrenia, or multiple sclerosis, and the remainder were conducted with healthy samples. Detailed characteristics of the included studies are summarized in Table 1.

3.3. Quality assessment results

Study quality was evaluated based on the scores it achieved, where scores <50% were identified as low quality, 50%–80% as medium quality, and > 80% as high quality (Andrade, 2019). Among the included correlational studies, 23.53% were rated as high quality, 70.59% as medium quality, and 5.88% as low quality. For between-group comparison studies, 15.96% were rated as high quality, 78.72% as medium quality, and 5.32% as low quality. Among the controlled trials, 31.82% were rated as medium quality and 68.18% as high quality. The quality scores for the included studies are detailed in Tables 2a–2c.

3.4. Meta-analysis of correlational studies

3.4.1. Average effect

A random-effects meta-analysis ($k = 20$) indicated a statistically significant yet weak positive correlation between video game play and cognitive ability. The overall effect size was $r = 0.162$, 95% CI [0.047, 0.272], $p = 0.006$. A high degree of heterogeneity was evident in the effect sizes ($I^2 = 95.21\%$), which justified the use of a random-effects model. We calculated the overall correlations of the five outcome measures. Significant correlations were found only in memory ($r = 0.182$, $p < 0.001$). The results of average effects, sorted by cognitive domains, are present in Table 3. The forest plot of correlational studies is provided in Fig. 2.

3.4.2. Moderating effect

Three moderating factors were examined in the meta-analysis of correlational studies. A meta-regression analysis was conducted for gender (percentage of females), and subgroup analyses were conducted for age group and cultural context. To minimize statistical errors, we applied the Bonferroni correction to moderator analyses, adjusting the significance level α to 0.016. The results showed that the moderating effects of gender ($Q = 2.53$, $p = 0.112$), age group ($Q = 2.907$, $p = 0.234$) and cultural context ($Q = 4.545$, $p = 0.033$) were not significant.

3.4.3. Publication bias

Funnel plots and Egger's regression test were used to assess publication bias. Visual inspection of the funnel plots (see Fig. S1 in the Supplementary Materials) revealed basic symmetry, suggesting no obvious publication bias. To further validate this finding, we then used Egger's regression test to assess funnel plot asymmetry (Egger et al., 1997). Egger's test was not significant ($p = 0.828$). Thus, the results suggested that publication bias was not present in this meta-analysis.

3.4.4. Sensitivity analysis

Sensitivity analyses were conducted by excluding low-quality studies and by conducting a leave-one-out analysis. The pooled correlation coefficient excluding the single lower-quality study was slightly attenuated but remained statistically significant ($k = 19$, $r = 0.138$, 95% CI [0.025, 0.247], $I^2 = 94.70\%$), compared to the primary analysis that included all studies ($k = 20$, $r = 0.162$, 95% CI [0.047, 0.272], $I^2 = 95.21\%$). Heterogeneity remained consistently high in both analyses. Furthermore, the leave-one-out analysis showed that the pooled estimates did not

change significantly when each study was omitted in turn, indicating that the results were robust (see Fig. S2 in the Supplementary Materials).

3.5. Meta-analysis of between-group comparison studies

3.5.1. Average effect

A random-effects meta-analysis ($k = 173$) indicated a statistically significant yet weak positive correlation between video game play and cognitive ability. The overall effect size was $r = 0.220$, 95% CI [0.129, 0.306], $p < 0.001$. This result shows that video gamers have better cognitive performance than non-video gamers. A high degree of heterogeneity was evident in the effect sizes ($I^2 = 96.63\%$), justifying the use of a random-effects model. We calculated the overall correlations of the five outcome measures. Significant correlations were found in video game play with spatial ability ($r = 0.233$, $p = 0.011$), visual attention ($r = 0.241$, $p < 0.001$), cognitive control ($r = 0.223$, $p = 0.010$), and intelligence ($r = 0.167$, $p = 0.009$). The results of average effects sorted by cognitive domains are presented in Table 4. For clearer presentation of the results, the forest plots for between-group comparison studies are displayed separately by cognitive domains (Fig. 3a–e).

3.5.2. Moderating effect

Five moderating factors were examined in the meta-analysis of between-group comparison studies. A meta-regression analysis was conducted for gender (percentage of females), and subgroup analyses were conducted for age group, cultural context, health condition, and game type. To minimize statistical errors, we applied the Bonferroni correction to moderator analyses, adjusting the significance level α to 0.01. The results showed that moderating effects of gender ($Q = 0.33$, $p = 0.563$), age group ($Q = 0.298$, $p = 0.862$), cultural context ($Q = 1.061$, $p = 0.303$), and health condition ($Q = 0.792$, $p = 0.374$) were not significant. Game type was marginally significant ($Q = 12.71$, $p = 0.013$).

3.5.3. Publication bias

Funnel plots and Egger's regression test were used to assess publication bias. Visual inspection of the funnel plots (see Fig. S3 in the Supplementary Materials) revealed basic symmetry, suggesting no obvious publication bias. To further validate this finding, we then used Egger's regression test to assess funnel plot asymmetry. Egger's test was not significant ($p = 0.321$). Thus, the results suggested that publication bias was not present in this meta-analysis.

3.5.4. Sensitivity analysis

Sensitivity analyses were performed by excluding lower-quality studies and by conducting a leave-one-out analysis. The pooled correlation coefficient excluding the lower-quality studies was slightly attenuated but remained statistically significant ($k = 168$, $r = 0.215$, 95% CI [0.121, 0.305], $I^2 = 96.64\%$), compared to the primary analysis that included all studies ($k = 173$, $r = 0.220$, 95% CI [0.129, 0.306], $I^2 = 96.63\%$). Heterogeneity remained consistently high in both analyses. Furthermore, the leave-one-out analysis showed that the pooled estimates did not change significantly when each study was omitted in turn, indicating that the results were robust (see Fig. S4a–e in the Supplementary Materials).

3.6. Meta-analysis of controlled trials

3.6.1. Average effect

A random-effects meta-analysis ($k = 76$) indicated a statistically significant yet weak positive correlation between video game play and cognitive ability. The overall effect size was $r = 0.088$, 95% CI [0.024, 0.152], $p = 0.007$. This result demonstrates that video game intervention has a positive effect on cognitive performance. A moderate degree of heterogeneity was evident in the effect sizes ($I^2 = 66.62\%$). We calculated the overall correlations of the five outcome measures. A significant correlation was found only in video game play for memory (r

Table 1
Characteristics of included studies in the meta-analysis.

Authors, Year	Study design	Sample size	Gender distribution	Age group-M _{age} (SD)	Health condition	Country	Game type	Intervention details	Outcomes	Measurement	Publication
Sjowall, 2010	Correlational studies	295	127 males; 168 females	Adolescents-12.2 (4.5)	Healthy	Sweden	Multiple Games-Action, Strategy	/	Memory	The Automated Working Memory Assessment test	Unpublished
Ji & Wang, 2010	Correlational studies	619	/	Adolescents-12–16	Healthy	China	Multiple Games-Strategy, Action, Shooting, Puzzle	/	Intelligence	The Intrapersonal Intelligence Scale	Published
Ferguson, 2011	Correlational studies	603	309 males; 294 females	Adolescents-12.35 (1.34)	Healthy	USA	/	/	Visual attention	The Child Behavior Checklist	Published
Jackson et al., 2012	Correlational studies	395	231 males; 209 females	Adolescents-12.34	Healthy	USA	Multiple Games-Sport, Violent, Action, Racing, and Others	/	Intelligence	The Torrance Tests of Creative Thinking	Published
Ferguson et al., 2013	Correlational studies	333	161 males; 172 females	Adolescents-12.76 (1.88)	Healthy	Spain	/	/	Spatial ability	The Matrices Subscale on the Kaufman Brief Intelligence Test-II	Published
Holfeld et al., 2015	Correlational studies	212	95 males; 117 females	Adults-21.08 (2.91)	Healthy	USA	Multiple Games-Action	/	Cognitive control	The Executive Functioning Inventory	Published
Motamedi & Yaghoubi, 2015	Correlational studies	300	300 males; 0 females	Adolescents-high school students	Healthy	Iran	Multiple Games-Educational, Sports, Adventure, Action	/	Spatial ability	The Newton and Bristol Spatial Ability Questionnaire	Published
Lau et al., 2017	Correlational studies	46	7 males; 39 females	Adolescents-16.98 (0.54)	Healthy	England	Puzzle Game-Tetris	/	Intelligence; cognitive control	The WAIS-III Matrix Reasoning Subtest; The Peabody Picture Vocabulary Test; The Automated Working Memory Assessment	Published
Blanco-Herrera et al., 2019	Correlational studies	352	162 males; 190 females	Adults-19.33 (1.67)	Healthy	USA	Multiple Games-Minecraft, NASCAR	/	Intelligence	The Alien Drawing Task	Published
Waris et al., 2019	Correlational studies	503	219 males; 283 females	Adults-34.2 (10.6)	Healthy	USA	Multiple Games-Card, Mobile, Action, Shooting, Exercise, Adventure, Puzzle, Role-playing, Simulation, Strategy, Educational	/	Cognitive control	N-back Task	Published
Yang et al., 2020	Correlational studies	119	58 males; 61 females	Children-4.64 (0.92)	Healthy	China	/	/	Cognitive control	Backward Digit Span Task, Stroop Task, Simon Task, Flanker Task, Tower of Hanoi Task (A Composite Score)	Published
Huang, 2020	Correlational studies	1126	605 males; 521 females	Children-9.83 (0.64)	Healthy	China	/	/	Cognitive control	Executive Functioning Rating Scale	Unpublished
Samson et al., 2021	Correlational studies	154	77 males; 77 females	Children-5.43	Healthy	Canada	Multiple Games-Fast/Low reaction	/	Visual attention	The Early Childhood Attention Battery	Published
Jadallah et al., 2023	Correlational studies	160	78 males; 82 females	Children- 11.67 (4.43)	Healthy	USA	Multiple Games-Action, Sports, Fighting, Role playing, Simulation, Music, Educational, Others	/	Intelligence	Cognitive Ability Test	Published
Xu et al., 2023	Correlational studies	431	227 males; 204 females	Children- 5.13 (1.24)	Healthy	China	Multiple Games-Puzzle, Action, Simulation, Art,	/	Cognitive control	The Children's Executive Functioning Inventory	Published

(continued on next page)

Table 1 (continued)

Authors, Year	Study design	Sample size	Gender distribution	Age group-M _{age} (SD)	Health condition	Country	Game type	Intervention details	Outcomes	Measurement	Publication
Zioga et al., 2024	Correlational studies	88	43 males; 45 females	Adults-28.39 (4.68)	Healthy	USA	Sports, Adventure, Role playing, Others Multiple Games-Sports, Shooting, Role playing, Action, Strategy, Puzzle	/	Memory; cognitive control; visual attention	Corsi Block Test; Digit Span Test; Deary-Liewald Choice Reaction Time Task	Published
Cudo et al., 2025	Correlational studies	527	259 males; 268 females	Adults-22.12 (2.84)	Healthy	Poland	Multiple Games-Shooting, Adventure, Sports, Strategy, Role-playing, Simulation, Music, Others	/	Cognitive control	The Operation Span Task and Symmetry Span Task	Published
Castel et al., 2005	Comparison studies	20 experiment; 20 control	38 males; 2 females	Adults-20.9	Healthy	USA	Multiple Games-Super Mario, Max Payne, Unreal Tournament, Counter-Strike, Zelda, NHL2002, Soul Calibur, Quake III, F-Zero, Grand Theft Auto3	/	Visual attention	Cueing Paradigm	Published
Satyen, 2005	Comparison studies	13 experiment; 12 control	0 males; 25 females	Adults-19.88 (2.39)	Healthy	Australia	Puzzle Game-Banjo Kazoie	/	Memory	Free Recall Tasks; Cued Recall Tasks	Unpublished
Green & Bavelier, 2006 ^a	Comparison studies	8 experiment; 8 control	16 males; 0 females	Adults-21.25	Healthy	USA	Multiple Games-Grand Theft Auto, Half-Life, Counter-Strike, Marvel vs. Capcom, Rogue Spear, Super Mario Kart	/	Visual attention	The Perceptual Load Paradigm	Published
Green & Bavelier, 2006 ^b	Comparison studies	8 experiment; 8 control	16 males; 0 females	Adults-19.8	Healthy	USA	Multiple Games-Grand Theft Auto, Half-Life, Counter-Strike, Marvel vs. Capcom, Rogue Spear, Super Mario Kart	/	Visual attention	The Useful Field of View Task	Published
Zaparyniuk, 2006	Comparison studies	34 experiment; 31 control	44 males; 21 females	Adults-21.45	Healthy	Canada	Puzzle Game	/	Memory	The Canadian Test of Cognitive Skills Test	Unpublished
Zetu, 2007	Comparison studies	11 experiment; 11 control	19 males; 3 females	Adults-23.5 (0.35)	Healthy	Canada	Multiple Games-Halo, Counterstrike, Doom, Half-Life, Need for Speed, NHL2002	/	Visual attention	The Useful Field of View Task	Unpublished
Li & Lv, 2008	Comparison studies	176 experiment; 95 control	148 males; 123 females	Adolescents-junior high school students	Healthy	China	/	/	Intelligence	IMAP Potential Assessment	Published
Dye et al., 2009	Comparison studies	56 experiment; 69 control	70 males; 55 females	Adolescents-13.24 (0.96)	Healthy	USA	Multiple Games-Action, Non-action	/	Visual attention	The Attentional Network Test	Published

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Table 1 (continued)

Authors, Year	Study design	Sample size	Gender distribution	Age group-M _{age} (SD)	Health condition	Country	Game type	Intervention details	Outcomes	Measurement	Publication
Li, 2009	Comparison studies	218 experiment; 213 control	182 males; 249 females	Adolescents-high school students	Healthy	China	Multiple Games-Role playing, Strategy, Sports, Simulation, Music, Puzzle, Educational	/	Intelligence	Williams Creative Assessment Packet	Unpublished
Murphy & Spencer, 2009	Comparison studies	32 experiment; 29 control	61 males; 0 females	Adults-20.56 (2.41)	Healthy	Australia	/	/	Visual attention	Attentional Blink Task	Published
Zhang et al., 2009	Comparison studies	9 experiment; 9 control	/	Adults-19–25	Healthy	China	Shooting Game-Counter-Strike	/	Visual attention	Flanker Compatibility Effect Paradigm	Published
Bailey et al., 2010	Comparison studies	25 experiment; 26 control	51 males; 0 females	Adults-18–33	Healthy	USA	Multiple Games-Counter-Strike, Grand Theft Auto, Resident Evil, Unreal Tournament	/	Cognitive control	Stroop Task	Published
Chisholm et al., 2010	Comparison studies	15 experiment; 17 control	32 males; 0 females	Adults-21.3	Healthy	Canada	Multiple Games-Action	/	Visual attention	Attentional Capture Task	Published
Irons et al., 2011	Comparison studies	19 experiment; 13 control	32 males; 0 females	Adults-19.16	Healthy	Australia	Shooting Game	/	Visual attention	Flanker Compatibility Effect Paradigm	Published
Zhai, 2011	Comparison studies	30 experiment; 30 control	60 males; 0 females	Adults-20.06 (1.96)	Healthy	China	Multiple Games-Puzzle, Sports, Shooting	/	Cognitive control	Stop-signal Paradigm	Unpublished
Li et al., 2011	Comparison studies	17 experiment; 20 control	32 males; 5 females	Adults-18.12 (1.42)	Clinical-internet gaming disorder	China	/	/	Cognitive control	The Revised Paradigm of Event-related Design	Published
Green et al., 2012 ^a	Comparison studies	8 experiment; 10 control	18 males; 0 females	Adults-19.37	Healthy	USA	Multiple Games-Action, Non-action	/	Cognitive control	Task-Switching Paradigm	Published
Green et al., 2012 ^b	Comparison studies	14 experiment; 14 control	28 males; 0 females	Adults-20.6	Healthy	USA	Multiple Games-Action, Non-action	/	Cognitive control	Task-Switching Paradigm	Published
Green et al., 2012 ^c	Comparison studies	12 experiment; 14 control	26 males; 0 females	Adults-20.15	Healthy	USA	Multiple Games-Action, Non-action	/	Cognitive control	Task-Switching Paradigm	Published
Wallace, 2012	Comparison studies	56 experiment; 49 control	64 males; 41 females	Children- 9-12	Healthy	USA	Multiple Games-Action, Non-action	/	Visual attention	The ADHD-Rating Scale IV	Unpublished
He, 2012 ^a	Comparison studies	28 experiment; 24 control	52 males; 0 females	Adults-Undergraduate	Healthy	China	/	/	Cognitive control	The Emotional Stroop Paradigm	Unpublished
He, 2012 ^b	Comparison studies	13 experiment; 15 control	28 males; 0 females	Adults-Undergraduate	Healthy	China	/	/	Cognitive control	Task-Switching Paradigm	Unpublished
He, 2012 ^c	Comparison studies	15 experiment; 15 control	30 males; 0 females	Adults-Undergraduate	Healthy	China	/	/	Cognitive control	The Keep-tracking Paradigm	Unpublished
Song et al., 2012	Comparison studies	89 experiment; 56 control	/	Adolescents-high school students	Healthy	China	Multiple Games-Simulation, Puzzle	/	Intelligence	Torrance Tests of Creative Thinking	Published
Strobach et al., 2012	Comparison studies	10 experiment; 10 control	20 males; 0 females	Adolescents-25.1 (6.3)	Healthy	Germany	Multiple Games-Action, Non-action	/	Cognitive control	Dual-task Test; Task-Switching Paradigm	Published

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Table 1 (continued)

Authors, Year	Study design	Sample size	Gender distribution	Age group-M _{age} (SD)	Health condition	Country	Game type	Intervention details	Outcomes	Measurement	Publication
Zhang et al., 2012 ^a	Comparison studies	19 experiment; 20 control	39 males; 0 females	Adults-21.5	Healthy	China	Multiple Games-Action	/	Cognitive control	Go/No-Go Task	Published
Zhang et al., 2012 ^b	Comparison studies	18 experiment; 19 control	37 males; 0 females	Adults-22.12	Healthy	China	Multiple Games-Action	/	Cognitive control	Antisaccade Task	Published
Zhang et al., 2012	Comparison studies	26 experiment; 24 control	43 males; 7 females	Adults-21.46 (2.2)	Healthy	China	Multiple Games-StarCraft, World of Warcraft, Warcraft, Counter-Strike, CrossFire, Candy Crush	/	Visual attention; cognitive control	Color Trail Test; Stroop Task	Published
Colzato et al., 2013	Comparison studies	26 experiment; 26 control	48 males; 4 females	Adults-23.1 (3.85)	Healthy	the Netherlands	Shooting Game	/	Intelligence; cognitive control	Raven Standard Progressive Matrices; N-Back Task	Published
Lu et al., 2013	Comparison studies	15 experiment; 15 control	30 males; 0 females	Adolescents-High school students	Healthy	China	/	/	Visual attention	Attention Focus Task; Attention Span Task	Published
Zhu, 2013 ^a	Comparison studies	10 experiment; 13 control	23 males; 0 females	Adults-21.57 (2.63)	Healthy	China	Shooting Game	/	Visual attention; cognitive control	Multiple Object Tracking Task	Published
Zhu, 2013 ^b	Comparison studies	10 experiment; 13 control	23 males; 0 females	Adults-21.13 (1.44)	Healthy	China	Shooting Game	/	Visual attention; cognitive control	Multiple Object Tracking Task	Published
Collins & Freeman, 2014	Comparison studies	46 experiment; 20 control	51 males; 15 females	Adults-22.61 (4.48)	Healthy	UK	/	/	Memory; spatial ability; visual attention; cognitive control	The Visual Short Term Memory Task; Mental Rotation Task; Flanker Compatibility Effect Paradigm; Task-Switching Paradigm	Published
Hollis, 2014	Comparison studies	57 experiment; 107 control	48 males; 116 females	Adults-18.8 (1.4)	Healthy	USA	/	/	Memory; spatial ability; cognitive control	Repeatable Battery of Neuropsychological Status; Stroop Task	Unpublished
Patton, 2014	Comparison studies	30 experiment; 30 control	60 males; 0 females	Adults-19.8 (1.56)	Healthy	USA	Multiple Games-Shooting, Sports, Strategy, Music	/	Visual attention; cognitive control	Cancellation Task; Digit Span Test	Unpublished
Li et al., 2014	Comparison studies	16 experiment; 15 control	31 males; 0 females	Adults-21 (2)	Healthy	China	/	/	Cognitive control	Go/No-Go Task	Published
Zhang et al., 2014	Comparison studies	14 experiment; 14 control	28 males; 0 females	Adults-21.4	Clinical-internet gaming disorder	China	/	/	Cognitive control	Attentional Focus Switching Task	Published
Buelow et al., 2015	Comparison studies	91 experiment; 137 control	114 males; 114 females	Adults-19.23 (2.59)	Healthy	USA	/	/	Cognitive control	The Wisconsin Card Sorting Task	Published
Chisholm & Kingstone, 2015	Comparison studies	28 experiment; 29 control	57 males; 0 females	Adults-20.5	Healthy	Canada	Multiple Games-Action	/	Visual attention	Oculomotor Capture Task	Published

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Authors, Year	Study design	Sample size	Gender distribution	Age group-M _{age} (SD)	Health condition	Country	Game type	Intervention details	Outcomes	Measurement	Publication
de Castell et al., 2015 ^a	Comparison studies	23 experiment; 22 control	16 males; 29 females	Adults-21.49	Healthy	Canada	/	/	Spatial ability	Mental Rotation Task	Published
de Castell et al., 2015 ^b	Comparison studies	19 experiment; 18 control	16 males; 21 females	Adults-22	Healthy	Canada	/	/	Spatial ability	Mental Rotation Task	Published
Dobrowolski et al., 2015	Comparison studies	56 experiment; 30 control	80 males; 6 females	Adults-23.23 (4.27)	Healthy	Poland	Multiple Games-Strategy, Shooting	/	Visual attention; cognitive control	Multiple Object Tracking Task; Task-Switching Paradigm	Published
Novak & Tassell, 2015	Comparison studies	10 experiment; 10 control	5 males; 15 females	Adults-18–24	Healthy	USA	Multiple Games-Action, Non-action	/	Spatial ability; cognitive control	Mental Rotation Task; Working Memory Operation Span Computer-based Assessment	Published
Steenbergen et al., 2015	Comparison studies	18 experiment; 18 control	28 males; 8 females	Adults-21.8 (0.85)	Healthy	the Netherlands	Shooting Game	/	Cognitive control	The Stop-change Paradigm	Published
Unsworth et al., 2015	Comparison studies	18 experiment; 29 control	/	Adults-19.49 (1.75)	Healthy	USA	Shooting Game	/	Intelligence; visual attention; cognitive control	Raven's Advanced Progressive Matrices Task; Antisaccade Task; Operation Span Task	Published
Zhang et al., 2015	Comparison studies	42 experiment; 41 control	83 males; 0 females	Adults-21.15 (0.3)	Healthy	China	/	/	Memory; visual attention; cognitive control	Auditory Verbal Learning Test; The Trail Making Test; Iowa Gambling Task	Published
Li et al., 2016	Comparison studies	14 experiment; 14 control	28 males; 0 females	Adults-21.5	Healthy	China	Multiple Games-Counter-Strike, Call of Duty, Grand Theft Auto, Battlefield, Assassin's Creed, Team Fortress	/	Visual attention	Visuomotor-Control Task	Published
Weinstein et al., 2016	Comparison studies	20 experiment; 20 control	38 males; 2 females	Adults-24.55	Healthy	Israel	/	/	Cognitive control	The Balloon Analogue Risk Take	Published
Wei, 2016 ^a	Comparison studies	30 experiment; 30 control	34 males; 26 females	Adults-19.28	Healthy	China	Multiple Games-Action adventure, Role-playing, MOBA, Puzzle, Simulation	/	Visual attention	Stroop Task	Unpublished
Wei, 2016 ^b	Comparison studies	30 experiment; 30 control	41 males; 19 females	Adults-19.27	Healthy	China	Multiple Games-Action adventure, Role-playing, MOBA, Puzzle, Simulation	/	Visual attention	Bilateral Flanker Task	Unpublished
Zhang, 2016	Comparison studies	18 experiment; 20 control	/	Adults-18–25	Healthy	China	/	/	Cognitive control	Stroop Task	Unpublished
Zhen et al., 2016	Comparison studies	35 experiment; 31 control	66 males; 0 females	Adults-19–21	Healthy	China	Multiple Games-Action	/	Cognitive control	Stop-signal Paradigm	Published
Huang et al., 2017	Comparison studies	34 experiment; 29 control	31 males; 32 females	Adults-20.59 (2.78)	Healthy	Canada	Multiple Games-Action, Non-action	/	Cognitive control	Go/No-Go Task; N-Back Task	Published

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Authors, Year	Study design	Sample size	Gender distribution	Age group-M _{age} (SD)	Health condition	Country	Game type	Intervention details	Outcomes	Measurement	Publication
Wang et al., 2017	Comparison studies	84 experiment; 82 control	89 males; 77 females	Adults-45.84 (18.4)	Healthy	China	Multiple Games-Action, Mimetic, Puzzle, Card/Chess	/	Memory; spatial ability; visual attention; cognitive control	Wordlist Recall; The Rey Complex Figure Test; Attention Cancellation and Network Test; Number Switch Task; Stroop Task; Trail Making Test; N-Back Task	Published
Kowal et al., 2018	Comparison studies	102 experiment; 53 control	120 males; 35 females	Adults-21.4 (2.5)	Healthy	Ireland	Multiple Games-Action, Non-action	/	Visual attention; cognitive control	The Trail Making Test; Stroop Task	Published
Qiu et al., 2018	Comparison studies	15 experiment; 14 control	29 males; 0 females	Adults-22.76 (0.19)	Healthy	China	MOBA-League of Legends	/	Visual attention	The Useful Field of View Task	Published
Trisolini et al., 2018	Comparison studies	30 experiment; 15 control	28 males; 17 females	Adolescents-15 (0.83)	Healthy	Italy	Multiple Games-Action, Non-action	/	Visual attention	Visual Enumeration Task	Published
Whynott, 2018	Comparison studies	52 experiment; 25 control	43 males; 34 females	Adults-18–22	Healthy	USA	Multiple Games-Exploratory/Constructive Don't Starve	/	Intelligence	The Alternate Uses Task; Wallach and Kogan Instances Assessment of Creativity	Unpublished
Feng, 2018	Comparison studies	11 experiment; 11 control	22 males; 0 females	Adults-26	Healthy	China	Shooting Game-Counter Strike	/	Visual attention	Eye Tracking Task	Unpublished
Özçetin et al., 2019	Comparison studies	46 experiment; 31 control	70 males; 7 females	Adolescents-12.52 (1.93)	Healthy	Turkey	Multiple Games-Role-playing, Shooting, Strategy, Action/Adventure, Survival/Platformer	/	Memory; visual attention; cognitive control	The California Verbal Learning Test-Children's Version; Benton Visual Retention Test; The Trail Making Test; Stroop Task	Published
Liang, 2019 ^a	Comparison studies	21 experiment; 21 control	21 males; 21 females	Adults-19.49 (1.45)	Healthy	China	Multiple Games-Battlefield, CrossFire, Honor of Kings, Racing Games, Football Live	/	Visual attention	Multiple-Target Visual Search Task	Unpublished
Liang, 2019 ^b	Comparison studies	22 experiment; 22 control	19 males; 25 females	Adults-19.25 (1.35)	Healthy	China	Multiple Games-Battlefield, CrossFire, Honor of Kings, Racing Games, Football Live	/	Visual attention	Multiple-Target Visual Search Task	Unpublished
Zhang, 2019 ^a	Comparison studies	26 experiment; 24 control	43 males; 7 females	Adults-20.29 (1.68)	Healthy	China	MOBA-League of Legends	/	Cognitive control	Color Trail Test; Stroop Task	Unpublished
Zhang, 2019 ^b	Comparison studies	26 experiment; 26 control	40 males; 12 females	Adults-20 (1.41)	Healthy	China	MOBA-League of Legends	/	Cognitive control	Color Trail Test; Stroop Task	Unpublished
Hazarika & Dasgupta, 2020	Comparison studies	16 experiment; 19 control	35 males; 0 females	Adults-20.9 (1.57)	Healthy	India	Shooting Game	/	Cognitive control	The Corsi Block-tapping Task	Published
Jeong et al., 2020	Comparison studies	18 experiment; 12 control	20 males; 10 females	Adults-25.3 (2.6)	Healthy	Korea	/	/	Visual attention; cognitive control	Saccade Task; Brief Self-Control Scale	Published

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Authors, Year	Study design	Sample size	Gender distribution	Age group-M _{age} (SD)	Health condition	Country	Game type	Intervention details	Outcomes	Measurement	Publication
Matern et al., 2020	Comparison studies	40 experiment; 40 control	41 males; 39 females	Adults-21.3	Healthy	South Africa	/	/	Visual attention	Stroop Task	Published
Schmidt et al., 2020	Comparison studies	25 experiment; 25 control	30 males; 20 females	Adults-24.8 (5.25)	Healthy	Germany	Multiple Games-Action, Non-action	/	Visual attention	The Spatial Contextual Cueing Paradigm	Published
Yao et al., 2020	Comparison studies	18 experiment; 19 control	37 males; 0 females	Adults-20.42 (2.6)	Healthy	China	MOBA-League of Legends	/	Memory	The Visual Change Detection Task	Published
Sun, 2020	Comparison studies	62 experiment; 32 control	/	Adults-20.18 (0.89)	Healthy	China	Simulations; MOBA	/	Cognitive control	Stroop Task; N-Back Task; Task-Switching Paradigm	Unpublished
Alsaad et al., 2022	Comparison studies	55 experiment; 42 control	63 males; 34 females	Adults-21.3 (1.78)	Healthy	Kingdom of Saudi Arabia	Multiple Games-Action	/	Visual attention	Validated Psychological Online Battery Test	Published
Qiu et al., 2021	Comparison studies	60 experiment; 60 control	66 males; 54 females	Adults-21.29 (2.47)	Healthy	China	/	/	Cognitive control	The Plus-minus task; The Tone-monitoring Task; Antisaccade Task (A Composite Score)	Published
Wu et al., 2021	Comparison studies	31 experiment; 28 control	31 males; 28 females	Adults-19.92 (1.51)	Healthy	China	Multiple Games-Action, Non-action	/	Visual attention	Attention Network Task	Published
Li, 2021 ^a	Comparison studies	27 experiment; 32 control	16 males; 43 females	Adults-20.46 (1.97)	Healthy	China	Multiple Games-Action, Non-action	/	Visual attention	Visual Search Task	Unpublished
Li, 2021 ^b	Comparison studies	27 experiment; 39 control	16 males; 50 females	Adults-20.81 (2.08)	Healthy	China	Multiple Games-Action, Non-action	/	Visual attention	Visual Search Task	Unpublished
Wang, 2021	Comparison studies	12 experiment; 12 control	12 males; 12 females	Adults-19.04 (0.93)	Healthy	China	/	/	Visual attention	Flanker Task	Unpublished
Hauck & Lien, 2022	Comparison studies	29 experiment; 101 control	28 males; 102 females	Adults-21.52	Healthy	USA	Multiple Games-Shooting, Massively multiplayer online, MOBA, Role playing, Strategy, Puzzle, Others	/	Visual attention	Attentional Capture Task	Published
Irmak et al., 2022	Comparison studies	277 experiment; 155 control	236 males; 196 females	Adolescents-15.79 (1.2)	Healthy	Turkey	/	/	Memory; cognitive control	Matrix Memory Test; Digit Span Test	Published
Maden et al., 2022	Comparison studies	33 experiment; 28 control	61 males; 0 females	Adults-22.5 (1.3)	Healthy	Turkey	Shooting Game	/	Memory; cognitive control	The Trail Making Test; Stroop Task	Published
Peracchia et al., 2022	Comparison studies	19 experiment; 19 control	38 males; 0 females	Adults-23.16 (1.98)	Healthy	Italy	/	/	Visual attention; cognitive control	Attention Network Task; Go/No-Go Task	Published
Valls-Serrano et al., 2022	Comparison studies	30 experiment; 30 control	60 males; 0 females	Adults-22.5 (3.35)	Healthy	Spain	MOBA-League of Legends	/	Memory; visual attention; cognitive control	The Corsi Block-tapping Task; Antisaccade Task; Number Letter Task; Stop-signal Paradigm	Published
Zinchenko et al., 2022	Comparison studies	20 experiment; 20 control	20 males; 20 females	Adults-22.5 (3.92)	Healthy	Germany, UK	Shooting Game	/	Visual attention	Visual Search Task	Published

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Authors, Year	Study design	Sample size	Gender distribution	Age group-M _{age} (SD)	Health condition	Country	Game type	Intervention details	Outcomes	Measurement	Publication
Geng, 2022	Comparison studies	37 experiment; 38 control	32 males; 43 females	Adults-20.79 (2.23)	Healthy	China	Multiple Games-Action, Non-action	/	Cognitive control	Simon Task; N-Back Task; Task-Switching Paradigm	Unpublished
Li, 2022	Comparison studies	35 experiment; 32 control	67 males; 0 females	Adolescents-13–15	Healthy	China	/	/	Cognitive control	Stroop Task	Unpublished
Xue et al., 2022	Comparison studies	43 experiment; 40 control	64 males; 19 females	Adults-19.19 (1.15)	Clinical-internet gaming disorder	China	MOBA-League of Legends	/	Cognitive control	Stroop Task	Published
Denga Ndemera, 2023 ^a	Comparison studies	9 experiment; 25 control	/	Adults-Undergraduate	Healthy	USA	Puzzle Game-Tetris	/	Spatial ability; cognitive control	Mental Rotation Task; Go/No-Go Task	Unpublished
Denga Ndemera, 2023 ^b	Comparison studies	22 experiment; 37 control	38 males; 20 females; 1 unknown	Adults-20.11 (4.83)	Healthy	USA	Puzzle Game-Tetris	/	Visual attention; cognitive control	Antisaccade Task; Flanker Task	Unpublished
AlWhaibi et al., 2024	Comparison studies	368 experiment; 198 control	196 males; 370 females	Adults-20.23 (1.58)	Healthy	Saudi	/	/	Spatial ability	Self-reported Spatial Ability Questionnaire	Published
Hamzeloo et al., 2024	Comparison studies	30 experiment; 30 control	30 males; 30 females	Adults-23.78 (3.12)	Healthy	/	Multiple Games-Shooting, Action/Adventure	/	Visual attention	Visual Search Task	Published
He et al., 2024 ^a	Comparison studies	25 experiment; 25 control	27 males; 23 females	Adults-20.48 (2.01)	Healthy	China	Real Time Strategy Game	/	Visual attention	Multiple Object Tracking Task	Published
He et al., 2024 ^b	Comparison studies	25 experiment; 25 control	27 males; 23 females	Adults-20.5 (2)	Healthy	China	Real Time Strategy Game	/	Visual attention	Visual 2-Back Task	Published
Valiente-Barroso et al., 2024	Comparison studies	117 experiment; 81 control	125 males; 73 females	Adults-26–35	Healthy	Spain	MOBA-League of Legends	/	Cognitive control	Short Inventory of Prefrontal Symptoms	Published
Yu, Leong Bin Abdullah, & Mansor, 2025 ^a	Comparison studies	25 experiment; 28 control	24 males; 29 females	Adults-19.21 (0.91)	Clinical-internet gaming disorder	Malaysia	/	/	Cognitive control	Flanker Task	Published
Yu, Leong Bin Abdullah, & Mansor, 2025 ^b	Comparison studies	29 experiment; 24 control	34 males; 19 females	Adults-19.26 (1.05)	Clinical-internet gaming disorder	Malaysia	/	/	Cognitive control	Go/No-Go Task	Published
Belchior et al., 2013	Controlled trials	29 experiment; 13 passive control (randomized)	23 males; 19 females	Older adults-74.82 (6.91)	Healthy	USA	Shooting Game-Medal of Honor; Puzzle Game-Tetris	9 h total (6 sessions over 2–3 weeks; 90 min per session)	Visual attention	The Useful Field of View Task	Published
Boot et al., 2013	Controlled trials	14 experiment; 20 passive control; 20 active control (randomized)	23 males; 31 females	Older adults-72.67 (1.45)	Healthy	USA	Sport Game -Mario Kart DS	60 h total (12 weeks; 5 sessions per week; 1 h per session)	Intelligence; visual attention; memory; cognitive control	Raven's Advanced Progressive Matrices Task; Flanker Task; Task-Switching Paradigm; The Corsi Block-tapping Task	Published
Shute et al., 2015	Controlled trials	42 experiment;	33 males; 44 females	Adults-19.7 (1.3)	Healthy	USA	Puzzle Game- Portal 2	9 h total (3 sessions over	Intelligence; spatial ability	Raven's Advanced Progressive Matrices Task;	Published

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Authors, Year	Study design	Sample size	Gender distribution	Age group-M _{age} (SD)	Health condition	Country	Game type	Intervention details	Outcomes	Measurement	Publication
Marra, 2016	Controlled trials	35 active control (randomized) 11 experiment; 14 active control (quasi-randomized)	6 males; 19 females	Older adults-66.16 (10.82)	Healthy	USA	Puzzle Game-Tetris	1–2 weeks; 3 h per session) 14 h total (20–45 min per day)	Intelligence; memory; visual attention; spatial ability; cognitive control	Mental Rotation Task; Virtual Spatial Navigation Assessment Wechsler Adult Intelligence Scale-III; Rivermead Behavioral Memory Test-Story Subtest; Digit Span Task; Mental Rotation Task; Controlled Oral Word Association Test; The Trail Making Test	Unpublished
Flynn & Richert, 2018	Controlled trials	35 experiment; 41 passive control (quasi-randomized)	38 males; 38 females	Children-9.04 (1.47)	Healthy	USA	Motion Sensing Game-Nintendo's Dance Dance Hottest Party 2	20 min	Cognitive control	Flanker Task	Published
Kühn et al., 2018	Controlled trials	9 experiment; 10 passive control (randomized)	/	Adults-45.17 (11.67)	Clinical-Depressed patients	Germany	Sport Game-Boson X	6 weeks	Spatial ability; cognitive control	Manikin Test of Spatial Orientation and Transformation; The Trail Making Test; The Corsi Block-tapping Task	Published
Belchior et al., 2019	Controlled trials	17 experiment; 18 passive control (randomized)	/	Older adults-73.2 (5.5)	Healthy	USA	Sport Game-Crazy Taxi	60 h total (12 weeks; 5 sessions per week; 1 h per session)	Visual attention; spatial ability	Multiple Object Tracking Task; Mental Rotation Task	Published
Perrot et al., 2019	Controlled trials	12 experiment; 11 passive control; 12 active control (randomized)	12 males; 23 females	Older adults-64.63 (2.87)	Healthy	France	Puzzle Game- Super Mario Bros	24 h total (8 weeks; 3 sessions per week; 1 h per session)	Intelligence; memory; spatial ability; cognitive control	The WAIS-III Matrix Reasoning Subtest; The Corsi Block-tapping Task; Subtest of DAT 5-Spatial Relations; The Trail Making Test; Stroop Task	Published
Xiong et al., 2019	Controlled trials	30 experiment; 30 active control (quasi-randomized)	30 males; 30 females	Children-4.52	Healthy	China	Motion Sensing Game	13.3 h total (8 weeks; 5 sessions per week; 20 min per session)	Cognitive control	Dimensional Change Card Sort Test	Published
Carrasco et al., 2020	Controlled trials	22 experiment; 16 passive control (quasi-randomized)	12 males; 26 females	Older adults-71.61 (6.44)	Healthy	France	Motion Sensing Game-Nintendo Wii Sports	12 h total (6 weeks; 2 sessions per week; 1 h per session)	Memory; visual attention; spatial ability; cognitive control	Rey's Complex Figure Test; The Trail Making Test	Published
West et al., 2020	Controlled trials	53 experiment; 24 passive control (randomized)	44 males; 32 females; 1 unknown	Adults-19.57	Healthy	USA	Shooting Game- Unreal Tournament; Simulations-Sims 2; Real Time Strategy Game-Faster than Light	10 sessions; no more than 2 h per session	Visual attention	The Useful Field of View Task	Published

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Authors, Year	Study design	Sample size	Gender distribution	Age group-M _{age} (SD)	Health condition	Country	Game type	Intervention details	Outcomes	Measurement	Publication
Bai, 2020	Controlled trials	18 experiment; 24 active control (randomized)	42 males; 0 females	Adults-37.9 (10.42)	Clinical-Schizophrenia	China	Puzzle Game- Super Mario 3D World	6–8 weeks; at least 6 h a week and no more than 2 h a day	Memory; cognitive control	Cambridge Neuropsychological Test Automated Battery-Paired Associate Learning and Spatial Working Memory Task	Unpublished
Wang, 2020	Controlled trials	15 experiment; 15 passive control (randomized)	/	Older adults->60	Healthy	China	Puzzle Game- Anipop	7 h total (7 weeks; 2 sessions per week; 30 min per session)	Memory; cognitive control	Two-Choice Oddball Paradigm; N-Back Task	Unpublished
Dobrowolski et al., 2021	Controlled trials	30 experiment; 15 passive control (quasi-randomized)	22 males; 23 females	Adults-24.77 (2.95)	Healthy	Poland	Real Time Strategy Game- <i>StarCraft II</i>	30 h total (4 weeks; no more than 5 h in any given day and 10 h in any given week)	Visual attention; cognitive control	The Attentional Window Task; The Memory Updating Task; Flanker Task	Published
Hou & Li, 2022	Controlled trials	22 experiment; 21 passive control (randomized)	8 males; 35 females	Older adults-67.67 (4.95)	Healthy	China	StepMania	18 h total (12 weeks; 3 sessions a week; 30 min per session)	Memory; visual attention; spatial ability; cognitive control	The Auditory Verbal Learning Test; Cancellation Task; Wechsler Adult Intelligence Scale-Block Design; N-Back Task; Stroop Task	Published
Safaei et al., 2022	Controlled trials	10 experiment; 10 passive control (randomized)	17 males; 3 females	Adults-35.25 (5.47)	Healthy	/	Puzzle Game- <i>Tetris</i> . Interlocked	12 h total (4 weeks)	Spatial ability	Mental Rotation Task; Mental Folding Task	Published
Zhao et al., 2022	Controlled trials	21 experiment; 16 passive control; 18 active control (quasi-randomized)	15 males; 40 females	Older adults-65.4 (3.7)	Healthy	China	Motion Sensing Game	45 h total (12 weeks; 3 sessions a week; 75 min per session)	Cognitive control	Stroop Task	Published
Molhemi et al., 2023	Controlled trials	18 experiment; 18 active control (randomized)	15 males; 21 females	Adults-39.17 (8.74)	Clinical-Multiple sclerosis	Iran	Motion Sensing Game	9 h total (6 weeks; 3 sessions per week; 30 min per session)	Cognitive control	The Trail Making Test	Published
Shi et al., 2024	Controlled trials	26 experiment; 29 active control (randomized)	35 males; 20 females	Adults-43.11 (10.11)	Clinical-Chronic schizophrenia	China	Puzzle Game- Anipop, Zuma, Talking Tom Gold Run	30 h total (6 weeks; 5 sessions a week; 1 h per session)	Memory; visual attention; spatial ability	Repeatable Battery of Neuropsychological Status	Published
Kianimotlagh et al., 2025	Controlled trials	15 experiment; 15 passive control (quasi-randomized)	24 males; 6 females	Older adults-65.75	Healthy	Iran	Motion Sensing Game-Kinect Sports game	7.5 h total (5 weeks; 2 sessions a week; 45 min per session)	Cognitive control	Stroop Task	Published
Yu, Wu, et al., 2025	Controlled trials	46 experiment;	16 males; 75 females	Older adults-63.1 (4.63)	Healthy	China	Motion Sensing Game	16.6 h total (10 weeks; 2	Cognitive control	Digit Span Test	Published

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Table 1 (continued)

Authors, Year	Study design	Sample size	Gender distribution	Age group-M _{age} (SD)	Health condition	Country	Game type	Intervention details	Outcomes	Measurement	Publication
Zhang et al., 2025	Controlled trials	45 passive control (randomized) 12 experiment; 15 active control (randomized)	16 males; 11 females	Adults-50.7 (6.34)	Clinical-Chronic schizophrenia	China	Puzzle Game-Anipop, Zuma, Talking Tom Gold Run	sessions per week; 50 min per session) 30 h total (6 weeks; 5 sessions a week; 1 h per session)	Memory; visual attention; spatial ability	Repeatable Battery of Neuropsychological Status	Published

Note. MOBA: Multiplayer Online Battle Arena Game.

Table 2a										
Quality assessment of correlational and between-group comparison studies.										
Authors, Year	1	2	3	4	5	6	7	8	Quality	
1. Sjowall, 2010	Y	Y	Y	NA	Y	Y	Y	Y	Y	H
2. Ji & Wang, 2010	N	Y	Y	NA	N	N	Y	Y	Y	M
3. Ferguson, 2011	N	Y	Y	NA	Y	Y	Y	Y	Y	M
4. Jackson et al., 2012	N	Y	Y	NA	N	N	Y	Y	Y	M
5. Ferguson et al., 2013	N	Y	Y	NA	Y	Y	Y	Y	Y	M
6. Holfeld et al., 2015	N	Y	Y	NA	Y	Y	Y	Y	Y	M
7. Motamedi & Yaghoubi, 2015	N	U	Y	NA	N	N	Y	Y	Y	L
8. Lau et al., 2017	N	Y	Y	NA	N	N	Y	Y	Y	M
9. Blanco-Herrera et al., 2019	N	Y	Y	NA	Y	Y	Y	Y	Y	M
10. Waris et al., 2019	N	Y	Y	NA	Y	Y	Y	Y	Y	M
11. Yang et al., 2020	N	Y	Y	NA	Y	Y	Y	Y	Y	M
12. Huang, 2020	N	Y	Y	NA	Y	N	Y	Y	Y	M
13. Samson et al., 2021	Y	Y	Y	NA	Y	Y	Y	Y	Y	H
14. Jadallah et al., 2023	N	Y	Y	NA	N	N	Y	Y	Y	M
15. Xu et al., 2023	Y	Y	Y	NA	Y	Y	Y	Y	Y	H
16. Zioga et al., 2024	Y	Y	Y	NA	Y	Y	Y	Y	Y	H
17. Cudo et al., 2025	N	Y	Y	NA	N	Y	Y	Y	Y	M
18. Castel et al., 2005	Y	Y	N	NA	N	N	Y	Y	Y	M
19. Satyen, 2005	N	Y	Y	NA	N	N	Y	Y	Y	M
20. Green & Bavelier, 2006 ^a	Y	Y	N	NA	N	N	Y	Y	Y	M
21. Green & Bavelier, 2006 ^b	Y	Y	N	NA	N	N	Y	Y	Y	M
22. Zaparyniuk, 2006	N	Y	Y	NA	N	N	Y	Y	Y	M
23. Zetu, 2007	Y	Y	Y	NA	N	N	Y	Y	Y	M
24. Li & Lv, 2008	N	Y	U	NA	N	N	Y	Y	Y	L
25. Dye et al., 2009	Y	Y	Y	NA	Y	Y	Y	Y	Y	H
26. Li, 2009	N	Y	U	NA	N	N	Y	Y	Y	L
27. Murphy & Spencer, 2009	N	Y	Y	NA	Y	Y	Y	Y	Y	M
28. Zhang et al., 2009	N	Y	N	NA	N	N	Y	Y	Y	L
29. Bailey et al., 2010	N	Y	Y	NA	N	N	Y	Y	Y	M
30. Chisholm et al., 2010	N	Y	Y	NA	N	N	Y	Y	Y	M
31. Irons et al., 2011	Y	Y	U	NA	N	N	Y	Y	Y	M
32. Zhai, 2011	N	Y	U	NA	N	Y	Y	Y	Y	M
33. Li et al., 2011	Y	Y	U	Y	N	Y	Y	Y	Y	M
34. Green et al., 2012 ^a	Y	Y	Y	NA	Y	Y	Y	Y	Y	H
35. Green et al., 2012 ^b	Y	Y	Y	NA	Y	Y	Y	Y	Y	H
36. Green et al., 2012 ^c	Y	Y	Y	NA	Y	Y	Y	Y	Y	H
37. Wallace, 2012	N	Y	Y	NA	Y	Y	Y	Y	Y	M
38. He, 2012 ^a	Y	Y	N	NA	N	N	Y	Y	Y	M
39. He, 2012 ^b	Y	Y	N	NA	N	N	Y	Y	Y	M
40. He, 2012 ^c	Y	Y	N	NA	N	N	Y	Y	Y	M
41. Song et al., 2012	N	U	Y	NA	N	N	Y	Y	Y	L
42. Strobach et al., 2012	N	Y	U	NA	Y	Y	Y	Y	Y	M
43. Zhang & Ou, 2012 ^a	Y	Y	N	NA	N	Y	Y	Y	Y	M
44. Zhang & Ou, 2012 ^b	Y	Y	N	NA	N	Y	Y	Y	Y	M
45. Zhang et al., 2012	Y	Y	Y	NA	N	N	Y	Y	Y	M
46. Colzato et al., 2013	N	Y	Y	NA	Y	Y	Y	Y	Y	M
47. Lu et al., 2013	U	Y	Y	NA	N	N	Y	Y	Y	M
48. Zhu, 2013 ^a	Y	Y	U	NA	N	N	Y	Y	Y	M
49. Zhu, 2013 ^b	Y	Y	U	NA	N	N	Y	Y	Y	M
50. Collins & Freeman, 2014	Y	Y	Y	NA	Y	Y	Y	Y	Y	H
51. Hollis, 2014	N	Y	Y	NA	Y	Y	Y	Y	Y	M
52. Patton, 2014	N	Y	Y	NA	Y	Y	Y	Y	Y	M
53. Li et al., 2014	Y	Y	Y	NA	Y	Y	Y	Y	Y	H
54. Zhang et al., 2014	Y	Y	Y	Y	N	N	Y	Y	Y	M
55. Buelow et al., 2015	N	Y	N	NA	Y	Y	Y	Y	Y	M
56. Chisholm & Kingstone, 2015	Y	Y	N	NA	N	N	Y	Y	Y	M
57. de Castell et al., 2015 ^a	N	Y	Y	NA	N	N	Y	Y	Y	M
58. de Castell et al., 2015 ^b	N	Y	Y	NA	N	N	Y	Y	Y	M
59. Dobrowski et al., 2015	Y	Y	Y	NA	N	N	Y	Y	Y	M
60. Novak & Tassell, 2015	N	Y	N	NA	Y	N	Y	Y	Y	M
61. Steenbergen et al., 2015	Y	Y	Y	NA	Y	Y	Y	Y	Y	H
62. Unsworth et al., 2015	N	Y	Y	NA	N	N	Y	Y	Y	M
63. Zhang et al., 2015	Y	Y	Y	NA	N	N	Y	Y	Y	M
64. Li et al., 2016	N	Y	N	NA	N	N	Y	Y	Y	L
65. Weinstein et al., 2016	N	Y	Y	NA	N	N	Y	Y	Y	M

(continued on next page)

Table 2a (continued)

Authors, Year	1	2	3	4	5	6	7	8	Quality
66. Wei, 2016 ^a	Y	Y	Y	NA	N	N	Y	Y	M
67. Wei, 2016 ^b	Y	Y	Y	NA	N	N	Y	Y	M
68. Zhang, 2016	Y	Y	Y	NA	N	N	Y	Y	M
69. Zhen et al., 2016	Y	Y	N	NA	N	N	Y	Y	M
70. Huang et al., 2017	N	Y	Y	NA	Y	Y	Y	Y	M
71. Wang et al., 2017	Y	Y	U	NA	Y	Y	Y	Y	M
72. Kowal et al., 2018	N	Y	U	NA	Y	Y	Y	Y	M
73. Qiu et al., 2018	Y	Y	Y	NA	Y	Y	Y	Y	H
74. Trisolini et al., 2018	Y	Y	Y	NA	N	N	Y	Y	M
75. Whynott, 2018	N	Y	Y	NA	N	N	Y	Y	M
76. Feng, 2018	N	Y	Y	NA	Y	Y	N	Y	M
77. Özçetin et al., 2019	Y	Y	Y	NA	Y	Y	Y	Y	H
78. Liang, 2019 ^a	Y	Y	N	NA	N	N	Y	Y	M
79. Liang, 2019 ^b	Y	Y	N	NA	N	N	Y	Y	M
80. Zhang, 2019 ^a	N	Y	Y	NA	N	N	Y	Y	M
81. Zhang, 2019 ^b	N	Y	Y	NA	N	N	Y	Y	M
82. Hazarika & Dasgupta, 2020	Y	Y	N	NA	N	N	Y	Y	M
83. Jeong et al., 2020	N	Y	N	NA	N	Y	Y	Y	M
84. Matern et al., 2020	Y	Y	Y	NA	N	N	Y	Y	M
85. Schmidt et al., 2020	N	Y	Y	NA	N	N	Y	Y	M
86. Yao et al., 2020	Y	Y	Y	NA	Y	Y	Y	Y	H
87. Sun, 2020	Y	Y	Y	NA	N	N	Y	Y	M
88. Alsaad et al., 2022	Y	Y	Y	NA	N	N	Y	Y	M
89. Qiu et al., 2021	N	Y	Y	NA	N	N	Y	Y	M
90. Wu et al., 2021	N	Y	Y	NA	N	N	Y	Y	M
91. Li, 2021 ^a	Y	Y	Y	NA	N	N	Y	Y	M
92. Li, 2021 ^b	Y	Y	Y	NA	N	N	Y	Y	M
93. Wang, 2021	Y	Y	Y	NA	Y	Y	Y	Y	H
94. Hauck & Lien, 2022	Y	Y	Y	NA	N	N	Y	Y	M
95. Irmak et al., 2022	N	Y	Y	NA	N	N	Y	Y	M
96. Maden et al., 2022	N	Y	Y	NA	Y	Y	Y	Y	M
97. Peracchia et al., 2022	Y	Y	Y	NA	N	N	Y	Y	M
98. Valls-Serrano et al., 2022	Y	Y	Y	NA	Y	Y	Y	Y	H
99. Zinchenko et al., 2022	Y	Y	Y	NA	Y	Y	Y	Y	H
100. Geng, 2022	Y	Y	Y	NA	N	N	Y	Y	M
101. Li, 2022	Y	Y	Y	NA	Y	N	Y	Y	M
102. Xue et al., 2022	Y	Y	Y	Y	N	Y	Y	Y	H
103. Denga Ndemera, 2023 ^a	Y	Y	N	NA	N	N	Y	Y	M
104. Denga Ndemera, 2023 ^b	Y	Y	N	NA	N	N	Y	Y	M
105. AlWhaibi et al., 2024	N	Y	N	NA	Y	Y	Y	Y	M
106. Hamzeloo et al., 2024	Y	Y	Y	NA	Y	Y	Y	Y	H
107. He et al., 2024 ^a	Y	Y	Y	NA	N	N	Y	Y	M
108. He et al., 2024 ^b	Y	Y	Y	NA	N	N	Y	Y	M
109. Valiente-Barroso et al., 2024	Y	Y	Y	NA	N	N	Y	Y	M
110. Yu, Leong Bin Abdullah, & Mansor, 2025 ^a	Y	Y	Y	Y	N	N	Y	Y	M
111. Yu, Leong Bin Abdullah, & Mansor, 2025 ^b	Y	Y	Y	Y	N	N	Y	Y	M

Notes. Number 1–17 are correlational studies, the remaining are between-group comparison studies. 1. Were the criteria for inclusion in the sample clearly defined? 2. Were the study subjects and the setting described in detail? 3. Was the exposure measured in a valid and reliable way? 4. Were objective, standard criteria used for measurement of the condition? 5. Were confounding factors identified? 6. Were strategies to deal with confounding factors stated? 7. Were the outcomes measured in a valid and reliable way? 8. Was appropriate statistical analysis used? Y: Yes. N: No. U: Unclear. NA: Not applicable. H: High. M: Medium. L: Low.

= 0.193, $p < 0.001$). The results of average effects sorted by cognitive domains are presented in Table 5. The forest plot of controlled trials is provided in Fig. 4.

3.6.2. Moderating effect

Six moderating factors were examined in the meta-analysis of controlled trials. Meta-regression analyses were conducted for gender (percentage of females) and intervention duration, and subgroup

Table 2b

Quality assessment of quasi-randomized controlled trials.

Authors, year	1	2	3	4	5	6	7	8	9	Quality
Marra, 2016	Y	Y	Y	Y	Y	Y	Y	Y	Y	H
Flynn & Richert, 2018	Y	Y	Y	Y	Y	Y	Y	U	Y	H
Xiong et al., 2019	Y	Y	Y	Y	Y	Y	Y	U	Y	H
Carrasco et al., 2020	Y	Y	Y	Y	Y	Y	Y	U	Y	H
Dobrowolski et al., 2021	Y	Y	Y	U	Y	Y	Y	N	Y	H
Zhao et al., 2022	Y	Y	U	Y	Y	Y	Y	N	Y	H
Kianimotlagh et al., 2025	Y	Y	Y	Y	Y	Y	Y	N	Y	H

Notes. 1. Is it clear in the study what is the “cause” and what is the “effect” (i.e. there is no confusion about which variable comes first)? 2. Was there a control group? 3. Were participants included in any comparisons similar? 4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest? 5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure? 6. Were the outcomes of participants included in any comparisons measured in the same way? 7. Were outcomes measured in a reliable way? 8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analyzed? 9. Was appropriate statistical analysis used? Y: Yes. N: No. U: Unclear. NA: Not applicable. H: High. M: Medium. L: Low.

analyses were conducted for age group, cultural context, health condition, and game type. To minimize statistical errors, we applied the Bonferroni correction to moderator analyses, adjusting the significance level α to 0.008. The results showed that moderating effects of gender ($Q = 0.34$, $p = 0.558$), intervention duration ($Q = 0.46$, $p = 0.5$), age group ($Q = 0.758$, $p = 0.685$), cultural context ($Q = 0.072$, $p = 0.788$), health condition ($Q = 0.296$, $p = 0.586$), and game type ($Q = 1.895$, $p = 0.863$) were not significant.

3.6.3. Publication bias

Funnel plots and Egger's regression test were used to assess publication bias. Visual inspection of the funnel plots (see Fig. S5 in the Supplementary Materials) revealed approximate symmetry, suggesting no obvious publication bias. To further validate this finding, we then used Egger's regression test to assess funnel plot asymmetry. Egger's test was not significant ($p = 0.513$). Thus, the results suggested publication bias was not present in this meta-analysis.

3.6.4. Sensitivity analysis

Sensitivity analyses were performed by conducting a leave-one-out analysis. The results showed that the pooled estimates did not change significantly when each study was omitted in turn, indicating that the results were robust (see Fig. S6 in the Supplementary Materials).

4. Discussion

The present meta-analysis synthesized evidence from 269 effect sizes across 133 independent studies (total $N = 14,245$) to comprehensively examine the association between video game play and cognitive ability. The corpus included 17 correlational studies (20 effect sizes; $N = 6263$), 94 between-group comparison studies (173 effect sizes; $N = 6970$), and 22 controlled trials (76 effect sizes; $N = 1012$). The findings consistently revealed statistically significant, albeit generally weak, positive associations across all three study designs. Specifically, correlational studies and between-group comparison studies demonstrated significant overall effects ($r = 0.162$ and $r = 0.22$, respectively), with the latter showing benefits across multiple cognitive domains, including memory, spatial ability, visual attention, cognitive control, and intelligence. Evidence from controlled trials, which provides the strongest causal inference, confirmed that video game interventions lead to a small but significant cognitive enhancement ($r = 0.088$). Furthermore, an extensive examination of potential moderators was conducted across the three meta-

Table 2c
Quality assessment of randomized controlled trials.

Authors, year	1	2	3	4	5	6	7	8	9	10	11	12	13	Quality
Belchior et al., 2013	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	H
Boot et al., 2013	Y	Y	Y	Y	U	Y	Y	Y	Y	N	N	Y	Y	M
Shute et al., 2015	Y	Y	N	Y	Y	Y	Y	Y	Y	N	N	Y	Y	M
Kühn et al., 2018	Y	Y	Y	Y	U	Y	Y	Y	Y	U	N	Y	Y	M
Belchior et al., 2019	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	H
Perrot et al., 2019	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	N	Y	Y	H
West et al., 2020	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	H
Bai, 2020	Y	U	Y	Y	U	Y	U	Y	Y	N	N	Y	Y	M
Wang, 2020	Y	U	Y	Y	U	Y	U	Y	Y	U	N	Y	Y	M
Hou & Li, 2022	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	N	Y	Y	H
Safaei et al., 2022	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	N	Y	Y	H
Molhemi et al., 2023	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	H
Shi et al., 2024	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	H
Yu, Wu, et al., 2025	Y	Y	Y	Y	U	Y	Y	Y	Y	U	N	Y	Y	M
Zhang et al., 2025	Y	Y	Y	Y	U	Y	Y	Y	Y	N	N	Y	Y	M

Notes. 1. Was true randomization used for assignment of participants to treatment groups? 2. Was allocation to treatment groups concealed? 3. Were treatment groups similar at the baseline? 4. Were participants blind to treatment assignment? 5. Were those delivering the treatment blind to treatment assignment? 6. Were treatment groups treated identically other than the intervention of interest? 7. Were outcome assessors blind to treatment assignment? 8. Were outcomes measured in the same way for treatment groups? 9. Were outcomes measured in a reliable way? 10. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed? 11. Were participants analyzed in the groups to which they were randomized? 12. Was appropriate statistical analysis used? 13. Was the trial design appropriate and any deviations from the standard RCT design accounted for in the conduct and analysis of the trial? Y: Yes. N: No. U: Unclear. NA: Not applicable. H: High. M: Medium. L: Low.

Table 3
The average effects of correlational studies sorted by cognitive domains.

Cognitive domain	k	r (95%CI)	p	I ² (%)
Memory	2	0.182 [0.083, 0.278]	<0.001	0
Spatial ability	2	0.304 [−0.257, 0.712]	0.286	98.152
Visual attention	3	−0.004 [−0.185, 0.177]	0.962	78.741
Cognitive control	8	0.181 [−0.031, 0.377]	0.094	96.756
Intelligence	5	0.162 [−0.009, 0.402]	0.222	95.865

Notes. k = number of effect sizes. CI = confidence interval.

analyses. After applying stringent Bonferroni corrections to control for multiple comparisons, nearly all tested factors—including participant gender, age group, cultural context, health condition, intervention duration, and game type—failed to demonstrate significant moderating

effects. Importantly, the sensitivity analyses conducted by excluding lower-quality studies and by conducting a leave-one-out analysis indicated that the pooled results remained robust across all study designs. This consistency across analyses strengthens confidence in the overall findings, suggesting that the observed associations between video game play and different domains of cognitive ability are not merely artifacts of methodological limitations in the included literature. Nevertheless, the body of evidence supporting our conclusions is characterized primarily by studies of moderate methodological quality, rather than those meeting the highest standards of methodological rigor. This predominance of moderate-quality evidence, particularly prevalent among the correlational and between-group comparison designs included in this review, necessitates a cautious and circumspect interpretation of the findings. In the meta-analysis of correlational studies, the findings revealed a

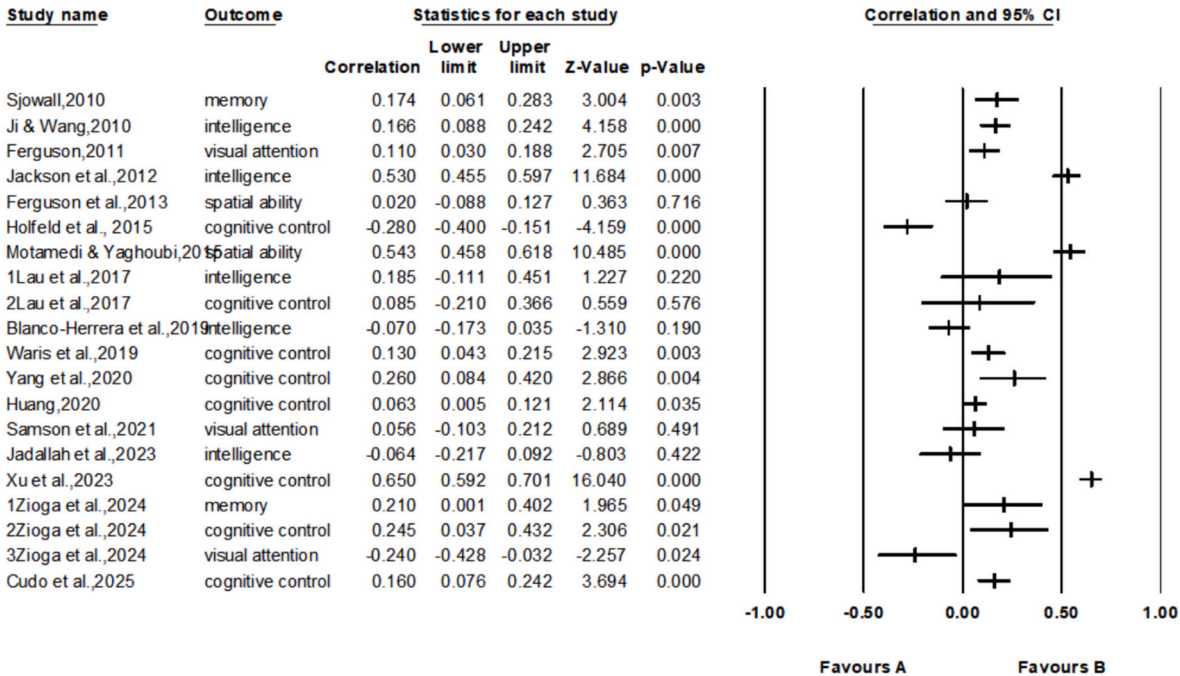


Fig. 2. Forest plot of correlational studies.

Table 4

The average effects of between-group comparison studies sorted by cognitive domains.

Cognitive domain	k	r (95%CI)	p	I ² (%)
Memory	11	0.067 [-0.111, 0.240]	0.462	88.417
Spatial ability	9	0.233 [0.054, 0.397]	0.011	86.528
Visual attention	65	0.241 [0.112, 0.362]	<0.001	94.550
Cognitive control	82	0.223 [0.053, 0.380]	0.010	97.826
Intelligence	6	0.167 [0.041, 0.287]	0.009	71.080

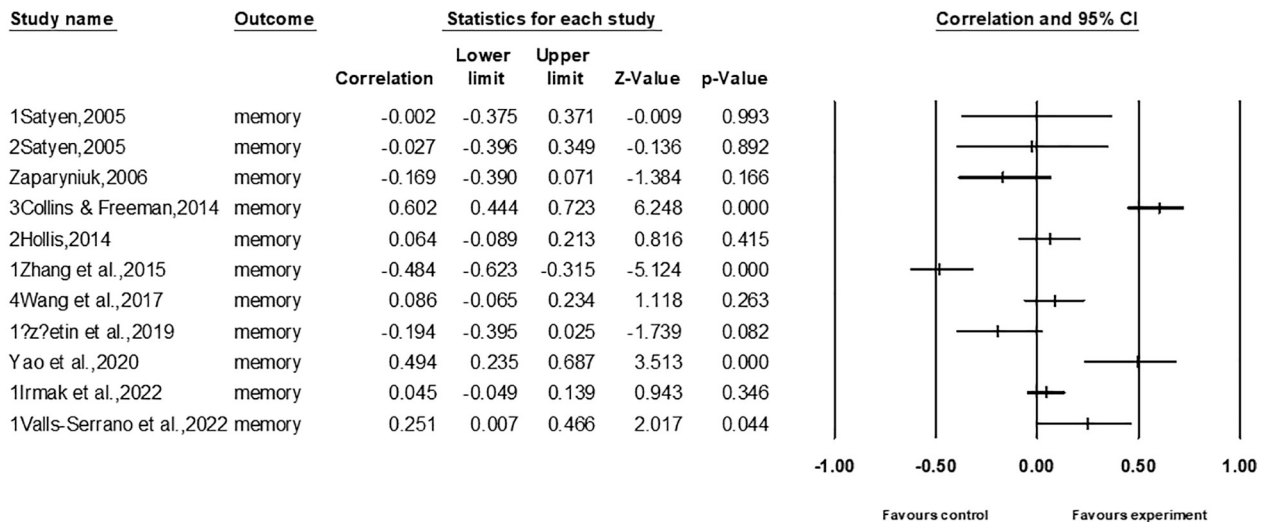
Notes. k = number of effect sizes. CI = confidence interval.

statistically significant, yet weak, positive correlation between video game play and overall cognitive ability. This indicates that a longer duration of video game play may be associated with higher scores on cognitive assessments. When examining specific cognitive domains, a significant association was found only for memory, suggesting that video game play may have a more consistent association with skills related to memory. One possible interpretation of this association is that individuals who invest more time in gaming engage in frequent and

sustained recruitment of memory-related skills during gameplay (Blacker & Curby, 2013). Regardless of whether gaming directly enhances memory, this repeated engagement itself constitutes a form of domain-specific practice. Thus, the observed correlation may reflect a connection between an individual's performance on memory tasks and their level of familiarity and practice within virtual environments that rely heavily on memory. However, the correlational design precludes any definitive conclusions about causality. Thus, it remains unclear whether engaging in video-game practice fosters memory, or if individuals with inherently superior memory skills are more drawn to and skilled at playing video games.

In the meta-analysis of between-group comparison studies, a small yet statistically significant positive correlation was again observed between video game play and cognitive ability. This result implies that video gamers generally demonstrate better cognitive performance than non-video gamers. More specifically, experienced players show superior performance over non-video gamers or less-experienced players in domains such as spatial ability, visual attention, cognitive control, and intelligence. From a neurophysiological perspective, video game

a



b

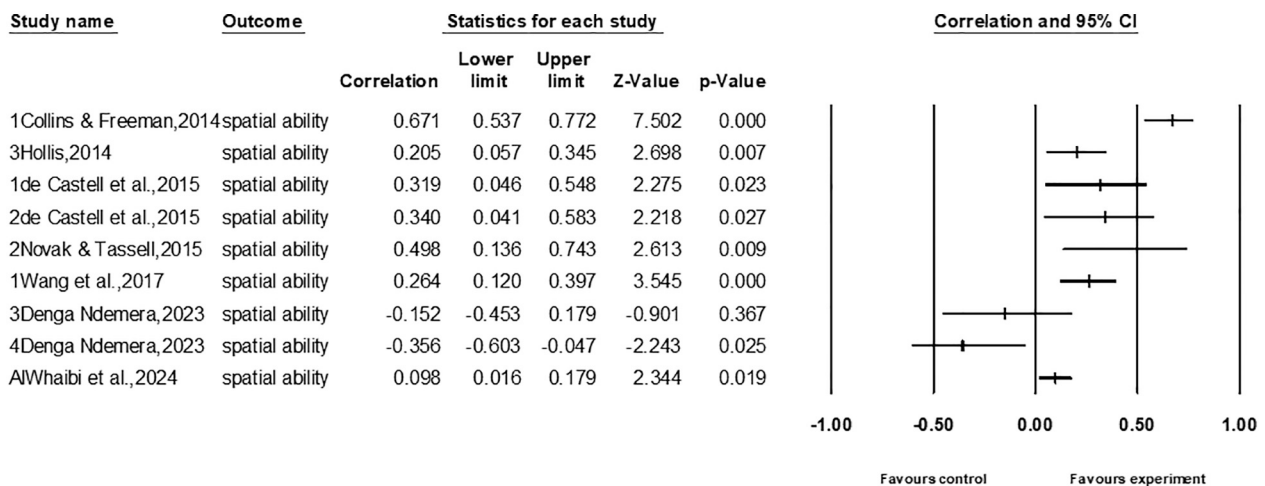


Fig. 3. a. Forest plot of between-group comparison studies for memory.
b. Forest plot of between-group comparison studies for spatial ability.
c. Forest plot of between-group comparison studies for visual attention.
d. Forest plot of between-group comparison studies for cognitive control.
e. Forest plot of between-group comparison studies for intelligence.

C

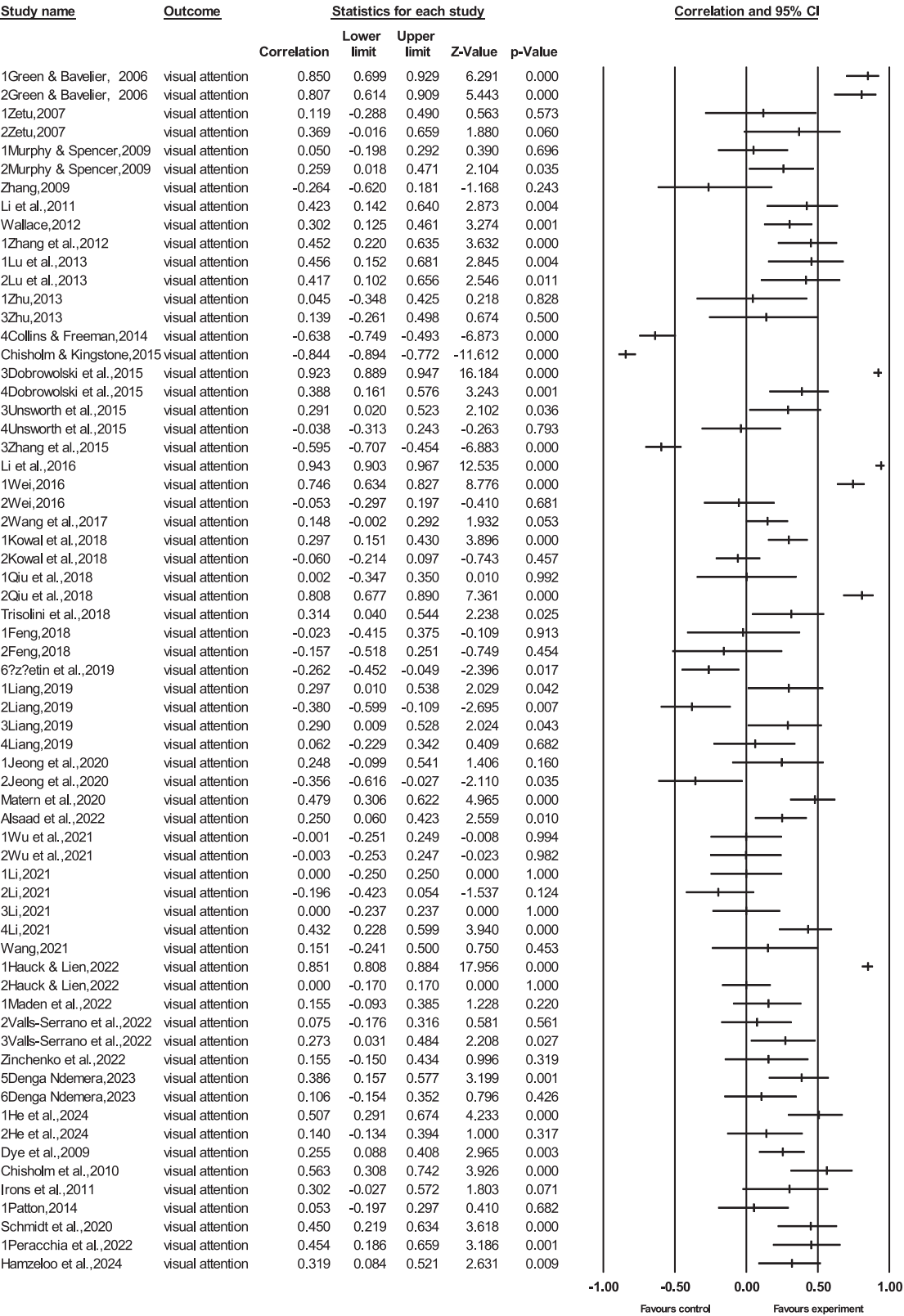


Fig. 3. (continued).

experience has been associated with functional and structural changes in brain networks that support high-level cognition. It has been proposed that video game play is related to the salience and central executive network, which are critical for visual attention (Kühn & Gallinat, 2014).

Furthermore, evidence suggests that video game play is linked to increased resting-state functional connectivity in regions such as the caudate nucleus, which plays a key role in cognitive control and selective inhibition (Benady-Chorney et al., 2020). Additionally, a recent

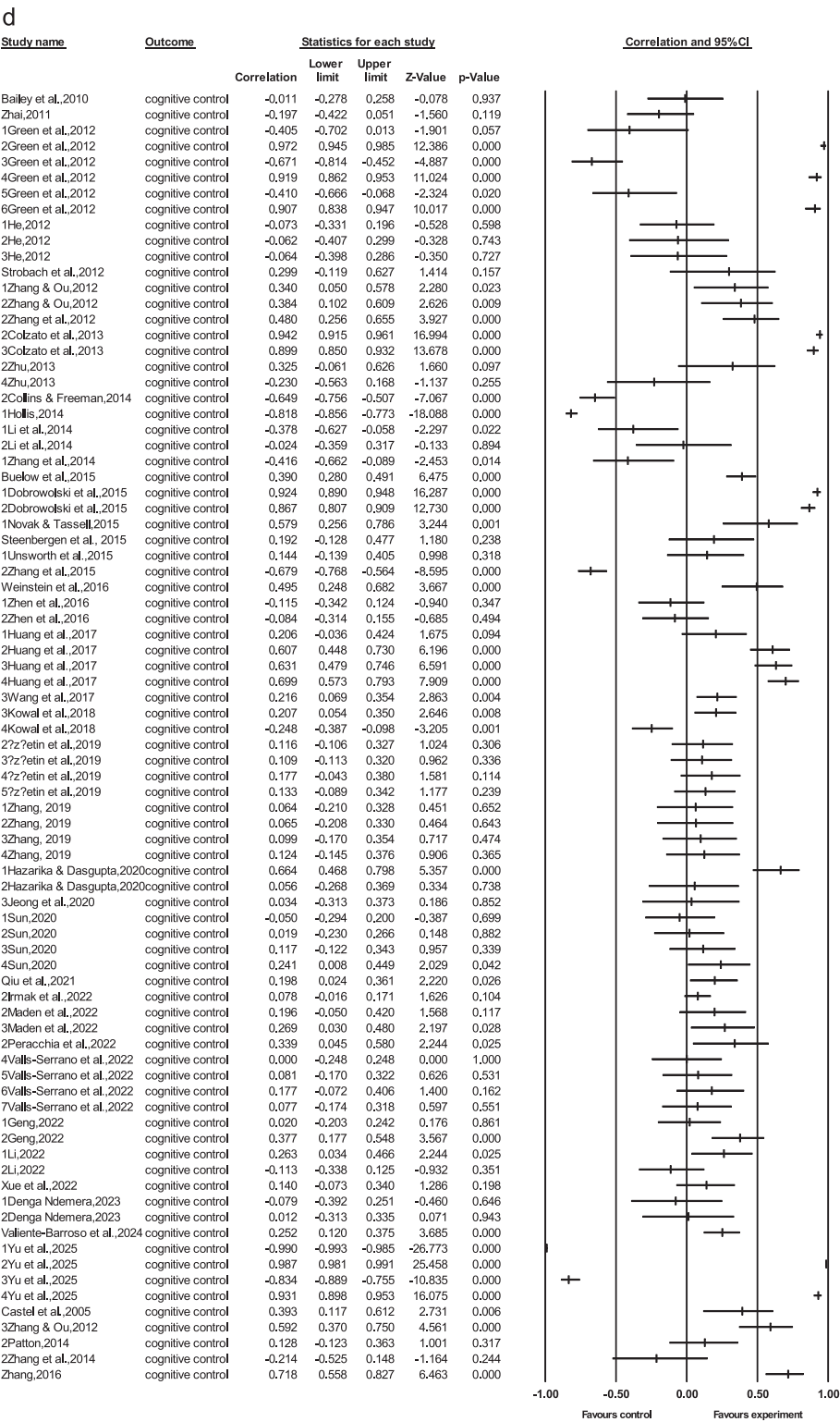


Fig. 3. (continued).

brain imaging study also indicated that video games may support the development of fluid intelligence by enhancing connectivity between the motor cortex and key regions like the left dorsolateral prefrontal cortex and the language center (Wang et al., 2024). These neural adaptations may collectively contribute to video gamers' enhanced ability to process complex information, allocate attention efficiently, and exert cognitive control. From a gaming perspective, these cognitive benefits may be rooted in the interactive and problem-solving nature of many

game genres. For instance, 3D-puzzle games and virtual reality games often present players with complex spatial problems in dynamic environments, providing repeated practice that may directly train and improve spatial and reasoning abilities (Albarracín et al., 2022). Finally, a similar small positive effect was identified in controlled trials. This finding suggests that video game interventions may yield a modest positive effect on cognitive enhancement compared to alternative interventions or no intervention. Among various cognitive domains,

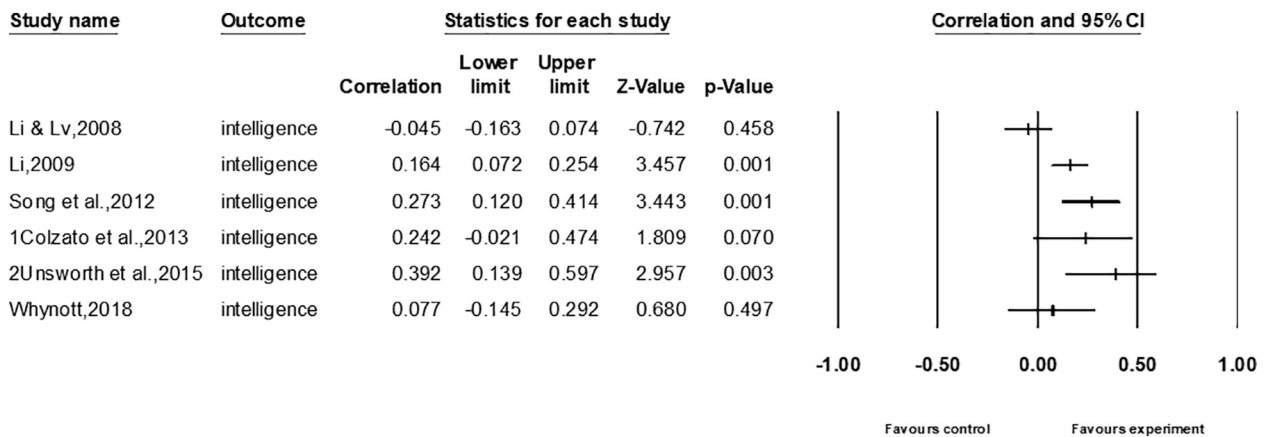


Fig. 3. (continued).

Table 5

The average effects of controlled trials sorted by cognitive domains.

Cognitive domain	k	r (95%CI)	p	I ² (%)
Memory	12	0.193 [0.097, 0.285]	<0.001	3.119
Spatial ability	15	0.076 [-0.008, 0.158]	0.077	0
Visual attention	16	0.109 [-0.001, 0.217]	0.053	45.738
Cognitive control	27	0.094 [-0.017, 0.203]	0.097	69.743
Intelligence	6	-0.162 [-0.567, 0.305]	0.503	92.345

Notes. k = number of effect sizes. CI = confidence interval.

memory was the only dimension found to have a significant effect. A plausible explanation for this memory-specific effect lies in the enriching nature of video game environments. The exploration of large, open worlds in modern video games may serve as a form of environmental enrichment for humans (Clemenson et al., 2020). This is supported by research consistently showing that exposure to enriched environments enhances hippocampal function in animals—a finding that aligns with improvements in hippocampal-dependent memory in humans following video game intervention (Clemenson et al., 2018). Additionally, the underlying neurobiological mechanism may involve the dopaminergic modulation of memory processes. According to the hippocampal-ventral tegmental area (VTA) loop model (Lisman & Grace, 2005), phasic dopamine release from the VTA serves as a gatekeeper, signaling the salience of information and facilitating its encoding and consolidation in the hippocampus. Video games deliver frequent and predictable reward feedback (e.g., achievements, level completion), which is likely to trigger such dopaminergic signaling (Han et al., 2007; Koeppe et al., 1998). Dopamine is not merely a mediator of pleasure but also plays a fundamental role in reinforcement learning and memory consolidation. By enhancing motivation, dopamine release during gameplay may promote more engaged and repetitive practice, thereby strengthening the cognitive strategies and neural circuits underlying memory performance.

Consistent with prior meta-analyses (e.g., Bediou et al., 2018; Powers et al., 2013), the present study identified a positive association between video game play and cognitive performance, with stronger effect sizes observed in correlational and quasi-experimental designs compared to controlled trials—a pattern aligning with existing literature. Methodologically, this meta-analysis adopted more precise procedures for effect size calculation and conversion. Specifically, for each independent sample, when multiple effect sizes derived from the same measure and assessment instrument were available, they were combined into a single effect size to ensure statistical independence. Additionally, the Cheung and Chan (2004) method was applied to correct for statistical dependencies among effect sizes originating from different instruments. In moderator analyses, the Bonferroni correction was implemented to

control for Type I error inflation resulting from multiple comparisons, while a broader and more fine-grained set of potential moderators was examined under an expanded coding framework. The divergence between our findings and those of Sala et al. (2018), who reported minimal effects, may be attributable to differences in inclusion criteria, demographic composition, and game-related factors. Specifically, the inclusion of clinical populations in our study, who may exhibit greater cognitive plasticity or responsiveness to intervention, could partially explain the more pronounced effects observed here.

This study provides preliminary review evidence for the association between video game play and cognitive ability. These preliminary findings encourage a shift from viewing video games solely as entertainment toward recognizing their structured cognitive potential, offering reasonable suggestions for educators and clinicians to better utilize video games. However, several limitations should be acknowledged in this study. First, there was substantial heterogeneity in intervention protocols, including gaming frequency, session duration, total intervention length, and follow-up periods, which may have introduced bias into the pooled estimates. Future studies should standardize these core parameters and establish dose-response models. Second, although most included studies employed standardized cognitive task paradigms, a subset relied on self-report questionnaires that have not been adequately validated. The accuracy of these measures and varying levels of participant compliance may compromise the reliability of the findings. Third, within the correlational studies, several cognitive domains were represented by a limited number of effect sizes, which reduced statistical power and constrained the interpretability of the results for those specific constructs. Fourth, concerning the quality assessment of included studies, the current meta-analysis adopted the JBI critical appraisal checklists, which are specifically designed to evaluate the methodological rigor of the observational designs that predominate in the existing literature. If future research could accumulate a more robust body of high-quality evidence (e.g., a larger body of RCTs), the application of the Grading of Recommendations Assessment, Development and Evaluation (GRADE) tool would be recommended to provide an integrated grading of the overall certainty of the evidence. Fifth, the exclusion of serious limits the generalizability of our findings, which are primarily applicable to commercial entertainment games. Finally, the absence of long-term follow-up data precludes definitive conclusions regarding the causal relation and sustained effects of video game play on cognitive ability. Large-scale longitudinal studies are strongly recommended to clarify the direction of causality and long-term cognitive trajectories.

5. Conclusions

This systematic review and meta-analysis investigated the

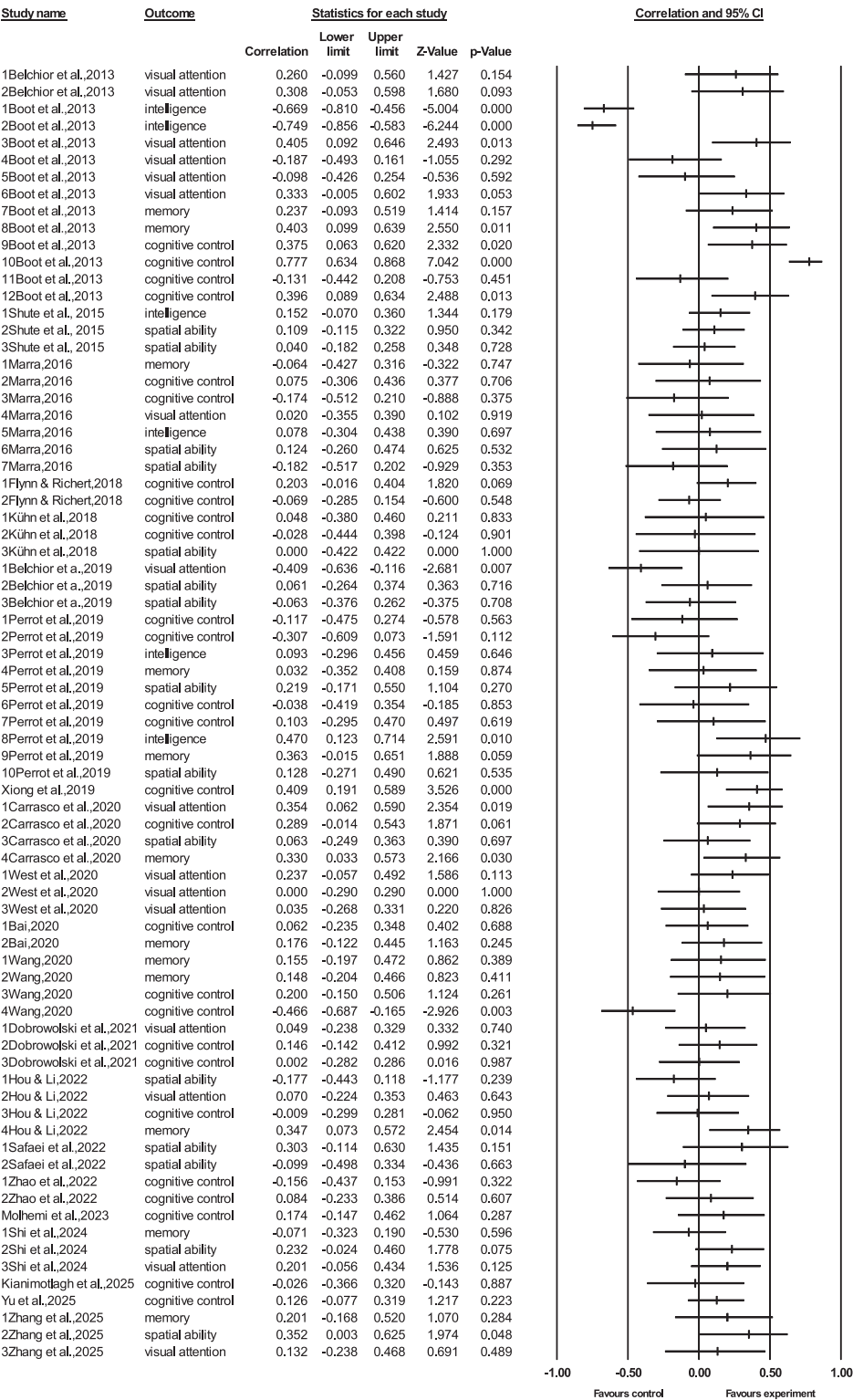


Fig. 4. Forest plot of controlled trials.

association between video game play and cognitive ability across multiple study designs (i.e., correlational studies, between-group comparison studies, and controlled trials) and cognitive domains (i.e., memory, spatial ability, visual attention, cognitive control, and intelligence). The meta-analysis revealed a consistent pattern of statistically significant yet generally small positive correlations, with the overall effect size varying by study design but consistently falling within a small range. Substantial heterogeneity and non-significant moderators highlight the complexity

of this association and limit the interpretability of the findings. Future research should identify more key factors to clarify the mechanisms and boundary conditions of this association, informing the potential for targeted cognitive interventions.

CRediT authorship contribution statement

Rumei Zhao: Writing – original draft, Formal analysis,

Conceptualization. **Kunzhen Pang:** Writing – original draft, Methodology, Formal analysis, Conceptualization. **Jie Yu:** Writing – original draft, Investigation, Data curation. **Wanyan Zhang:** Investigation, Data curation. **Xiaoxue Kong:** Writing – review & editing. **Jiyueyi Wang:** Investigation. **Aersheng Haidabieke:** Data curation. **Xuechen Ding:** Writing – review & editing, Supervision, Project administration, Funding acquisition. **Junyi Li:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.actpsy.2026.107110>.

Data availability

Data will be made available on request.

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