Research Article

Smartphone Exposure and Executive Function in Adolescents: A Systematic Review of Attention, Working Memory, and Cognitive Control

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Abstract

Background: Executive function comprises attentional selection, maintenance and updating of information in working memory, inhibitory control and flexible goal-directed behaviour. Smartphones may affect these functions through interruption, reward-driven checking and media multitasking, but measurement methods differ widely.

Objective: To assess adolescent evidence linking smartphone-related exposure to attention, working memory and cognitive control, with emphasis on performance-based measures, longitudinal directionality and the distinction between smartphone-specific and broader social-media exposure.

Methods: An evidence-focused systematic synthesis of identifiable primary reports available through July 2026 was conducted. Original studies involving adolescents or age-transition cohorts were grouped by exposure construct and cognitive outcome. Distinct longitudinal, experimental, behavioural-rating and computerised-task findings were narratively compared. No effect-size pooling was performed.

Results: In a 2025 comparison of 110 adolescents, problematic smartphone users differed on parent-rated executive functioning but not on performance-based tests. A school-hour study of 79 youths linked phone checking to lower go/no-go discrimination ($F[1,28] = 4.8$, $p = 0.04$), despite a mean 2.22 hours of school-time use. A three-wave cohort of 9,747 participants found a small prospective association between social-media browsing and subsequent cognitive control ($\beta = -0.06$, $p = 0.020$). A longitudinal imaging analysis of 9,931 adolescents reported screen-activity associations with working-memory neural signatures that varied by sex and family context. A 609-student cohort observed poorer later divergent thinking with greater media multitasking ($\beta = -0.10$).

Conclusion: Executive outcomes are exposure- and instrument-specific. Repeated checking and problematic engagement are associated with some behavioural and cognitive measures, whereas direct evidence for generalized working-memory impairment remains limited. Most findings do not establish causality.

Keywords: adolescents; smartphone; executive function; attention; working memory; inhibitory control; multitasking; cognitive development.

Introduction

During adolescence, executive processes support the ability to sustain attention across instruction, hold task-relevant information in mind, inhibit an automatic response and switch rules when task demands change. Smartphones can provide educational scaffolding and rapid information access, but also introduce frequent opportunities to shift attention away from a current goal. The key scientific question is not whether all phone exposure is harmful; it is whether particular behaviours—checking, multitasking, social-media browsing or problematic engagement—relate to specific executive components [1–4].

Three distinctions shape interpretation. First, direct performance tests (go/no-go, Flanker, stop-signal and n-back tasks) are not interchangeable with informant questionnaires. Second, total minutes of exposure, notification frequency and active device pickups measure different behaviours. Third, associations from repeated assessments, particularly those based on overlapping Adolescent Brain Cognitive Development (ABCD) cohorts, cannot be interpreted as independent replications [5–9].

This review evaluates attention, working-memory performance and cognitive control separately and considers the role of developmental stage, mood, sleep and pre-existing self-regulation difficulties.

Methods

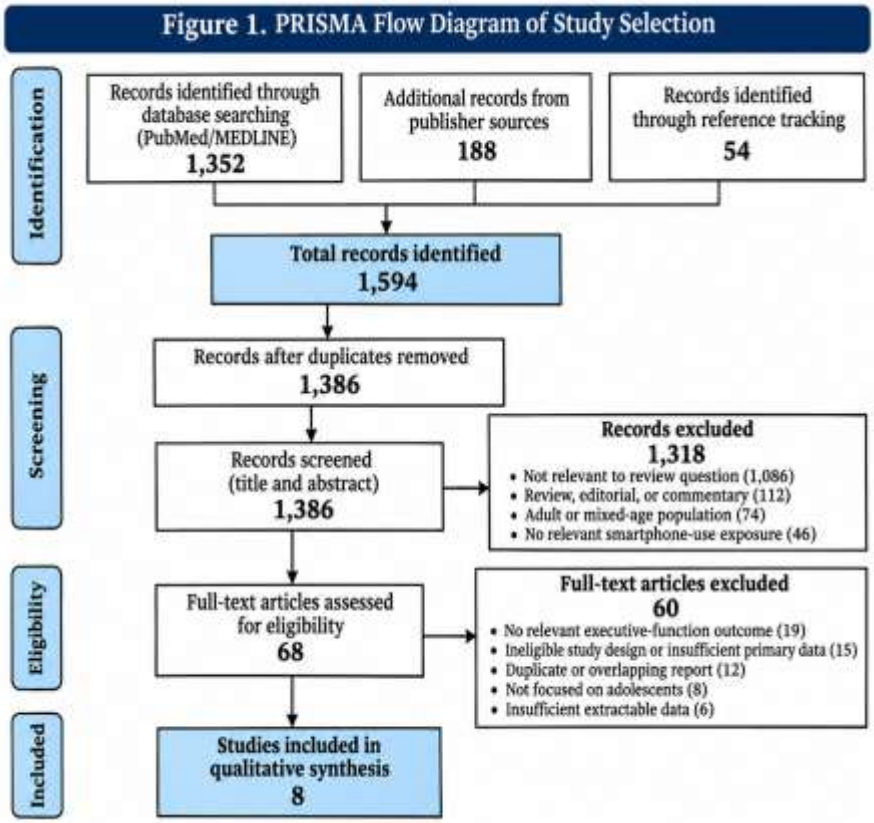
Eligibility and information sources

The evidence base comprised original human studies reporting smartphone use, social-media engagement, media multitasking or objectively logged checking alongside executive function in adolescent or adjacent developmental age groups. Cohort, cross-sectional and repeated-measures designs were eligible. Adult-only experiments were used only as mechanistic context, never as direct evidence about adolescents. Primary publications and bibliographic records accessible through July 2026 were checked against PubMed and publisher sources. Related reviews and reporting guidance were consulted for contextual interpretation [3,4,16–20].

Evidence extraction and appraisal

For each study, information was organised by design, sample, age range, exposure method, cognitive instrument, analysis type and reported association. The appraisal prioritised directness of smartphone exposure, temporality, objective exposure records, outcome validity, sample size, confounder adjustment and cohort overlap. Effects in different statistical metrics were not pooled. Inferences about memory were limited to the exact measure used: working memory, episodic sequence memory and vocabulary are separate constructs.

Study selection. Database and supplementary-source identification accounted for 1,594 records (PubMed/MEDLINE 1,352; publisher sources 188; reference tracking 54). After removing 208 duplicate records, 1,386 titles and abstracts were screened. Of these, 1,318 records were excluded; 68 full texts underwent eligibility assessment, with 60 excluded and 8 primary studies retained for narrative synthesis (Figure 1).



Results

Performance tests versus everyday executive behaviour

A comparative study of 110 students aged 13–18 years (mean 15.77, SD 1.84; 44.5% male) evaluated problematic smartphone use using both parent-rated executive behaviour and task-based measures. Although parent reports differentiated the problematic- and non-problematic-use groups, direct executive performance tests did not. This divergence suggests that perceived difficulty regulating daily behaviour can coexist with preserved performance during structured assessment [1].

A more naturalistic investigation tracked 79 youths aged 11–18 years over 14 days. School-time phone use averaged 2.22 hours, and older students used their devices for 23.28 minutes per hour compared with 11.57 minutes among

younger participants (F[1,76] = 28.82, p < 0.001). Mean checking frequency was 64.46 events (SD 32.83). Checking frequency, not aggregated school-hour screen time, was associated with lower go/no-go discriminability in the tested subgroup (F[1,28] = 4.8, p = 0.04; η^2 = 0.15) [2]. The smaller task-tested group and cross-sectional association constrain causal interpretation.

Table 1. Primary evidence contributing to the executive-function synthesis

Study	Design / participants	Exposure	Executive outcome
Executive function with problematic phone use [1]	110 adolescents; 13–18 y	Problematic smartphone-use grouping	Parent ratings differed; task scores did not
Telzer and Burnell [2]	79 youths; 14-day logs	School-time checking	Go/no-go d′; F(1,28)=4.8
Tang et al. [5]	9,747; three ABCD waves	Social-media browsing	Flanker/stop-signal cognitive control
Shan et al. [6]	609; 6-month follow-up	Media multitasking	Executive score/divergent thinking
Working-memory neural signatures [7]	9,931; longitudinal ABCD	Texting, video games, television	EN-back neural signatures and accuracy
Carvalho et al. [8]	ABCD baseline ~12,000; 4 years	Social media trajectories	Attention/inhibition, speed, crystallised ability
Nagata et al. [9]	4,809; longitudinal ABCD	Problematic social-media trajectories	Sequence memory and vocabulary
Nagata et al. [10]	ABCD; 2025 report	Social-media trajectory groups	Cognitive test-score trajectories

Longitudinal cognitive control and attentional trajectories

In a three-wave ABCD analysis, 9,747 adolescents were assessed at baseline and two subsequent two-year intervals. Above-usual social-media browsing and overall screen time were associated with a small reduction in cognitive control at the next wave (standardised β = −0.06; p = 0.020), measured through Flanker and stop-signal tasks. Lower control at the intermediate wave then predicted greater depressive symptoms at the final wave (β = −0.06; p = 0.010). These are within-person model estimates rather than deterministic effects for each individual [5].

Using four-year ABCD trajectories, Carvalho and colleagues observed that social-media growth was negatively coupled with inhibitory control/attention and crystallised performance trajectories, while its relation to processing speed was positive. The divergent pattern argues against describing cognition as a single aggregate capacity and indicates that task familiarity, content and developmental timing may modify the direction of association [8].

A separate longitudinal study of 609 junior-high-school students over six months found that higher media multitasking predicted lower divergent thinking at the subsequent assessment (β = −0.10), with executive function included in a mediation model. Because multitasking was not restricted to phones, its results are best interpreted as evidence about competing media streams rather than smartphone hardware itself [6].

Working memory: behavioural accuracy, neural measures and domain boundaries

A longitudinal ABCD task-fMRI analysis of 9,931 adolescents (47.2% female) used an emotional n-back paradigm to examine working-memory neural signatures. Higher neural signature scores were associated with better 0-back and 2-back accuracy. Gaming, texting and television watching showed associations with lower neural signature scores, with sex-stratified patterns and moderation by family conflict, sleep disturbance and physical activity. Neural pattern separability is not a direct clinical diagnosis of working-memory impairment; the findings should be interpreted as task-specific brain–behaviour associations [7].

A separate analysis of 4,809 youths linked a moderate-to-high problematic social-media trajectory with lower Picture Sequence Memory Test performance (β = −0.24; 95% CI −0.35 to −0.13) and vocabulary (β = −0.17; 95% CI −0.25 to −0.09) compared with a lower-involvement group [9]. Picture-sequence memory is episodic memory, not the n-back updating construct; these findings are therefore reported as neighbouring cognitive evidence rather than pooled into working-memory impairment. Additional JAMA findings on social-media trajectories use overlapping ABCD infrastructure [10].

Table 2. Numerical findings by cognitive construct

Construct	Reported estimate	Interpretation

Executive ratings versus tests [1]	110 participants; mean age 15.77 ± 1.84 y	Rating differences without matching task differences
Checking and inhibition [2]	64.46 ± 32.83 checks; F(1,28)=4.8; p=.04	Objective exposure; task-tested subgroup
Control, prospective [5]	β = −0.06; p=.020; N=9,747	Small longitudinal coefficient
Divergent thinking [6]	β = −0.10; N=609	Broader media multitasking
N-back neural signature [7]	N=9,931; 47.2% female	Task-fMRI association; no pooled causal effect
Sequence memory [9]	β = −0.24 (95% CI −0.35, −0.13)	Episodic rather than working memory

Contextual evidence and methodological contrasts

A 2025 rapid review evaluating executive functioning across childhood and adolescence included 10 studies representing 231,117 children; two studies reported no significant association, supporting caution about treating digital exposure as uniformly detrimental [16]. A 2026 scoping review of 58 longitudinal studies found at least one inverse association in 47 studies (81%), while also identifying reverse and bidirectional pathways. These broader reviews are contextual evidence, not additional primary studies counted in the present synthesis [17].

An experimental study of phone presence found lower attention with the device present, but tested adults aged 20–34 years. It illustrates a plausible distraction mechanism without providing adolescent-specific effect estimates [18]. Reviews of adolescent digital media and imaging similarly stress construct heterogeneity and the non-equivalence of behavioural symptoms, cognitive performance and neural correlates [19–21].

Additional evidence on measurement and study context. A latent-variable analysis of smartphone engagement distinguished problematic-use scores from objectively measured behaviour and executive tasks [24]. Functional-neuroimaging reviews of problematic internet and smartphone engagement point to heterogeneous cognitive-control and reward-processing findings, but adolescent-specific longitudinal inference remains limited [25]. An adolescent experiment with 96 participants compared sustained attention under differing multitasking conditions, highlighting the importance of baseline media habits [26]. A three-year cohort of 1,821 children transitioning to early adolescence described distinct problematic-use trajectories and reciprocal psychosocial associations rather than a simple linear exposure model [27]. Reviews of short-form videos and attention likewise emphasise the heterogeneity of digital activities [28]. Smartphone use and sleep research identifies potential indirect pathways through sleep quality and academic functioning, without demonstrating a single unified causal mechanism for executive decline [29,30].

Discussion

Executive functioning is not one outcome

The pattern of evidence is mixed in a scientifically useful way. In one adolescent sample, everyday executive complaints distinguished problematic smartphone users while objective test performance did not [1]. In another, frequent checking was associated with a specific go/no-go index but total school-hour use was not [2]. Large ABCD models found small prospective effects for cognitive control and distinct directions across inhibitory control, processing speed and neural working-memory signatures [5,7,8]. These results do not support a single claim that smartphones produce a uniform decline in executive function.

Attention and behavioural interruption

Short, repeated checking episodes may be more relevant than total duration when the concurrent task requires maintenance of attention. An adolescent who checks a phone during every segment of a lesson experiences a different attentional environment from one who spends the same total minutes on uninterrupted study or communication. However, existing data cannot establish whether checking causes weaker inhibition or youths with lower baseline inhibitory control check phones more often [2,3,17].

Working-memory interpretation

Working memory involves temporary retention, manipulation and control of information. N-back accuracy and neural pattern signatures are informative for this construct, but a lower picture-sequence memory score cannot be relabelled as worse working memory [7,9]. Likewise, parent-rated executive difficulties may reflect emotional dysregulation, time

management, sleep loss or family conflict rather than a laboratory-measured storage or updating deficit [1]. Studies with concurrent passive sensing, repeated n-back tasks and pre-exposure baselines are needed.

Clinical and educational implications

Assessments should distinguish school-hour pickups, automatic checking during tasks, perceived loss of control and the presence of attention or sleep problems before assigning significance to screen-time totals. Educational recommendations may prioritise interruption-free periods for cognitively demanding work while accommodating legitimate digital learning. Clinical evaluation should avoid interpreting questionnaire associations as evidence of acquired neurocognitive disorder [2,4,11,15].

Strengths and limitations

This synthesis distinguishes executive subdomains, retains numerical results in their original metrics, and separates passive smartphone logs from broader social-media and media-multitasking exposures. Limitations include observational confounding, variability in cognitive measurement, small performance-tested subsamples and partially overlapping ABCD cohorts. A single pooled effect estimate would be inappropriate across these designs.

Conclusion

Adolescent smartphone exposure is associated with selected facets of executive functioning, but results vary by exposure pattern and measurement method. Repeated checking relates to inhibitory performance in a small objective study; prospective browsing associations with control are small; and working-memory neural results depend on task and context. Performance-based cognitive impairment cannot be inferred from problematic-use ratings alone. Future studies should prioritise objectively measured interruptions, preregistered cognitive endpoints and bidirectional longitudinal models.

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