Computers in Human Behavior 182 (2026) 109025

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

The tug-of-war between engagement and dysregulation: A comprehensive analysis of cognition and internet gaming disorder in adolescents

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ARTICLE INFO

Keywords:
Internet gaming disorder
Adolescence
Cognitive development
Psychomotor abilities
Video games
Structural equation modeling

ABSTRACT

Research on video games faces a paradox. Many epidemiological studies have documented developmental harms; however, experimental research often highlights cognitive benefits. We theorize that this discrepancy stems from a common tendency to conflate high behavioral engagement (time spent) and dysregulation. Utilizing structural equation modelling, we simultaneously examined the independent associations of both Internet Gaming Disorder (IGD, dysregulation) and average daily gaming time (engagement) with a comprehensive, psychometrically validated test battery of cognitive and motor assessments in a substantial adolescent sample (N = 3,854, age 12–16 years). Although IGD and gaming time shared notable variance (r = .59), they exhibited independent, opposing associations with cognitive performance. Specifically, IGD was consistently associated with lower performance across cognitive tests whereas gaming time was positively related to multiple cognitive domains, including visual-spatial and reasoning skills. At the genre level, *Strategy* and *Role-playing* games were associated with better reasoning and verbal skills, whereas *Shooters* were strongly associated with IGD severity. Further analysis of favorite game titles also revealed heterogeneity within genres, suggesting that cognitive correlates are linked to specific in-game mechanics (e.g., complex planning) rather than the overall genre. Overall, the findings support the conclusion that the negative associations between gaming and cognitive ability reflect a dysregulated state rather than dose, while specific positive associations depend on the mechanics of the title played.

1. Introduction

Video games have evolved into a global cultural phenomenon that engages around three billion players (Statista, 2025). Consequently, the neurocognitive associations of gaming remain subject of investigation, with ongoing debate regarding whether high-frequency engagement represents a context for cognitive skill development or a developmental risk for adolescents (Alzahrani & Griffiths, 2025; Bediou et al., 2023). A critical gap in the literature arises from a frequent challenge to explicitly dissociate high behavioral engagement (i.e., gaming time) from dysregulated usage, such as Internet Gaming Disorder (IGD). While these two constructs often overlap in clinical presentations, conflating enthusiasts with dysregulated gamers likely masks their distinct relationships with cognitive and motor development. The present investigation addresses this ambiguity by simultaneously disentangling the independent associations of gaming time, specific game genres, and IGD severity with cognitive and motor performance in a substantial sample of adolescents (N = 3,854).

Current research regarding the cognitive correlates of gaming is characterized by significant heterogeneity. On the one hand, numerous investigations suggest that the cognitive demands inherent in action and strategy games are positively associated with perception, top-down attention, and spatial cognition (e.g., Bediou et al., 2023; Chaarani et al., 2022; Granic et al., 2014; Green & Bavelier, 2003; Powers et al., 2013). Theoretical frameworks of skill transfer suggest that the continuous practice of complex in-game mechanics may relate to higher performance in specific cognitive domains (Oei & Patterson, 2013, 2014; Smith & Basak, 2023). Conversely, a parallel body of literature highlights the negative correlates of excessive gaming, identifying associations with reduced academic achievement, sleep disturbances, and psychosocial maladaptation (e.g., Borgonovi, 2016; Brunborg et al., 2014; Ferguson, 2015; Kristensen et al., 2021; Schmitt & Livingston, 2015).

To reconcile these divergent findings, it is essential to examine the *quality* of psychological engagement. The Interaction of Person-Affect-Cognition-Execution (I-PACE) model proposes that initial engagement

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https://doi.org/10.1016/j.chb.2026.109025
Received 21 January 2026; Received in revised form 8 April 2026; Accepted 9 April 2026
Available online 10 April 2026

in video games is based on gratification and mood regulation and thus represents an adaptive response to provide psychological rewards (Brand et al., 2019). However, when an individual's reward mechanism is paired with certain dispositional factors (e.g., academic failure or anxiety), the behavior may shift from a goal-oriented activity to a compulsive habit characterized by cue-reactivity and craving. This clinical presentation aligns with the DSM-5 classification of IGD, which characterizes gamers who develop addictive-like symptoms and impaired control (American Psychiatric Association, 2013). Thus, a high frequency of playing video games may demonstrate two distinct states: the deliberate practice of a healthy gaming enthusiast or the compulsive repetition of a disordered gamer. While the exact mechanisms remain to be established, it is theorized that deliberate gaming may relate to higher proficiency in distinct cognitive skills, whereas the compulsive nature of IGD may be associated with profiles of executive dysfunction (Billieux et al., 2019).

By ignoring the distinction between frequency of play and the quality of engagement, prior research may have masked the independent associations between gaming behaviors and cognitive performance. To address this, we utilized structural equation modeling (SEM) to investigate how duration, genre, and dysregulation relate to a comprehensive profile of cognitive and fine motor skills. This study extends previous work in three critical dimensions: first, by utilizing an extensive sample size to ensure robust statistical estimation; second, by simultaneously modeling engagement and dysregulation as independent predictors in a single analytic framework; and third, by employing a battery of psychometrically validated, standardized cognitive tests rather than brief self-reports to ensure a detailed, reliable assessment of performance. We tested the following hypotheses:

(1) We hypothesized that after controlling for dysregulated gaming (IGD), the amount of time gamers spend playing games per day will be positively associated with reasoning and visuospatial skills, potentially reflecting practice-related effects.
(2) We hypothesized that higher levels of IGD will independently relate to decreased cognitive functioning, consistent with theories of executive dysfunction.
(3) We modeled game genre as a predictor, hypothesizing that genres which require high level of spatial planning and resource management (e.g., *Strategy* and *Role-playing* games) would have positive associations with cognitive measures, while genres which have low cognitive demand (e.g., *Sports* titles) will show no significant associations.

Finally, recognizing that broad genre labels can be quite general, and therefore do not fully capture the underlying game mechanisms, we conducted an exploratory analysis at the individual game title level to determine if certain favorite game titles (e.g., *Minecraft* vs. *Fortnite*) correlate with specific types of cognitive ability that might be missed when categorizing games into broader genre groups.

2. Methods and materials

2.1. Participants

The sample comprised $N = 3{,}854$ participants (47.4% girls; age $M = 13.5$ years, $SD = 0.5$, range 12–16). The majority of participants attended middle school (83.3%), followed by academic secondary school (German “Gymnasium”, 15.0%), and other (1.7%).

Data collection started in April 2024 and ended in October 2024. Parents and adolescents gave written informed consent before the study and the study was conducted in accordance with the Declaration of Helsinki. The study was approved by the Commission for Scientific Integrity and Ethics of the Karl Landsteiner University, Krems, Austria (Nr. 1020/2023).

2.2. Procedure

Adolescents were recruited through the Austrian Institute for Economic Development's vocational information center (see also Stieger & Wunderl, 2022). Testing included psychometrically validated and normed cognitive and motor ability assessments, administered in German under standardized conditions by trained staff. For our analysis, we focused exclusively on validated instruments measuring cognitive (*Inventory for testing cognitive abilities,* INT; Schuhfried, 2019) and psychomotor abilities (*Motor Performance Series*, MLS; information processing).

2.3. Measures

All participants were asked to provide demographic information at the beginning of the study including the variables age and gender. An overview of all core variables is presented in Table 1.

2.3.1. Internet Gaming Disorder scale

Internet Gaming Disorder symptoms were assessed with the 9-item short form of the German Internet Gaming Disorder scale (IGDS9-SF; Montag et al., 2019; Wartberg et al., 2019). The items assess the DSM-5 criteria for IGD and ask about experiences within the past 12 months (e.g., preoccupation with gaming, loss of control, continued use despite problems). Each item was rated on a 5-point Likert scale ranging from 1 = *never* to 5 = *very often* (sum score range: 9–45). Internal consistency of the scale in the present sample was good (Cronbach's $\alpha = .81$).

2.3.2. Gaming time

Participants reported their average daily gaming time in minutes using a single item (“How much time do you spend playing video games normally per day”). Extreme values for gaming time were retained as they might reflect participants who leave games running in the background. For analysis, this variable was log-transformed to address skewness ($\gamma_1 = 3.72$). Please refer to Supplementary Table S1 and Supplementary Fig. S1 for an overview of the joint distribution between gaming time and IGD.

2.3.3. Game genre items

We assessed game genre preferences using a checklist adapted from Frei and Süss (2019). Participants were asked, “Which genre do you play predominantly?” (German: “Welches Genre spielst Du vorwiegend?“), and they could choose from nine different categories, including prominent examples of each category: (1) First- and Third-Person Shooters (e.g., Fortnite, Call of Duty, Counter-Strike); (2) Action-Adventure (e.g., Assassin's Creed, Uncharted, GTA); (3) Sports (e.g., FIFA, NHL, NBA); (4) Racing (e.g., Need for Speed, Mario Kart, Gran Turismo); (5) Jump ‘n’ Run/Platformers (e.g., Super Mario, Temple Run, Subway Surfers); (6) Strategy (e.g., Age of Empires, Total War, Plants vs. Zombies); (7) Simulation (e.g., The Sims, Hay Day, Animal Crossing); (8) Role-Playing Games (RPGs) (e.g., The Legend of Zelda, World of Warcraft, League of Legends); and (9) Puzzle Games (e.g., Portal, Candy Crush). Multiple selections were allowed; for statistical analyses, each genre was dummy-coded as a binary variable (0 = *not selected*, 1 = *selected*). An overview of genres played in the sample is shown in Supplementary Fig. S2.

2.3.4. Favorite game and franchise

Participants also provided a free-text answer about their favorite video game (“What is your favorite game at the moment?” [German: “Was ist momentan Dein Lieblingsspiel?“]). They were standardized through a process, where abbreviations, spelling variations, and inconsistent naming were semi-automatically harmonized using pattern-based rules and fuzzy matching to a reference list of known game titles. Each response was then linked to a corresponding game franchise (e.g., “FIFA 23” and “EA FC 24” to *FIFA*). Finally, all mappings were

Table 1
Descriptive statistics of study variables.

Measure	*N*	*M*	*SD*	Mdn	Min	Max	Skew
Gaming measures							
IGD Total Score	3854	15.38	5.44	14.00	9.00	45.00	0.95
Daily Gaming Time (Minutes)	3854	99.06	121.14	60.00	0.00	1440.00	3.72
Cognitive abilities							
Reasoning ability	3842	−1.76	1.25	−1.83	−6.66	2.02	−0.24
Visual-Spatial ability	3846	−0.03	0.98	0.05	−4.38	4.65	−0.36
Verbal ability	3848	−1.27	1.01	−1.30	−5.40	1.73	−0.22
Numerical ability	3846	−3.27	1.54	−3.00	−6.53	1.60	−0.26
Long-term memory	3847	−0.18	1.01	−0.23	−5.25	4.95	0.05
Motor abilities & information processing							
Information processing errors	3841	15.26	10.67	13.00	1.00	149.00	3.10
Tapping performance	3841	93.74	15.94	94.00	21.00	160.00	0.13
Finger dexterity (gross)	3782	135.04	22.49	132.30	81.30	354.80	1.61
Finger dexterity (fine)	3710	180.69	52.53	168.40	84.10	600.00	2.26
Hand guidance errors	3812	18.87	13.53	16.00	1.00	140.00	2.37

Note. IGD = Internet Gaming Disorder. Raw scores are presented prior to standardization. Cognitive abilities represent IRT-derived person parameters.

manually checked to ensure that games were correctly assigned to their respective franchises.

2.3.5. Cognitive abilities

The *Inventory for testing cognitive abilities* (INT) represents a comprehensive cognitive assessment tool using an adaptive testing design for measuring multiple facets of higher-order cognition through five distinct subtests (Schuhfried, 2019). The adaptive assessment demonstrates a configurable reliability coefficient of 0.70 for all five subtests (overall cognitive score: weighted omega of Ω = 0.85).

The INT includes subtests for: (a) *verbal ability* (comprehension and linguistic inference); (b) *logical reasoning* (visual pattern recognition and rule application); (c) *numerical ability* (computational skills and quantitative reasoning); (d) *visual-spatial ability* (mental rotation and manipulation); and (e) *long-term memory* (encoding, consolidation, and retrieval processes). For all subsequent analyses, we used the Item Response Theory (IRT)-derived person parameters for each subtest.

2.3.6. Information processing

This assessment evaluates rapid information processing under conditions of high cognitive load and controlled stress. Participants are required to respond immediately to a specific sequence of visual (colored lights) and auditory stimuli using hand buttons or foot pedals. While the test records correct, delayed, and incorrect reactions, our analysis focused primarily on the frequency of erroneous responses as an indicator of processing accuracy under pressure.

2.3.7. Motor abilities

Fine motor skills were assessed using the *Motor Performance Series* (MLS), a standardized battery based on Fleishman's dimensionality of motor performance (Fleishman et al., 1984). The MLS evaluates the specific components: *tapping speed, gross and fine finger dexterity* (completion time of large and small pins), and *hand guidance* (tracking errors). All tasks are completed on a specialized device. Our analysis utilized both completion times and error counts to create a comprehensive profile of motor proficiency.

2.4. Statistical analysis

All statistical analyses were performed in *R* version 4.5.1 (R Core Team, 2025) using the package *lavaan* (Rosseel, 2012).

2.4.1. Assessing data quality and preprocessing

Variables of cognitive and motor abilities were standardized for comparability of estimates (z-scores). Gaming time was log-transformed before standardization.

We removed definitive technical artifacts and physically impossible performances from the dataset (e.g., error codes, reaction times of 0, impossible or implausible tapping scores or finger dexterity times). Those artifacts were handled as "missing" in the final dataset. Visual inspection of the transformed data showed approximately normal distributions of the cognitive subtest variables, while motor performance and error-count variables showed a degree of skewness typical for performance data, which was accounted for during model estimation. The frequency of missings for individual variables are reported in Table 1.

2.4.2. Structural equation modelling

We used structural equation modeling to quantify how (a) the latent construct of *Internet Gaming Disorder* (IGD) and (b) self-reported *gaming time* jointly relate to the standardized cognitive and motor outcomes, while adjusting for age, gender, school type (reference = middle school), self-reported game genres (reference category = not playing genre), and favorite game franchise (reference category = no favorite game; see Fig. 1 for a conceptual overview). SEM accounts for measurement error in IGD via a factor model, and jointly estimates all parameters in one framework, controlling shared variance across predictors and outcomes.

The measurement model of IGD included a single latent factor using the nine items of the IGDS-9 as indicators: *gaming activity, irritability, craving, deception, continuation, relationship loss, failure, reduced interest,* and *escape*. To identify the model and scale the latent factor, the unstandardized factor loading of the first indicator was constrained to 1. The models were estimated with a diagonally weighted least squares (DWLS) estimator, accounting for the ordered-categorical nature of the IGD indicators and the deviations from normality of some dependent variables, with missing data handled via pairwise deletion.

For the structural models, we specified manifests of IGD and gaming time and outcome regressions on IGD and gaming time, each additionally adjusted for age, gender, and played game genres (Model 1) and favorite game franchise (Model 2), respectively. IGD and gaming time were allowed to covary. To capture domain-specific (cognitive, motor) shared variance not explained by predictors, we estimated the within-domain residual covariances. No cross-domain residuals were specified. Model fit was evaluated using CFI/TLI, RMSEA (with 90% CI), and SRMR.

Furthermore, because IGD and gaming time shared notable variance, we calculated variance inflation factors (VIF) before estimating the structural models to ensure their simultaneous inclusion did not introduce problematic multicollinearity. All VIF values were well below conservative thresholds of concern (VIF = 1.87 for gaming time; VIF = 1.51 for IGD; Kock, 2015), confirming that the predictors capture sufficiently distinct variance to be interpreted independently.

To assess the robustness of our findings, we conducted two comprehensive sensitivity analyses. First, to rule out non-linear threshold effects (e.g., whether cognitive deficits only emerge at

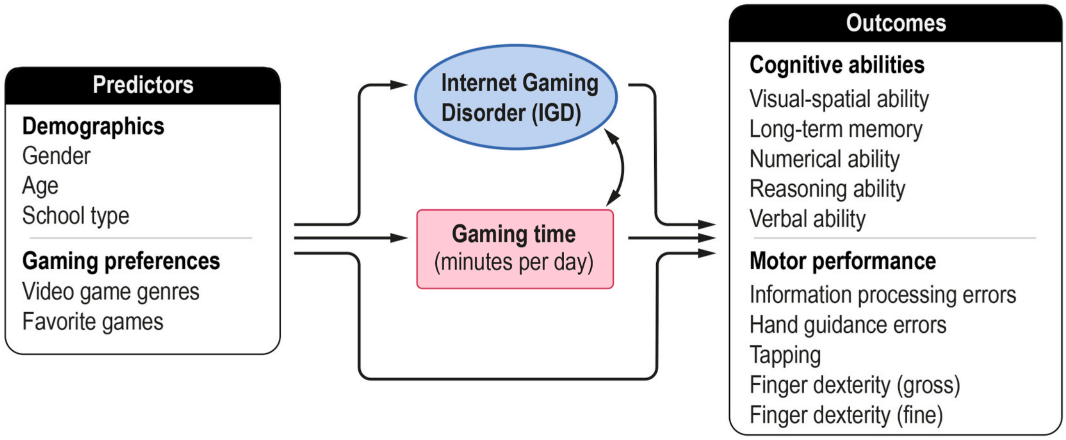

Fig. 1. Conceptual structural equation model (SEM). The pathways between gaming preferences, gaming behaviors, and cognitive and motor outcomes. IGD is modeled as a latent construct defined by the IGDS-9SF items. We employed two primary models differing in the gaming preferences: while Model 1 included 11 genres, Model 2 included 15 specific titles of favorite games. Effects were adjusted for gender, age, and school type. Residual covariances were estimated within the cognitive and motor outcome domains, respectively, and between IGD and gaming time.

extreme levels of gaming duration; see also Supplementary Fig. S1), we tested a model incorporating a quadratic term for standardized gaming time. Preliminary polynomial regressions demonstrated that while a quadratic term was statistically significant due to our sizeable sample, the relationship was predominantly linear: the linear model alone accounted for 30.8% of the variance in IGD scores ($R^2 = .308$), whereas the quadratic term added only a marginal 3.4% of explained variance ($\Delta R^2 = .034$). In the SEM sensitivity check, the quadratic term was included as a predictor for all outcomes and allowed to covary with the latent IGD factor to regress out any quadratic relationship. Because the quadratic term did not significantly predict any cognitive or motor outcomes, and the structural paths from IGD remained virtually identical in magnitude and significance, we retained the more parsimonious linear model for our primary analyses. Second, we also assessed a *g*-factor model to see if observed associations could be explained by a domain-general factor. In this specification, all cognitive outcomes loaded onto a single higher-order latent general cognition factor (*g*-factor), which was subsequently regressed on IGD, gaming time, and the covariates.

For all primary regression paths we report both unstandardized estimates and fully standardized coefficients. Comprehensive parameter estimates including the factor loadings of the measurement model and all estimated residual covariances are provided in the supplement. All *p*-values of the structural regression paths were adjusted for multiple comparisons using Benjamini-Hochberg procedure to control the false discovery rate (FDR; Benjamini & Hochberg, 1995) across all cognitive and motor outcomes for each predictor.

All reported coefficients are partial regression associations from a structural equation model: each path represents the association between a predictor and an outcome holding all other variables in the same equation constant. The model was estimated jointly, so these partial coefficients are derived simultaneously and the latent IGD factor accounts for measurement error in its indicators.

3. Results

Descriptive statistics for all variables are presented in Table 1. On average, our cohort showed an IGD sum score of $M = 15.38$ ($SD = 5.44$, $Mdn = 14$; Table 1). The self-reported average daily gaming time was $M = 99.06$ min ($SD = 121.14$, $Mdn = 60$).

For cognitive abilities, the IRT-derived person parameters yielded negative means across all five subtests, ranging from $M = -3.27$ ($SD = 1.54$) for numerical ability to $M = -0.03$ ($SD = 0.98$) for visual-spatial ability (see Table 1). These negative values reflect the cohort's performance relative to the test's normative sample (where $M = 0$), indicating that, on average, the current cohort, consisting primarily of students from vocational track, scored below the general population mean.

Regarding motor abilities and information processing, the cohort demonstrated an average of $M = 15.26$ ($SD = 10.67$) information processing errors, and $M = 18.87$ ($SD = 13.53$) hand guidance errors. Tapping performance showed a mean of 93.74 taps ($SD = 15.94$). For manual dexterity, the average completion times were $M = 135.04$ ($SD = 22.49$) seconds for gross motor tasks and $M = 180.69$ ($SD = 52.53$) seconds for fine motor tasks.

3.1. Excellent global fit and stable measurement of IGD

Two primary structural equation models (SEMs) were fitted to investigate the relations between gaming genres, gaming time, IGD, and behavioral outcomes. The global fit metrics showed excellent fit (genre model: $\chi^2 = 1050.40$, $df = 219$, CFI = 0.972, TLI = 0.976, RMSEA = 0.031 [90% CI 0.029–0.033], SRMR = 0.035; favorite game model: $\chi^2 = 1178.23$, $df = 315$, CFI = 0.971, TLI = 0.982, RMSEA = 0.027 [0.025–0.028], SRMR = 0.035), with large loadings in both models (standardized $\lambda = 0.58$–0.76 in the genre model; $\lambda = 0.57$–0.77 in the game model), supporting one latent factor. Unless otherwise noted, reported coefficients are standardized estimates (β) from the structural equation models.

3.2. Demographic effects: age, gender, and school type

Age was related to modest declines in reasoning ($\beta = -.07$), numerical ($\beta = -.09$), and visual–spatial abilities ($\beta = -.05$). Girls scored lower on cognitive tasks (e.g., numerical ability: $\beta = -.04$, see Table 2), but performed better on fine motor tasks, indicated by faster fine finger dexterity ($\beta = -.18$) and fewer errors in the hand guidance task ($\beta = -.17$). Furthermore, we found that students attending academic secondary schools (*Gymnasium*) showed consistently higher performance across all cognitive domains compared to middle school students (β range .17–.28) as well as slightly better performance in fine motor tasks. Note that girls were significantly younger than boys in our sample, $t(3852) = 3.04$, $p = .002$, Cohen $d = 0.10$).

3.3. Cognitive performance shows modest positive associations with gaming time but declines with IGD

IGD and gaming time (log-transformed) shared considerable

Table 2
Associations between gaming factors and cognitive abilities.

	Cognitive abilities (INT)					Information processing	Motor abilities (MLS)			
Predictor	Reasoning	Visual-Spatial	Memory	Numerical	Verbal	Errors	Tapping	Hand guidance errors	Dexterity (Gross)	Dexterity (Fine)
Gaming measures										
Gaming time	.07*	.12***	.08*	.07	.04	−.08*	.06	.03	.06	.03
IGD	−.12***	−.11***	−.11***	−.12***	−.11***	.15***	−.01	.02	.07*	.02
High Cognitive Load Genres										
Strategy	.10***	.05**	.03	.05**	.06**	−.05*	.03	.02	−.05*	−.05*
Role-Playing (RPG)	.09***	.10***	.08***	.04*	.13***	−.01	.03	−.04	−.01	−.03
Simulation	.03	.02	.02	.00	.06**	−.02	−.01	−.00	−.03	.00
Action & Sports Genres										
Shooter	−.02	−.03	−.01	−.01	−.05**	.01	.05	.00	−.06*	−.01
Sports	−.08***	−.09***	−.02	−.01	−.04*	.00	.00	−.02	−.01	.00
Adventure	−.05*	−.04*	−.01	−.06**	−.08***	.03	.00	.02	.03	.00
Platformer	.01	.02	−.00	.04	−.00	−.02	−.03	.01	.01	.01
Demographics										
Age	−.07***	−.05***	−.03	−.09***	−.09***	.06***	.01	.01	.04	.04
Gender (Female)	−.00	−.10***	−.07**	−.04	−.02	−.17***	−.07*	−.17***	−.11***	−.18***
Gymnasium	.26***	.20***	.17***	.21***	.28***	−.05*	.02	−.07**	−.03	−.03
Other school	−.03*	−.00	−.02	−.03	−.04	.04**	−.01	−.04	.01	−.01

Note. N = 3,854. Coefficients are standardized estimates (β) from the structural equation model. For information processing, dexterity and hand guidance positive coefficients indicate worse performance (more errors or slower completion time). Significance levels are false discovery rate (FDR)-adjusted within outcome. ***p < .001, **p < .01, *p < .05. IGD = Internet Gaming Disorder, INT = Inventory for testing cognitive abilities, German: "Gymnasium" = Academic secondary school, reference category = Middle school (German: "Mittelschule").

variance (standardized residual covariance r = .59), however they showed statistically independent and opposing associations with cognitive performance. Across domains, IGD was consistently associated with lower cognitive performance (all ps < .001). In contrast, after adjusting for covariates and multiple comparisons, total gaming time showed a significant positive association across multiple cognitive domains (see Table 2, Fig. 2).

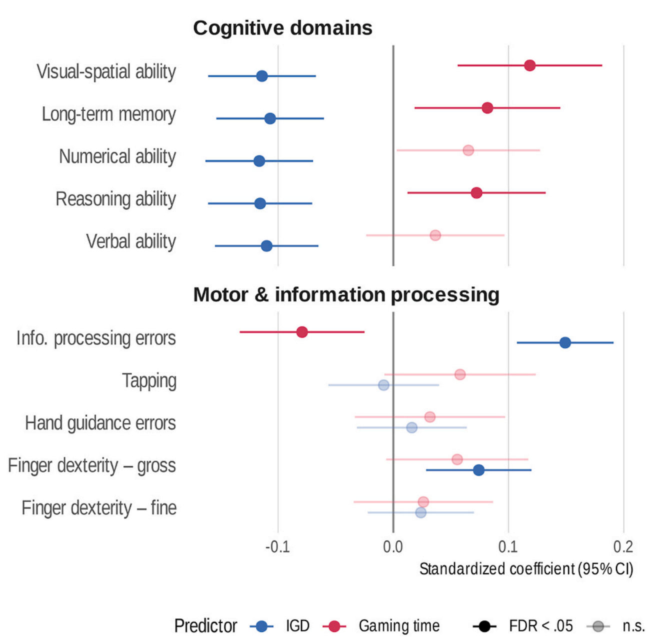

Fig. 2. Opposing structural pathways of digital gaming on cognitive and motor performance. Standardized partial regression coefficients with 95% confidence intervals derived from the structural equation model (N = 3,854) adjusted for age, gender, school type, and genre preference. Cognitive abilities show a distinct tug-of-war pattern: internet gaming disorder (IGD) was independently associated with lower performance across all domains, whereas average daily gaming time was associated with higher performance, specifically for visual-spatial skills. For measures of error rates and motor time (information processing, dexterity), positive coefficients indicate worse performance (more errors or slower speed). FDR = false discovery rate.

Visual–spatial ability increased with total gaming time (β = .12) but decreased with IGD (β = −.11). Role-playing (β = .10) and strategy (β = .05) genres showed the largest positive associations, while platformers were not significant (β = .02). Conversely, sports (β = −.09) and adventure (β = −.04) were negative.

Long-term memory was negatively associated with IGD (β = −.11) and showed a significant positive association with gaming time (β = .08). Role-playing games were associated with higher memory scores (β = .08), whereas sports titles were not significant (β = −.02).

Reasoning ability was linked negatively to IGD (β = −.12) and was significantly related to gaming time after adjustment (β = .07). Genre coefficients were largest for strategy (β = .10) and role-playing games (β = .09), whereas sports (β = −.08) and adventure games (β = −.05) were negative.

For numerical ability we found a negative association with IGD (β = −.12), however total gaming time showed no significant association after adjustment (β = .07). Strategy (β = .05) and role-playing genres (β = .04) were related to better scores, while adventure games showed lower scores (β = −.06).

Verbal ability was associated with lower IGD (β = −.11) and unrelated to gaming time (β = .04). However, players of simulation (β = .06), strategy (β = .06), and role-playing games (β = .13) scored higher. Adventure (β = −.08) and sports titles (β = −.04) again correlated negatively.

Similarly, regarding information processing under stress, IGD was associated with a significantly higher error rate (β = .15), whereas gaming time was associated with a lower error rate (β = −.08).

Finally, regarding motor performance, neither IGD nor gaming time were significantly associated with fine finger dexterity or hand guidance errors. However, higher IGD was associated with slightly lower performance in the gross finger dexterity task (β = .07), while gaming time showed no significant association with this motor domain (β = .06).

Detailed results are reported in Supplemental Table S2.

3.4. Genre is strongly associated with both gaming time and IGD severity

Gaming time showed large variation between preferred genres (Fig. 3; Table 3). For instance, shooters were associated with longer

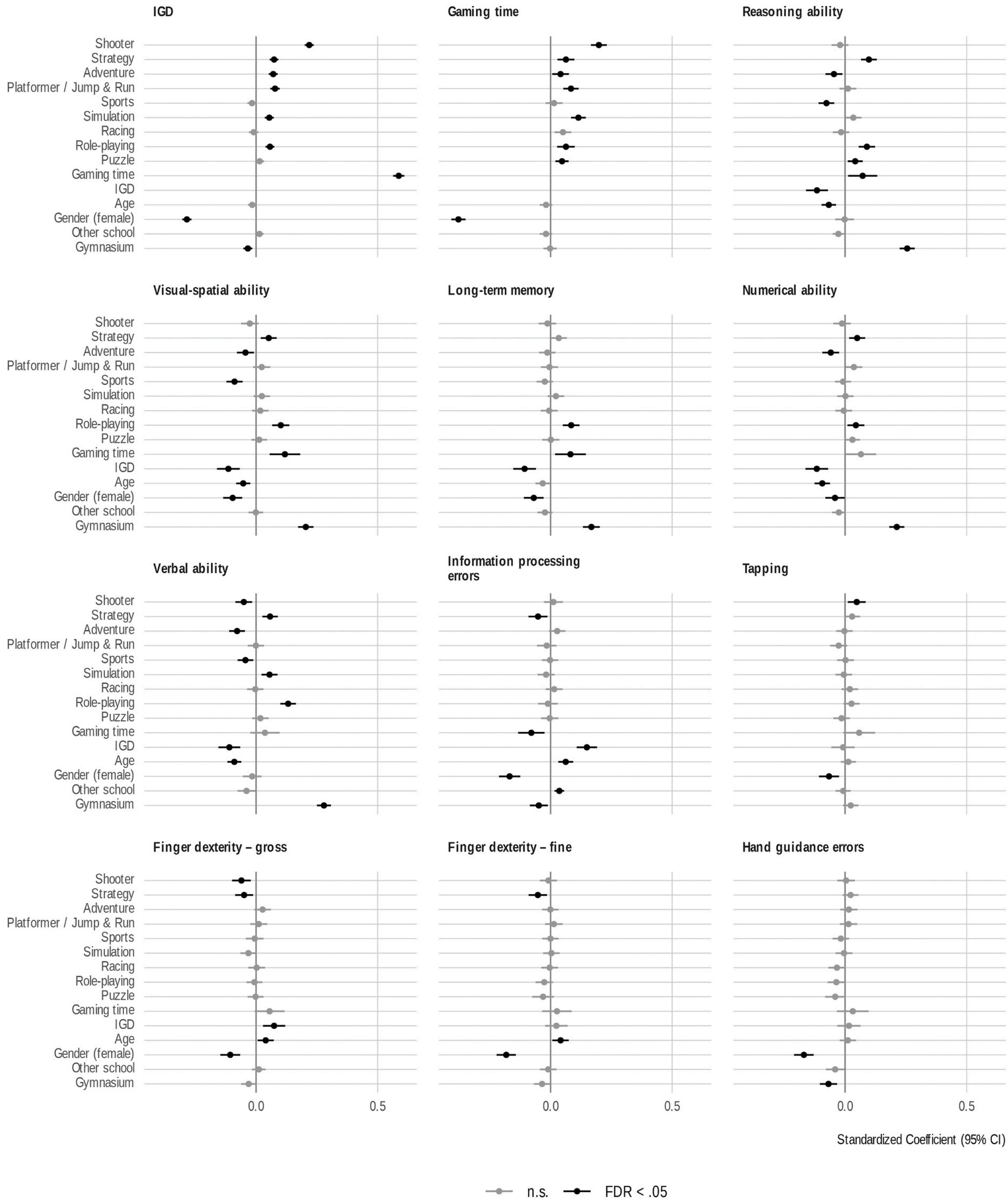

Fig. 3. Relationship between preferred game genres and Internet Gaming Disorder (IGD), gaming time, cognition, and motor skills. Dots represent the mean estimate, errorbars the 95% CI. FDR = false discovery rate.

gaming time (β = .20), followed by simulation (β = .11) and platform games (β = .08). Sports titles showed no reliable association (β = .01).

Moreover, IGD scores were also genre-dependent (Table 3). Shooters (β = .22) and strategy games (β = .07) yielded the strongest positive coefficients, while sports games were unrelated (β = −.02). Age was unrelated to IGD severity (β = −.02), and girls reported lower IGD than boys (β = −.28).

3.5. Gender-specific multigroup SEM

To evaluate whether the structural genre-specific relations observed in the main model differed between boys and girls, we estimated a multigroup SEM. The IGD factor showed highly comparable loadings across groups, supporting practical measurement invariance; multigroup model fit was excellent (CFI = .977, TLI = .979, RMSEA = .030).

Across groups, the pattern of genre associations was largely consistent: shooter, strategy, adventure, and role-playing games were positively associated with IGD in both genders. However, gender differences

Table 3
Predictors of gaming intensity and dysregulation.

Predictor	IGD severity β [95% CI]	Gaming time β [95% CI]
High Cognitive Load Genres		
Strategy	.07 [.06, .09]***	.06 [.03, .10]**
Role-Playing (RPG)	.06 [.04, .08]***	.06 [.03, .10]**
Simulation	.05 [.04, .07]***	.11 [.08, .14]***
Action & Sports Genres		
Shooter	.22 [.20, .24]***	.20 [.17, .23]***
Sports	−.02 [-.04, .00]	.01 [-.02, .05]
Adventure	.07 [.05, .09]***	.04 [.01, .08]*
Platformer/Jump & Run	.08 [.06, .10]***	.08 [.05, .12]***
Racing	−.01 [-.03, .01]	.05 [.02, .09]**
Puzzle	.01 [-.00, .03]	.05 [.02, .07]**
Demographics		
Gender (Female)	−.28 [-.30, −.27]***	−.38 [-.41, −.35]***
Age	−.02 [-.03, .00]	−.02 [-.04, .01]
Gymnasium	−.03 [-.05, −.02]***	−.00 [-.03, .03]
Other school	.01 [-.00, .03]	−.02 [-.04, .01]

Note. $N = 3{,}854$. Coefficients are standardized estimates (β). Significance levels are false discovery rate (FDR)-adjusted within outcome. ***$p < .001$, **$p < .01$, *$p < .05$. IGD = Internet Gaming Disorder, German: “Gymnasium” = Academic secondary school, reference category = Middle school (German: “Mittelschule”).

emerged in the predictors of gaming time: while shooters were related to longer gaming time for both boys (β = .19) and girls (β = .22), simulation games were associated with gaming time for boys (β = .20) but showed no reliable association for girls (β = .02; Supplementary Fig. S3; Supplementary Table 4).

Regarding cognitive pathways, the main findings were largely consistent across gender groups, with some domain-specific variations. IGD was associated with lower performance in reasoning, numerical, verbal, and visual-spatial abilities for both boys and girls (β ranges approx. −.07 to −.16). However, the negative association between IGD and long-term memory was significant only for girls (β = −.12) but not for boys (β = −.06).

Conversely, gaming time showed a consistent positive association with visual-spatial ability in both girls (β = .07) and boys (β = .14). While gaming time was unrelated to reasoning and numerical skills in both groups, girls showed an additional positive association with long-term memory (β = .08). The complete results for both boys and girls are presented in the Supplement.

3.6. *Game-level analyses and title-specific effects*

The favorite-game model replicated the above findings. While having any favorite game was naturally associated with higher gaming time and IGD scores relative to adolescents with no favorite game, modeling individual titles revealed notable heterogeneity in the magnitude of these associations. For gaming time, *Fortnite* (β = .40), *Brawl Stars* (β = .37), *and Minecraft* (β = .32) showed the strongest positive associations. Conversely, titles such as *Subway Surfers* (β = .08), *Animal Crossing* (β = .11), and *Mario Kart* (β = .11) yielded weaker associations with daily gaming duration (Fig. 4; Supplementary Table S3).

IGD scores followed a similar direction. Action-oriented titles including *Fortnite* (β = .33), *Roblox* (β = .29), and *Brawl Stars* (β = .29) showed highest positive associations with IGD. In contrast, casual or single-player titles like *Mario Kart* (β = .05), *Subway Surfers* (β = .05), and *Animal Crossing* (β = .07) demonstrated the weakest associations with dysregulation.

Titles with higher IGD loadings, such as *Fortnite* and *FIFA*, showed lower reasoning (β = −.07 for both) and visual-spatial scores (β = −.05 and β = −.06, respectively), with *Fortnite* being additionally associated with lower verbal scores and memory performance. Titles emphasizing exploration or construction, notably *Minecraft*, were associated with higher verbal ability (β = .05) and visual-spatial performance (β = .07). *The Sims* (β = .05) and *Animal Crossing* (β = .05) were associated with small but significantly better verbal ability, consistent with the simulation genre's positive link to language-related measures. In contrast, the highly prevalent mobile platformer *Subway Surfers* showed no reliable associations across any cognitive domain.

Motor outcomes were largely consistent across levels of analysis. Fine and gross motor dexterity showed minimal title-specific differentiation, with only *Brawl Stars* showing a weak association with faster gross dexterity (β = −.07).

3.7. *Sensitivity and robustness analyses*

The results of our sensitivity analyses confirmed the robustness our primary analyses. In the non-linear specification (CFI = .968, TLI = .980, RMSEA = .029; Supplementary Table S5), we partialled out the significant non-linear overlap between IGD and gaming time (standardized residual covariance $r = -.29$). Crucially, even after regressing out the quadratic relationship, the quadratic term for gaming time did not significantly predict any cognitive or motor outcomes (all $ps > .207$). The unique, opposing associations of IGD and linear gaming time with cognitive performance remained virtually identical in both magnitude and significance to the primary model (e.g., IGD to reasoning: β = −.11, $p < .001$).

Second, we evaluated whether the observed associations could be explained by a domain-general mechanism by estimating a *g*-factor model (CFI = .972, TLI = .974, RMSEA = .031). In this specification, all cognitive subtests loaded onto a single higher-order latent general cognitive factor (standardized λ = 0.49–0.74). Consistent with our primary subtest-specific models, IGD was strongly associated with lower general cognitive performance (β = −.18), whereas total gaming time showed a significant positive association with the general factor (β = .12). Full results for the *g*-factor model, including its associations with game genres, are provided in Supplementary Table S6.

4. Discussion

This study investigated the relationship of cognitive and motor skills and video gaming, disentangling the correlates of healthy engagement from dysregulated behavior. Our main result shows that IGD severity and daily gaming time demonstrated independent, opposing associations with cognitive performance when modeled concurrently. Specifically, higher IGD severity was independently associated with lower performance across all assessed cognitive domains, whereas gaming time exhibited distinct, positive associations with visual-spatial ability, reasoning ability, and memory. Crucially, the strong association between gaming time and IGD ($r \approx .59$), combined with their opposing associations with cognition (β ≈ −0.11 vs. +0.08) can explain why previous studies that did not explicitly distinguish between “high engagement” and “dysregulation”, have yielded inconsistent results: the aggregation of these variables without isolating the unique variance of dysregulation likely resulted in mutual suppression.

Our findings align closely with the *Interaction of Person–Affect–Cognition–Execution* (I-PACE) model (Brand et al., 2019), which posits that cognitive harm arises not from the duration of media consumption, but from the dysregulatory processes that maintain it. We observed that IGD was negatively associated with cognitive scores independent of play duration, indicating a state-dependent rather than strictly dose-dependent relationship. While our cross-sectional design precludes causal inference, drawing upon existing literature, this negative association may be theoretically underpinned by two non-mutually exclusive mechanisms: first, a diminished top-down cognitive control related to excessive cue-reactivity (Zheng et al., 2019), and second, the secondary displacement of restorative activities, such as sleep. This is corroborated by recent large-scale clinical observations demonstrating that pathological internet use is linked to deficits in behavioral inhibition, even when controlling for exposure time (Müller et al., 2025). That IGD was able to account for unique variance in our model, separate from

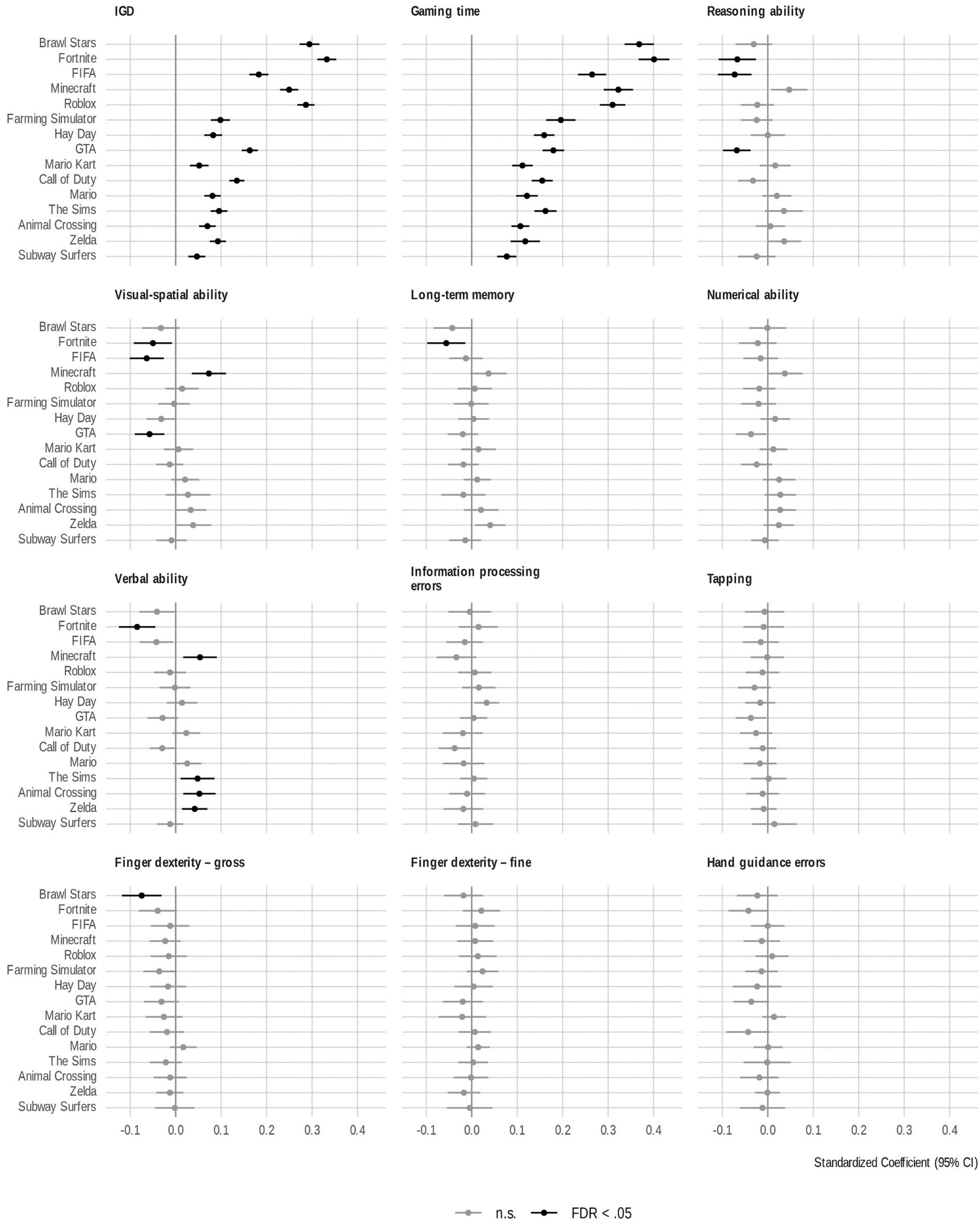

Fig. 4. Relationship between favorite game and Internet Gaming Disorder (IGD), gaming time, cognition and motor skills. Covariates (age, gender, school type are omitted for space). Dots represent the mean estimate, errorbars the 95% CI. FDR = false discovery rate.

time spent gaming, challenges the view that heavy gaming is always detrimental and suggests that individuals with high IGD scores experience a qualitative behavioral shift where gaming correlates with cognitive interference.

Furthermore, the small but significant positive association between gaming time and visual-spatial skills is consistent with previous research on specific cognitive transfer (Oei & Patterson, 2013). The observed patterns are consistent with theories proposing that the specific mechanics of video games (e.g., navigation, spatial rotation) share overlapping demands with cognitive tasks.

However, while prior meta-analytic evidence has emphasized the cognitive benefits of *Action* video games (Bediou et al., 2023), the present data revealed no significant associations between shooter titles and cognitive performance. Instead, the consistent positive associations with visual-spatial and reasoning skills were primarily observed for *Strategy* and *Role-playing* games. This suggests that the complex cognitive load associated with planning and resource management may exhibit stronger associations with higher-order cognition in adolescents than the rapid attentional demands characteristic of competitive shooters.

Another major contribution of this study is the finding that aggregating genre hides the heterogeneous associations with cognition, potentially explaining in part why prior meta-analyses reported null associations (Sala et al., 2018). Our analyses suggest that the relationship between gaming and cognition is not simply weak, but varies in direction depending upon genre. Specifically, *Strategy* and *Role-playing* games were positively associated with reasoning and verbal skills ($\beta \approx$ .06 to .13), while *Adventure* and *Sports* games had lower negative associations ($\beta \approx -.04$ to $-.08$). If these opposing associations were averaged into a single measure of *video game play*, as often occurs in epidemiologic studies, they would cancel one another out, resulting in an illusion of no effect.

An exploratory analysis at the game-level further narrows down these findings as well, indicating that specific mechanics could explain cognitive associations better than (comparatively) heterogeneous genre classifications. For example, although the *Platformer* genre has been historically associated with spatial processing (e.g., *Super Mario 64;* Kühn et al., 2014), no reliable correlation was found with cognition in our data set. An examination of our data at the game level resolved this issue by demonstrating that this genre was heavily weighted toward the mobile "endless runner" type games, such as *Subway Surfers*, which require minimal spatial complexity and rely on simple gesture-based reactions.

Similarly, the distinction between *Simulation* and *Sports* titles highlights the importance of in-game mechanics. While both genres are generally characterized as non-violent and casual simulation titles (e.g., *The Sims, Animal Crossing*) exhibited a significant positive correlation with verbal ability, likely reflecting their heavy reliance on text interaction and vocabulary-rich environments. Conversely, there was no significant correlation between sports games (i.e., *FIFA*) and verbal ability; instead, these games demonstrated a modest negative correlation with spatial ability and reasoning.

We also found that action and sports games (e.g., *Fortnite*, *FIFA*) showed some of the weakest or even negative associations with cognition. Furthermore, action games like *Fortnite*, *Roblox*, or *Brawl Stars* showed the highest association with IGD. Games with live-service (i.e., providing new paid content over time) or continuous progression elements may encourage repeated engagement and may represent a shift from "deliberate practice", where engagement is theoretically linked to performance changes, to dysregulated use.

For educational policy, our findings do not support a simplistic binary view of playing video games. The observation that time spent engaging in strategic and construction oriented games correlates positively with reasoning and numeracy suggests that cognitively demanding digital play is not inherently detrimental and may align with specific cognitive proficiencies, even if effect sizes are modest (Adachi & Willoughby, 2013). However, given the cross-sectional nature of the data, this should not be interpreted as a direct recommendation for utilizing gaming to foster developmental benefits (Granic et al., 2014), but rather as an indication of complex, domain-specific associations.

For clinical practice, the data provide preliminary evidence supporting diagnostic approaches that focus on dysregulation (loss of control, persistence in spite of harm) rather than time limits (Billieux et al., 2019; Kardefelt-Winther, 2014). Since time spent playing video games itself was positively correlated with specific cognitive skills in the absence of IGD, clinical interventions might find utility by targeting the compulsive dimensions of the behavior rather than exclusively focusing on screen time reduction.

Although our study has many strengths, we also acknowledge limitations. First, the cross-sectional nature of this study precludes any causal or directional inferences. While we reference theoretical frameworks such as skill transfer through practice, these must be strictly interpreted as potential models to explain observed associations, rather than evident directional effects. The data cannot rule out self-selection effects or reverse causality. For instance, it is perfectly plausible that those with higher baseline reasoning abilities are selectively drawn to complex strategy games. Similarly, pre-existing cognitive vulnerabilities may predispose individuals to develop IGD. Consequently, longitudinal research is crucial to establish the temporal precedence and directionality of these relationships.

Second, gaming time was assessed using a single self-report item, which represents a common but important limitation in larger-scale epidemiological research. Our self-reports of average daily gaming time are susceptible to recall bias and may not fully capture all real gaming patterns, such as differences between weekday and weekend usage. Future research should prioritize the use of objective telemetry data or high-resolution diaries to improve measurement precision.

Third, we did not directly assess several potentially important confounding or mediating variables. Specifically, omitted variables such as socioeconomic status, sleep quality, and comorbid mental health conditions (e.g., ADHD or depression) could account for some of the shared variance between IGD and cognitive or motor performance. For example, poor sleep quality is a known correlate of excessive screen time and can significantly impair executive functioning. Therefore, the specific physiological and psychological mechanisms through which IGD relates to lower cognitive and motor function remain a critical topic for future investigation.

Fourth, our recruitment through a vocational information center resulted in a sample predominantly composed of middle school students. Consequently, our findings may be more representative of adolescents pursuing vocational tracks than those in academic secondary schools, limiting the generalizability of our results to the broader adolescent population.

Finally, the assessment of gaming genres relies on broad, self-reported categories, which poses a validity limitation. Modern video games increasingly blend multiple genres (e.g., "Battle Royale" games like *Fortnite* combine elements of shooters, survival games, and building mechanics), making strict categorization difficult. Hence, self-reported genre preferences may lack the granularity needed to completely isolate the specific in-game mechanics (e.g., spatial navigation, resource management, rapid targeting) that are theoretically linked to the observed associations with cognitive and motor performance.

In conclusion, the present study contributes to a long-standing debate by showing that video gaming does not represent a general cognitive threat nor a universal enhancer. Instead, video gaming involves a trade-off between two distinct constructs: a dysregulatory process associated with lower cognitive performance, and a behavioral engagement process that is associated with specific cognitive correlates. By simultaneously modeling the "how much" (time spent gaming), and the "how healthy" (IGD), we demonstrate that meaningful advances in the science of digital media depend upon moving beyond aggregating screen time to specify which patterns of use, in which contexts, are associated with cognitive function.

CRediT authorship contribution statement

David Willinger: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Conceptualization. **Sabine Wunderl:** Writing – review & editing, Supervision, Project administration, Investigation. **Stefan Stieger:** Writing – review & editing, Visualization, Project administration, Methodology, Investigation, Conceptualization.

Code availability

The code for the analysis is available on OSF (https://osf.io/jusw2/).

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work, the authors used Gemini 3 in order to improve readability and language (i.e., style and grammar). After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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.

Acknowledgements

We thank Petra Freinberger for her support in data preparation. We acknowledge the support by the Open Access Publishing Fund of Karl Landsteiner University, Krems, Austria.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chb.2026.109025.

Data availability

The minimum dataset supporting the conclusions of this study contains sensitive information collected from adolescents under a binding cooperation agreement and in accordance with the GDPR. Therefore, the dataset is not publicly available; however, upon reasonable request, qualified researchers may access the dataset under the terms of the cooperation agreement and ethics approval.

References

Adachi, P. J. C., & Willoughby, T. (2013). More than just fun and games: The longitudinal relationships between strategic video games, self-reported problem solving skills, and academic grades. *Journal of Youth and Adolescence, 42*(7), 1041–1052. https://doi.org/10.1007/s10964-013-9913-9

Alzahrani, A. K. D., & Griffiths, M. D. (2025). Problematic gaming and students' academic performance: A systematic review. *International Journal of Mental Health and Addiction, 23*(5), 4062–4095. https://doi.org/10.1007/s11469-024-01338-5

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). American Psychiatric Publishing. https://doi.org/10.1176/appi.books.9780890425596

Bediou, B., Rodgers, M. A., Tipton, E., Mayer, R. E., Green, C. S., & Bavelier, D. (2023). Effects of action video game play on cognitive skills: A meta-analysis. *Technology, Mind, and Behavior, 4*(1). https://doi.org/10.1037/TMB0000102. Spring 2023.

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society: Series B, 57*(1), 289–300.

Billieux, J., Flayelle, M., Rumpf, H.-J., & Stein, D. J. (2019). High involvement versus pathological involvement in video games: A crucial distinction for ensuring the validity and utility of gaming disorder. *Current Addiction Reports, 6*(3), 323–330. https://doi.org/10.1007/s40429-019-00259-x

Borgonovi, F. (2016). Video gaming and gender differences in digital and printed reading performance among 15-year-olds students in 26 countries. *Journal of Adolescence, 48*, 45–61. https://doi.org/10.1016/j.adolescence.2016.01.004

Brand, M., Wegmann, E., Stark, R., Müller, A., Wölfling, K., Robbins, T. W., & Potenza, M. N. (2019). The interaction of person-affect-cognition-execution (I-PACE) model for addictive behaviors: Update, generalization to addictive behaviors beyond internet-use disorders, and specification of the process character of addictive behaviors. *Neuroscience & Biobehavioral Reviews, 104*, 1–10. https://doi.org/10.1016/j.neubiorev.2019.06.032

Brunborg, G. S., Mentzoni, R. A., & Frøyland, L. R. (2014). Is video gaming, or video game addiction, associated with depression, academic achievement, heavy episodic drinking, or conduct problems? *Journal of Behavioral Addictions, 3*(1), 27–32. https://doi.org/10.1556/JBA.3.2014.002

Chaarani, B., Ortigara, J., Yuan, D., Loso, H., Potter, A., & Garavan, H. P. (2022). Association of video gaming with cognitive performance among children. *JAMA Network Open, 5*(10), Article e2235721. https://doi.org/10.1001/jamanetworkopen.2022.35721

Ferguson, C. J. (2015). Do angry birds make for angry children? A meta-analysis of video game influences on children's and adolescents' aggression, mental health, prosocial behavior, and academic performance. *Perspectives on Psychological Science: A Journal of the Association for Psychological Science, 10*(5), 646–666. https://doi.org/10.1177/1745691615592234

Fleishman, E. A., Quaintance, M. K., & Broedling, L. A. (1984). *Taxonomies of human performance: The description of human tasks*. Academic Press.

Frei, M., & Süss, D. (2019). Nutzungsdauer und Präferenzen für Videospiele und ihre Zusammenhänge mit dem Ärgerempfinden bei Fehlern in der Schule. *Diskurs Kindheits- und Jugendforschung, 14*(3), 345–357. https://doi.org/10.3224/diskurs.v14i3.07

Granic, I., Lobel, A., & Engels, R. C. M. E. (2014). The benefits of playing video games. *American Psychologist, 69*(1), 66–78. https://doi.org/10.1037/a0034857

Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423*(6939), 534–537. https://doi.org/10.1038/nature01647

Kardefelt-Winther, D. (2014). A conceptual and methodological critique of internet addiction research: Towards a model of compensatory internet use. *Computers in Human Behavior, 31*, 351–354. https://doi.org/10.1016/j.chb.2013.10.059

Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. *Int. J. e-Collab., 11*(4), 1–10. https://doi.org/10.4018/ijec.2015100101

Kristensen, J. H., Pallesen, S., King, D. L., Hysing, M., & Erevik, E. K. (2021). Problematic gaming and sleep: A systematic review and meta-analysis. *Frontiers in Psychiatry, 12*. https://doi.org/10.3389/fpsyt.2021.675237

Kühn, S., Gleich, T., Lorenz, R. C., Lindenberger, U., & Gallinat, J. (2014). Playing super mario induces structural brain plasticity: Gray matter changes resulting from training with a commercial video game. *Molecular Psychiatry, 19*(2), 265–271. https://doi.org/10.1038/mp.2013.120

Montag, C., Schivinski, B., Sariyska, R., Kannen, C., Demetrovics, Z., & Pontes, H. M. (2019). Psychopathological symptoms and gaming motives in disordered gaming-A psychometric comparison between the WHO and APA diagnostic frameworks. *Journal of Clinical Medicine, 8*(10), 1691. https://doi.org/10.3390/jcm8101691

Müller, S. M., Antons, S., Schmid, A. M., Thomas, T. A., Kessling, A., Joshi, M., Krikova, K., Kampa, M., Mallon, L., Schmidt, L. D., Klein, L., Dominick, N., Büsche, K., Oelker, A., Brandtner, A., Montag, C., Wölfling, K., Wolf, O. T., Diers, M., … Brand, M. (2025). Self-control abilities in specific types of problematic usage of the internet: Findings from clinically validated samples with neurocognitive tasks. *American Journal of Psychiatry, 182*(7), 660–670. https://doi.org/10.1176/appi.ajp.20240486

Oei, A. C., & Patterson, M. D. (2013). Enhancing cognition with video games: A multiple game training study. *PLoS One, 8*(3), Article e58546. https://doi.org/10.1371/journal.pone.0058546

Oei, A. C., & Patterson, M. D. (2014). Are videogame training gains specific or general? *Frontiers in Systems Neuroscience, 8*. https://doi.org/10.3389/fnsys.2014.00054

Powers, K. L., Brooks, P. J., Aldrich, N. J., Palladino, M. A., & Alfieri, L. (2013). Effects of video-game play on information processing: A meta-analytic investigation. *Psychonomic Bulletin & Review, 20*(6), 1055–1079. https://doi.org/10.3758/s13423-013-0418-z

R Core Team. (2025). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. https://www.R-project.org/.

Rosseel, Y. (2012). Lavaan: An R package for structural equation modeling. *Journal of Statistical Software, 48*(2), 1–36. https://doi.org/10.18637/jss.v048.i02

Sala, G., Tatlidil, K. S., & Gobet, F. (2018). Video game training does not enhance cognitive ability: A comprehensive meta-analytic investigation. *Psychological Bulletin, 144*(2), 111–139. https://doi.org/10.1037/bul0000139

Schmitt, Z. L., & Livingston, M. G. (2015). Video game addiction and college performance among males: Results from a 1 year longitudinal study. *Cyberpsychology, Behavior, and Social Networking, 18*(1), 25–29. https://doi.org/10.1089/cyber.2014.0403

Schuhfried. (2019). *Manual: Inventory for testing cognitive capabilities (INT) version 54*. Schuhfried.

Smith, E. T., & Basak, C. (2023). A game-factors approach to cognitive benefits from video-game training: A meta-analysis. *PLoS One, 18*(8), Article e0285925. https://doi.org/10.1371/journal.pone.0285925

Statista. (2025). Video gaming worldwide—Statistics & facts. *Stat* Accessed on 14 Jan 2026 https://www.statista.com/topics/1680/gaming/.

Stieger, S., & Wunderl, S. (2022). Associations between social media use and cognitive abilities: Results from a large-scale study of adolescents. *Computers in Human Behavior, 135*, Article 107358. https://doi.org/10.1016/j.chb.2022.107358

Wartberg, L., Kriston, L., Zieglmeier, M., Lincoln, T., & Kammerl, R. (2019). A longitudinal study on psychosocial causes and consequences of internet gaming disorder in adolescence. *Psychological Medicine, 49*(2), 287–294. https://doi.org/10.1017/S003329171800082X

Zheng, H., Hu, Y., Wang, Z., Wang, M., Du, X., & Dong, G. (2019). Meta-analyses of the functional neural alterations in subjects with internet gaming disorder: Similarities and differences across different paradigms. *Progress in Neuro-Psychopharmacology & Biological Psychiatry, 94*, Article 109656. https://doi.org/10.1016/j.pnpbp.2019.109656