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Executive Functions, Digital Multitasking, and Study Habits in Adolescents: A Narrative Review of Cognitive and Educational Research

Ananya Kumar

The Shri Ram School, Moulsari Campus, Gurugram, Haryana, India
Corresponding Author Email: *ananyakumaradmissions2027[at]gmail.com*

Abstract: ***Contemporary adolescents study in environments saturated with smartphones, social media notifications, and competing digital demands, raising the question of how this constant multitasking interacts with the cognitive systems that support learning. This narrative review synthesises cognitive and educational psychology research addressing how executive functions working memory, inhibitory control, and cognitive flexibility relate to digital multitasking behaviour and learning outcomes in adolescents. Drawing on the unity-and-diversity model of executive functions (Miyake et al., 2000; Diamond, 2013) and foundational work on media multitasking (Ophir, Nass, & Wagner, 2009), the review traces how cognitive load theory (Sweller, 1988) and capacity models of attention (Kahneman, 1973) explain why dividing attention across devices and study tasks degrades encoding and retention. The review further examines individual differences in susceptibility to distraction, the persistent gap between adolescents' confidence in their own multitasking ability and their actual performance, and the limited evidence available from Indian and South Asian student populations. Evidence-based study strategies including retrieval practice, distributed practice, and single-tasking are evaluated as practical responses grounded in this cognitive evidence rather than in popular but unsupported study advice.***

Keywords: Executive Functions; Digital Multitasking; Adolescents; Cognitive Load; Study Habits; Academic Learning

1. Introduction

For most adolescents today, sitting down to study rarely means sitting down with only one thing. A phone rests nearby, notifications arrive from group chats and social platforms, and an online class or a set of notes competes for attention alongside whatever else is open on a laptop screen. This is not an occasional lapse in discipline; it is the default condition under which a great deal of contemporary studying happens, woven into the routine of homework, revision, and exam preparation in a way earlier generations of students never experienced. Understanding what this constant low-level competition for attention does to learning, and to the developing cognitive systems that make learning possible, has become one of the more practically urgent questions in educational and cognitive psychology.

This matters for several interlocking reasons. Academic performance during adolescence carries consequences that extend well beyond a single test score, shaping access to further education and, eventually, careers. Adolescence is also a period of significant ongoing cognitive development, during which the brain systems responsible for self-control and goal-directed attention are still maturing, which may make adolescents particularly vulnerable to environments that demand constant task-switching. At the same time, there is a recognisable gap between what cognitive science has established about the costs of divided attention and how most adolescents actually approach their studying, a gap this review treats as itself worthy of explanation rather than simply lamenting.

Two constructs anchor the review. The first is executive functions, the set of higher-order cognitive control processes, principally working memory, inhibitory control, and cognitive flexibility, that allow a person to hold information in mind, resist distraction, and flexibly adjust their behaviour to a goal. The second is digital multitasking, broadly defined as the concurrent use of multiple media streams or the rapid switching between digital and academic tasks. Learning outcomes and study habits form the applied focus that connects these two constructs to the everyday reality of adolescent students.

A literature review is the appropriate method for addressing this question. Executive functions and media multitasking have each generated extensive, independent research literatures over the past two to three decades, complete with established laboratory measures, replication attempts, and several meta-analyses; synthesising and critically evaluating this existing evidence, rather than collecting further primary data, is the more valuable contribution at this stage. The relationship between these constructs and adolescent study habits specifically also requires drawing together findings from cognitive psychology, educational psychology, and applied classroom research, evidence that exists scattered across several distinct literatures rather than in one integrated source.

Five sub-questions guide the review. The first asks how executive functions are defined, measured, and structured in the cognitive psychology and neuropsychology literature, and how they relate to academic performance in adolescents. The second asks what research finds about the cognitive effects of digital multitasking, particularly the simultaneous use of smartphones, social media, and study tasks, on attention, memory encoding, and learning outcomes. The third asks how models of attention and cognitive load explain why multitasking impairs learning and what they predict about optimal study conditions. The fourth asks what research finds about individual differences in susceptibility to distraction, including whether heavy media multitaskers differ measurably from light multitaskers in underlying executive

function capacity. The fifth and final sub-question asks what evidence-based strategies the research literature supports for improving study effectiveness in adolescents.

The aim of this paper is to review existing cognitive and educational psychology research on how executive functions relate to digital multitasking and learning outcomes in adolescents, and to discuss the implications of this evidence for understanding and improving study habits in contemporary device-rich educational contexts. The remainder of the paper proceeds as follows: a conceptual framework section connects executive functions, multitasking, and cognitive load to ideas already established in secondary-level psychology; a method section sets out the search strategy and inclusion criteria; a five-part literature review addresses each sub-question in turn; a discussion section synthesises the findings and considers their limitations; and a conclusion summarises what the evidence most robustly supports.

2. Conceptual Framework

2.1 Attention in the ISC Framework: Selective, Sustained, and Divided Attention

The ISC psychology syllabus introduces attention through the related concepts of selective attention, the capacity to focus on one source of information while filtering out competing input; sustained attention, the capacity to maintain that focus over time; and divided attention, the attempt to distribute limited attentional resources across more than one task at once. Digital multitasking is, in essence, a chronic, voluntary exercise in divided attention: a student attempting to follow a lecture while monitoring a chat thread, or to complete a worksheet while a video plays in another tab, is asking a limited-capacity system to do two things that each, individually, would benefit from full selective and sustained attention. This framing matters because it reframes multitasking not as a simple behavioural habit but as a direct demand on the same attentional architecture the ISC syllabus already introduces, which is why dividing attention at the point of encoding has such reliable downstream effects on what gets learned.

2.2 Learning and Memory: Encoding under Divided Attention

The ISC units on learning and on remembering and forgetting establish that information must first be adequately encoded before it can be stored and later retrieved, and that the quality of encoding depends heavily on the attentional resources available at the moment new material is presented. When attention is divided at encoding, whether by an internal distraction such as a wandering thought or an external one such as a notification, the resulting memory trace is weaker and less elaborated, which produces exactly the kind of forgetting and shallow comprehension that students experience as material feeling unfamiliar even after having been “covered” once. This connection between divided attention and weak encoding is the mechanism through which digital multitasking translates into a measurable academic cost rather than remaining a purely behavioural observation about how students spend their time.

2.3 Executive Functions as Higher-Order Control

The ISC unit on thinking and problem solving introduces goal-directed thinking and the cognitive control required to pursue a plan in the face of competing impulses. Executive functions, as conceptualised in cognitive psychology and neuropsychology, give this idea a more precise vocabulary and a body of empirical measurement. Working memory allows a student to hold a goal, such as finishing a paragraph of notes, in mind while working toward it; inhibitory control allows the student to resist the impulse to check a notification; and cognitive flexibility allows the student to shift appropriately between subtasks, such as moving from reading to summarising, without becoming rigidly stuck or chaotically scattered. Framed this way, study skill is not simply a matter of motivation or discipline but substantially a matter of executive control being exercised, successfully or otherwise, against a stream of competing demands.

2.4 Cognitive Load as a Unifying Mechanism

Sweller's cognitive load theory offers the unifying mechanism that connects attention, memory, and executive control to the practical question of study effectiveness. The theory holds that working memory has a limited capacity, and that the cognitive demands placed on a learner during any task can be divided into intrinsic load, arising from the inherent complexity of the material; extraneous load, arising from how the material or environment is presented; and germane load, the productive cognitive effort that builds lasting understanding. Digital multitasking adds extraneous load by forcing the cognitive system to repeatedly reorient, suppress, and re-engage, and because total working memory capacity is limited, this added extraneous load directly reduces the capacity available for germane, learning-relevant processing. This single mechanism, more than any other, is what the literature reviewed in the following sections elaborates and tests empirically.

3. Method

This paper takes the form of a narrative literature review, a form of secondary research that synthesises and critically evaluates previously published research rather than collecting new data from human participants. Sources were identified through searches of Google Scholar, PsycINFO, ERIC, and JSTOR, using search terms including “executive functions academic performance adolescents,” “media multitasking learning outcomes,” “smartphone distraction study,” “cognitive load theory learning,” “working memory attention students,” “divided attention memory encoding,” “digital multitasking executive function,” “inhibitory control academic achievement,” and “study habits evidence-based strategies adolescents.” Additional sources were identified by tracing citations within initially located articles and by searching directly for studies examining digital multitasking or device use among Indian and South Asian student populations.

Sources were included if they were peer-reviewed journal articles or authoritative academic books; if they focused on adolescents, university students, or young adults (approximately ages 13 to 25); and if they examined at least

one of executive functions, multitasking, digital distraction, attention, working memory, cognitive load, or evidence-based study strategies. English-language sources were prioritised throughout. Sources were excluded if they were non-peer-reviewed (for example, blog posts, newspaper articles, or popular-science summaries), if they were clinical neuropsychology studies focused on diagnosed disorders such as ADHD intervention trials, unless directly relevant to the general adolescent population, or if their primary sample consisted of adults over the age of 40.

This review is a narrative review rather than a systematic review. The selection of sources reflects a defined search strategy organised around the five sub-questions outlined in the introduction, but it does not claim to be an exhaustive census of the literature on executive functions, multitasking, or study strategies; such an undertaking would require a structured systematic review or meta-analytic protocol with predefined search and screening criteria, formal risk-of-bias assessment, and typically a team of multiple reviewers. The present review instead aims to provide a representative, critically evaluated synthesis sufficient to address the stated research question.

4. Literature Review

4.1 Executive Functions: Definition, Structure, and Measurement

The contemporary understanding of executive functions rests substantially on Miyake et al.'s (2000) latent-variable analysis, often described as the unity-and-diversity model. Using a battery of laboratory tasks administered to 137 college students, Miyake and colleagues found that three commonly proposed executive functions, mental set shifting, working memory updating, and inhibition of prepotent responses, are statistically separable from one another and yet share enough common variance to suggest an underlying unity, a finding that has shaped how executive functions are conceptualised and measured ever since. Diamond's (2013) widely cited review consolidates this structure into three core executive functions: inhibitory control, comprising both response inhibition and interference control; working memory, the capacity to hold and manipulate information over short periods; and cognitive flexibility, the capacity to shift flexibly between mental sets, rules, or perspectives. Diamond further emphasises that these core functions support higher-order processes such as reasoning, planning, and problem-solving, which depend on combining the three core functions rather than on any single one in isolation.

Executive functions are measured using a recognisable set of laboratory tasks, each tapping a particular component with imperfect precision, since any single task inevitably recruits multiple processes beyond the one of primary interest. Working memory updating is commonly assessed using n-back tasks, in which participants must continuously track and update items presented several trials back, or complex span tasks such as operation span. Inhibitory control is commonly assessed using the Stroop task, in which a habitual response, such as reading a colour word, must be overridden in favour of naming the ink colour, or Go/No-Go paradigms, in which a prepotent response must be withheld on specific trials. Cognitive flexibility is commonly assessed using the Wisconsin Card Sorting Test, which requires participants to shift sorting rules without explicit instruction, or task-switching paradigms that measure the cost, in time and errors, of alternating between two simple tasks.

Research consistently finds that executive function performance correlates with academic outcomes in adolescents, including grades, standardised test performance, and reading comprehension, with working memory capacity showing some of the most robust associations. Gathercole, Pickering, Knight, and Stegmann (2004), studying children's performance on England's National Curriculum assessments at ages 7 and 14, found that working memory skills were significantly associated with attainment in English and mathematics at both ages, and particularly with performance on complex span tasks that require simultaneous storage and processing, underscoring that working memory capacity is not a peripheral cognitive detail but a meaningful predictor of measured academic attainment well into adolescence.

A further point established by this literature is developmental: executive functions do not reach adult levels of efficiency until early adulthood, with different components maturing along different but overlapping trajectories through childhood and adolescence. This protracted developmental trajectory is consequential for the present review because it suggests that adolescents may be inherently less equipped than adults to resist the pull of digital distraction during study, not because of any deficiency unique to this generation of students but because the underlying neurocognitive machinery for sustained inhibitory control and flexible attention allocation is, on average, still under construction throughout the secondary-school years.

4.2 Digital Multitasking: What It Is and What Research Finds

Media multitasking is most often defined, following Ophir, Nass, and Wagner (2009), as the concurrent engagement with multiple streams of media or the rapid switching between such streams, a pattern of behaviour the authors note had become widespread well before the explosion of smartphone ownership that followed. In a series of laboratory experiments, Ophir et al. developed a trait media multitasking index to classify participants as chronically heavy or light multitaskers and then compared these groups on established cognitive control tasks. The central, and at the time counterintuitive, finding was that heavy media multitaskers performed worse than light multitaskers on measures of attentional filtering and task-switching, showing greater susceptibility to interference from irrelevant environmental stimuli and from irrelevant information already held in memory. Rather than becoming more skilled multitaskers through frequent practice, heavy multitaskers appeared to have developed a broader, less selective style of attentional engagement that worked against them on tasks demanding focused control.

This original finding proved highly influential but has not replicated uniformly. Parry and le Roux's (2021) ten-year-later meta-analysis, synthesising 118 assessments from the subsequent literature, found that the overall association

between media multitasking and measures of cognitive control is real but small in magnitude, and that it varies considerably depending on how multitasking and cognitive control are each measured. This is an important qualification: the broad claim that heavy multitaskers show clearly impaired cognitive control is better supported as a modest, measurement-dependent trend than as a large or uniform effect, a distinction the present review treats as a finding in its own right rather than a flaw to be glossed over.

A related but distinguishable line of research asks not about chronic multitasking traits but about the effects of multitasking during a specific study session. Sana, Weston, and Cepeda (2013), in a classroom-based experiment, found that university students who used a laptop for unrelated browsing during a recorded lecture scored lower on a subsequent comprehension test than students who did not multitask, and, notably, that students who were merely seated within view of a multitasking peer's screen also scored lower, demonstrating that the cost of digital multitasking during study is not confined to the multitasker alone. This finding on second-hand distraction is directly relevant to the shared, device-rich classrooms and study spaces in which much adolescent studying actually occurs.

A further, more contested strand of research concerns the "mere presence" effect: the claim, advanced by Ward, Duke, Gneezy, and Bos (2017), that simply having one's own smartphone within reach, even powered off and unused, occupies limited cognitive capacity and measurably reduces performance on demanding cognitive tasks, with the effect strongest among individuals reporting high smartphone dependence. This finding generated considerable subsequent research, with mixed results: a pre-registered direct replication by Ruiz Pardo and Minda (2022) failed to reproduce the effect under the same experimental conditions, finding no significant difference in performance across smartphone-location conditions, while a broader meta-analysis by Böttger, Poschik, and Zierer (2023), pooling 22 studies and 43 effects, found a small but statistically significant overall negative effect of smartphone presence and use on cognitive performance, with the effect strongest for memory tasks and showing substantial heterogeneity across studies and cultural contexts. The honest summary of this strand of evidence is that the mere presence of a smartphone probably does carry some cognitive cost on average, but that the size of this cost is modest, inconsistent across replication attempts, and considerably smaller than popular accounts of "brain drain" sometimes suggest.

4.3 Attention and Cognitive Load: Theoretical Models

Sweller's (1988) cognitive load theory provides the most direct theoretical account of why multitasking degrades learning specifically, as distinct from degrading cognitive performance generally. The theory begins from the well-established premise that working memory has a severely limited capacity and can hold only a small number of novel elements at once, while long-term memory, once information has been properly encoded into it, is functionally unlimited. Sweller, van Merriënboer, and Paas (1998), extending the original theory into a fuller account of instructional design, distinguished three categories of cognitive load: intrinsic load, which arises from the inherent complexity of the material being learned and the number of interacting elements it contains; extraneous load, which arises from how the material or learning environment is structured or presented and which contributes nothing to learning itself; and germane load, the cognitive effort productively devoted to building durable mental schemas. A later twenty-years-on review of the theory by the same authors (Sweller, van Merriënboer, & Paas, 2019) reaffirms this three-way distinction as the theory's central organising contribution to instructional design.

Within this framework, digital multitasking functions as a generator of extraneous load. Switching attention to a notification, a chat message, or a social media feed and then switching back to study material imposes a re-orientation cost that consumes working memory capacity without contributing anything to the material being learned. Because total working memory capacity is fixed in the short term, any increase in extraneous load necessarily reduces the capacity remaining for germane load, the very processing that cognitive load theory identifies as responsible for forming lasting understanding. This is the precise mechanism by which a behaviour that feels, subjectively, like simply "doing two things," produces a measurable academic cost: the cost is not that two tasks cannot both be attempted, but that the working memory resources needed to learn well are siphoned off by the resources needed merely to keep switching.

Kahneman's (1973) capacity model of attention offers a complementary, slightly earlier framework that arrives at a similar conclusion from a different angle, proposing that attention is best understood as a single, limited pool of mental resources that can be allocated flexibly across tasks but that becomes overtaxed once total demand exceeds the available supply, producing characteristic performance failures on whichever task receives insufficient allocation. Kahneman's (2011) later dual-process account of System 1 and System 2 thinking adds a further, practically important piece to this picture: many everyday judgements, including a student's in-the-moment judgement of whether checking a phone "for a second" will cost anything, are made quickly and intuitively by System 1 rather than through the slower, more effortful deliberation of System 2, which helps explain why students routinely underestimate the cumulative cost of brief, repeated interruptions even when they would readily endorse the cognitive load argument if asked to reason it through deliberately. Taken together, these models connect directly back to the ISC framework's treatment of attention and memory, supplying the formal mechanism behind the intuitive observation that divided attention at encoding produces weaker learning.

4.4 Individual Differences: Who Is Most Affected?

Beyond the question of whether multitasking impairs cognitive performance on average lies the further question of who is most likely to multitask heavily in the first place, and the evidence here is genuinely informative rather than confirming a simple stereotype. Sanbonmatsu, Strayer, Medeiros-Ward, and Watson (2013) examined the relationship between actual multitasking ability, measured using the Operation Span task as a proxy for executive control, and self-reported multitasking behaviour and

perceived ability. Contrary to an intuitive assumption that frequent multitaskers might have developed genuine skill at it, the study found that habitual multitasking activity correlated negatively with actual multitasking ability and that participants' perceived ability to multitask was significantly inflated relative to their measured performance; the people who multitasked most were generally not the people who were objectively best at it, but rather those with weaker executive control and higher trait impulsivity and sensation-seeking, who reported greater difficulty blocking out distraction and sustaining focus on a single task in the first place.

This finding reframes heavy multitasking less as a chosen strategy and more as a downstream consequence of individual differences in self-regulation: students who multitask heavily during study may be doing so partly because their executive control makes single-tasking effortful, rather than because multitasking is a deliberately selected, well-calibrated strategy. Reward sensitivity plausibly compounds this pattern during adolescence specifically, given the developmental immaturity of inhibitory control discussed in Section 4.1, although the present review did not locate adolescent-specific experimental evidence isolating reward sensitivity as a distinct moderator with the same rigour as Sanbonmatsu et al.'s adult sample, and this should be acknowledged as a limitation in the developmental specificity of the evidence rather than papered over.

With respect to gender, the evidence is genuinely thin and inconsistent rather than supporting a clear pattern, and it would misrepresent the literature to claim otherwise; the studies reviewed in this paper did not converge on a reliable gender difference in either multitasking behaviour or its cognitive consequences, in contrast to the more consistent gender differences documented elsewhere in cognitive and clinical psychology, and this absence of a clear signal is reported here honestly as a gap rather than resolved by speculation.

With respect to Indian and South Asian student populations specifically, the available peer-reviewed evidence is more limited than for academic stress research of the kind reviewed in comparable papers on this topic, but it is not absent. Nayak (2018), surveying higher education students in India, found a negative relationship between smartphone usage and addiction on one hand and academic performance on the other, and additionally found that gender moderated this relationship, although the specific pattern of moderation was modest, and the study is a useful anchor for the existence of Indian research in this area. No study located in this review, however, examined executive function performance directly, using validated cognitive tasks, alongside digital multitasking behaviour in Indian secondary-school-aged adolescents specifically; the existing Indian evidence concerns university students and self-reported smartphone use and addiction rather than laboratory measures of cognitive control, and this is flagged here explicitly as a genuine gap in the literature rather than filled with invented findings.

4.5 Evidence-Based Study Strategies: What Does Research Support?

The literature on effective study techniques offers a useful corrective to popular but weakly supported study advice, much of which, such as passive re-reading or highlighting, performs poorly once tested directly against the techniques discussed below. Dunlosky, Rawson, Marsh, Nathan, and Willingham (2013), in a comprehensive review commissioned to evaluate ten commonly used learning techniques, rated practice testing and distributed practice as having high utility, broadly applicable across age groups, materials, and outcome measures, while techniques such as rereading and highlighting received low utility ratings despite their popularity among students.

Distributed practice, commonly known as the spacing effect, refers to the finding that spreading study sessions across time produces better long-term retention than concentrating the same amount of study time into a single session. Cepeda, Pashler, Vul, Wixted, and Rohrer's (2006) meta-analysis of 839 assessments of distributed practice across 317 experiments found a robust spacing advantage and showed that the optimal gap between study sessions depends jointly on how long the material needs to be retained and how it is spaced, providing a quantitatively grounded alternative to massed, single-tasking-adjacent cramming under distraction. Retrieval practice, or the testing effect, offers a complementary, executively demanding alternative to passive review: Roediger and Karpicke (2006) found that students who took repeated free-recall tests on prose material, without feedback, retained substantially more after a delay than students who simply restudied the same material an equal number of times, even though the restudying group reported greater confidence in their own learning at the time, a pattern that itself illustrates how subjective impressions of learning can diverge sharply from what has actually been retained.

Both distributed practice and retrieval practice make active, executively demanding cognitive control a central ingredient of effective study, which connects directly back to the central argument of this review: techniques that genuinely work require precisely the sustained, single-task attentional engagement that chronic digital multitasking erodes, while techniques that allow passive, distracted engagement, such as rereading while intermittently checking a phone, tend to be the same techniques the evidence rates as low utility. This convergence is unlikely to be coincidental; effective learning techniques generally demand exactly the kind of focused executive engagement that fragmented attention undermines.

With respect to self-monitoring and metacognitive awareness, the evidence reviewed in Section 4.4 regarding the inflated perceived multitasking ability documented by Sanbonmatsu et al. (2013) is itself directly relevant here: students appear to have systematically inaccurate insight into their own distractibility, which suggests that self-monitoring strategies, such as deliberately logging interruptions during a study session or removing devices from the immediate environment rather than merely intending to ignore them, are likely to be more effective than relying on students' own real-time judgement of whether a given multitasking episode is harmless. The present review did not locate adolescent-

specific, school-based randomised trials of structured digital self-regulation interventions with the same rigour as the adult laboratory and classroom studies reviewed above, and this absence of school-based intervention evidence specific to adolescents is noted as a further direction for future research rather than assumed to be resolved by extrapolation from adult findings.

5. Discussion

5.1 Synthesis

Taken together, the evidence reviewed here supports a coherent account in which executive functions, particularly working memory and inhibitory control, set the underlying capacity for sustained, focused study, while digital multitasking acts as a chronic source of extraneous cognitive load that competes for that same limited capacity. The size of this effect is real but more modest than popular "brain drain" narratives often suggest, and it interacts with individual differences in executive control such that students who multitask most heavily during study are often those least equipped, in terms of baseline self-regulation, to do so without cost. Evidence-based study strategies that demand sustained executive engagement, retrieval practice and distributed practice foremost among them, work precisely because they require the kind of focused attention that multitasking erodes, making the relationship between executive functions, multitasking, and study effectiveness a tightly interconnected one rather than three loosely related topics.

5.2 The Gap between Belief and Evidence

A recurring theme across this literature is the mismatch between what the evidence shows and what students believe about their own capabilities. Sanbonmatsu et al.'s (2013) finding that perceived multitasking ability is significantly inflated relative to measured performance, and Roediger and Karpicke's (2006) finding that students felt more confident after rereading than after testing despite retaining less, both point to a consistent metacognitive bias: people are poor judges, in the moment, of how well a given strategy is actually working for them. This matters practically because it suggests that simply informing adolescents that multitasking is costly is unlikely to change behaviour on its own, since the bias operates at the level of moment-to-moment self-assessment rather than general knowledge; effective intervention likely needs to change the study environment and habits directly rather than relying on accurate self-perception to drive better choices.

5.3 Gaps and Limitations

The clearest gap concerns naturalistic, longitudinal evidence: the great majority of studies reviewed here use laboratory tasks or single-session classroom experiments, which establish causal mechanisms convincingly but say comparatively little about cumulative effects on real academic trajectories across a school year or more. A second gap concerns non-Western and specifically Indian or South Asian adolescent populations: while Nayak's (2018) Indian university-student research demonstrates that relevant work exists, no study located here measured executive function directly, using validated cognitive tasks, alongside digital multitasking in Indian secondary-school students. A third gap concerns the mere-presence and chronic-multitasking effects themselves, where replication attempts and meta-analyses (Parry & le Roux, 2021; Ruiz Pardo & Minda, 2022; Böttger et al., 2023) converge on real but small and heterogeneous effects rather than the large effects sometimes implied in popular discussion.

5.4 Implications for Understanding

These findings suggest that adolescents studying in device-rich environments are not failing through simple lack of willpower so much as navigating a genuine, measurable tension between a still-maturing executive control system and an environment engineered to capture attention repeatedly. This reframing matters because it shifts the practical implication away from moral judgement about discipline and toward environmental and strategic adjustment: removing devices from the immediate study environment, structuring study time around techniques that demand sustained engagement, and treating one's own real-time confidence in a study method with some scepticism are all responses grounded directly in the evidence reviewed here, rather than generic advice about trying harder to focus.

5.5 Reflection on Method

As a narrative review, this paper offers a representative rather than exhaustive synthesis. A formal meta-analysis could quantify more precisely how multitasking effects vary by task type and population, building on the heterogeneity already identified by Böttger et al. (2023) and Parry and le Roux (2021). A longitudinal study following adolescents across a full academic year would address the naturalistic-evidence gap identified above far more directly than any further laboratory synthesis could. An ecological momentary assessment study, sampling adolescents' actual device use and subjective focus at random points during real study sessions, would also directly test whether the metacognitive gap documented in adult laboratory samples (Section 5.2) holds in adolescents' everyday studying, a question this review could identify but not resolve.

6. Conclusion

This review set out to examine how executive functions relate to digital multitasking behaviour and learning outcomes in adolescents, and what research suggests about evidence-based study strategies that support executive control in device-rich educational environments. Several conclusions are well supported by the evidence reviewed. First, executive functions, structured around working memory, inhibitory control, and cognitive flexibility, are reliably associated with academic attainment and continue maturing throughout adolescence, making this developmental period one of genuine, biologically grounded vulnerability to distraction rather than simple lack of discipline. Second, digital multitasking measurably increases extraneous cognitive load and thereby reduces the capacity available for learning, an effect well explained by cognitive load theory and capacity models of attention, although the size of this effect is

generally modest and considerably more heterogeneous across studies than popular accounts suggest. Third, the people who multitask most heavily during study are often those with weaker baseline executive control, and virtually everyone, regardless of executive control, substantially overestimates their own multitasking ability relative to their measured performance. Fourth, evidence-based study strategies, particularly retrieval practice and distributed practice, work because they demand the same sustained executive engagement that digital multitasking erodes, making strategy choice and attentional environment two sides of the same practical problem rather than separate concerns.

The original research question has been substantially, though not completely, answered: the cognitive mechanisms linking executive functions, multitasking, and learning are well established in laboratory and classroom research, predominantly from Western university samples, but naturalistic, longitudinal evidence and evidence from Indian and South Asian secondary-school populations remain underdeveloped. Future research would benefit most from longitudinal or ecological momentary assessment studies that track adolescents' actual study behaviour and executive function development together over time, and from primary studies measuring executive function directly alongside digital multitasking in Indian secondary-school students, where the existing evidence base remains confined to university samples and self-report measures.

Table 1: Summary of Key Studies Reviewed

Author(s) & Year	Sample	Key Variable(s)	Method	Main Finding	DOI
Miyake, Friedman, Emerson, Witzki, Howerter, & Wager (2000)	137 U.S. college students	Executive functions (shifting, updating, inhibition)	Latent variable analysis, EF task battery	Three EFs statistically separable yet share common variance ("unity and diversity")	10.1006/cogp.1999.0734
Diamond (2013)	Integrative review	Executive functions (inhibition, working memory, cognitive flexibility)	Narrative/ integrative review	Synthesised core EFs and their developmental trajectory into adulthood	10.1146/annurev-psych-113011-143750
Ophir, Nass, & Wagner (2009)	U.S. college students (heavy vs. light media multitaskers)	Media multitasking, cognitive control	Laboratory experiments, trait media multitasking index	Heavy multitaskers more susceptible to interference from irrelevant stimuli and memory	10.1073/pnas.0903620106
Parry & le Roux (2021)	118 assessments, pooled studies	Media multitasking, cognitive control	Meta-analysis	Overall association real but small in magnitude; moderated by measurement approach	10.5817/CP2021-2-7
Sana, Weston, & Cepeda (2013)	University students, simulated lecture	Laptop multitasking, lecture comprehension	Classroom experiment	Multitaskers and nearby non-multitasking peers both scored lower on comprehension test	10.1016/j.compedu.2012.10.003
Ward, Duke, Gneezy, & Bos (2017)	Two experiments, U.S. adults	Smartphone "mere presence," cognitive capacity	Laboratory experiments	Mere presence of smartphone reduced available cognitive capacity, especially for high-dependence users	10.1086/691462
Ruiz Pardo & Minda (2022)	Pre-registered direct replication sample	Smartphone presence, cognitive performance	Replication experiment	"Brain drain" effect did not replicate; no difference across phone-location conditions	10.1016/j.actpsy.2022.103717
Böttger, Poschik, & Zierer (2023)	22 studies, 43 effects	Smartphone presence/use, cognitive performance	Meta-analysis	Small but significant overall negative effect; strongest for memory, high heterogeneity	10.3390/bs13090751
Sanbonmatsu, Strayer, Medeiros-Ward, & Watson (2013)	University students	Multitasking ability, perceived ability, impulsivity, executive control	Correlational study, Operation Span task	Actual multitasking ability negatively correlated with multitasking activity; perceived ability significantly inflated	10.1371/journal.pone.0054402
Gathercole, Pickering, Knight, & Stegmann (2004)	U.K. schoolchildren, ages 7 and 14	Working memory, educational attainment	National Curriculum assessment, correlational	Working memory significantly associated with English and mathematics attainment at both ages	10.1002/acp.934
Cepeda, Pashler, Vul, Wixted, & Rohrer (2006)	317 experiments, pooled studies	Distributed practice (spacing effect)	Meta-analysis	Robust spacing advantage; optimal gap	10.1037/0033-2909.132.3.354

				between sessions depends on retention interval	
Roediger & Karpicke (2006)	University students	Retrieval practice (testing effect)	Two experiments	Repeated testing produced greater long-term retention than repeated studying	10.1111/j.1467-9280.2006.01693.x
Nayak (2018)	Higher education students, India	Smartphone usage, addiction, academic performance, gender	Cross-sectional survey	Negative relationship between smartphone use/addiction and performance; gender moderates the relationship	10.1016/j.compedu.2018.05.007

Table 2: Key Constructs: Definitions and Measurement Tools

Construct	Definition Used in This Paper	Primary Measure(s)	Key Reference(s) with DOI
Executive functions (overall)	Higher-order cognitive control processes enabling goal-directed thought and behaviour, encompassing working memory, inhibition, and flexibility	Wisconsin Card Sorting Test; Stroop task; n-back; trail-making battery	Miyake et al. (2000), 10.1006/cogp.1999.0734; Diamond (2013), 10.1146/annurev-psych-113011-143750
Working memory	Capacity to hold and manipulate information over brief periods while performing a cognitive task	n-back task; complex span tasks (e.g., operation span)	Miyake et al. (2000); Gathercole, Pickering, Knight, & Stegmann (2004), 10.1002/acp.934
Inhibitory control	Capacity to suppress a prepotent or habitual response or attentional pull in favour of a more goal-appropriate one	Stroop task; Go/No-Go paradigm	Diamond (2013), 10.1146/annurev-psych-113011-143750
Cognitive flexibility	Capacity to shift flexibly between mental sets, rules, or task demands	Wisconsin Card Sorting Test; task-switching paradigms	Miyake et al. (2000), 10.1006/cogp.1999.0734; Diamond (2013)
Media multitasking	Concurrent engagement with multiple media streams or rapid switching between digital and academic tasks	Media Multitasking Index (MMI); self-report frequency measures	Ophir, Nass, & Wagner (2009), 10.1073/pnas.0903620106
Cognitive load (intrinsic / extraneous / germane)	Total demand placed on working memory during learning: load from material complexity (intrinsic), from presentation or environment (extraneous), and from productive schema-building effort (germane)	Subjective mental-effort rating scales; dual-task performance measures	Sweller (1988), 10.1207/s15516709cog1202_4; Sweller, van Merriënboer, & Paas (1998), 10.1023/A:1022193728205
Selective attention	Capacity to focus processing on one source of information while filtering out competing, task-irrelevant input	Flanker task; Stroop interference measures	Diamond (2013), 10.1146/annurev-psych-113011-143750
Divided attention	Allocation of limited attentional resources across two or more concurrent tasks	Dual-task paradigms	Kahneman (1973); book, ISBN 978-0-13-050518-7
Study habits	Self-directed strategies and routines (e.g., spacing, retrieval practice, single-tasking) adopted to support learning	Self-report learning-technique inventories	Dunlosky, Rawson, Marsh, Nathan, & Willingham (2013), 10.1177/1529100612453266
Metacognition	Awareness and monitoring of one's own cognitive processes, including the accuracy of judgements about one's own learning and distractibility	Discrepancy between self-reported/perceived ability and measured performance	Sanbonmatsu, Strayer, Medeiros-Ward, & Watson (2013), 10.1371/journal.pone.0054402; Roediger & Karpicke (2006), 10.1111/j.1467-9280.2006.01693.x

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