

THE EFFECTS OF DIGITAL STIMULUS OVERLOAD ON ATTENTION, PERCEPTION, AND INFORMATION PROCESSING IN CHILDREN

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Abstract: Digital media increasingly expose children to rapidly changing visual and auditory stimuli and to a high density of simultaneously available information. Against this backdrop, this study investigates the extent to which digital sensory overload influences attentional control, visual and auditory perception processing, and the selection, processing and organisation of information in childhood. Furthermore, it examines whether highly stimulating digital environments favor stimulus-driven bottom-up processes whilst simultaneously placing greater demands on controlled, goal-directed top-down processes.

The study is based on a structured literature search in the PubMed, Web of Science and PsycINFO databases. Peer-reviewed publications in German and English published from 2021 onwards have been included. The analysis encompassed systematic reviews and literature reviews, as well as experimental, cross-sectional and longitudinal studies involving child samples. A total of 14 studies have been summarized into a study matrix and evaluated with regard to attention, perception, executive control, sensory processing and cognitive overload.

The findings show that intensive and unstructured patterns of digital media use may be associated with increased distractibility, attention problems and greater processing of task-irrelevant stimuli. Furthermore, there is evidence of reduced executive control and difficulties in the targeted selection and organized processing of relevant information. Individual studies also point to differences in auditory and visual perceptual processing, as well as to neurobiological correlates. Overall, the findings suggest that digital stimulus environments may amplify bottom-up processes, whilst placing a greater strain on top-down processes such as inhibition, sustained attention and goal-directed information selection. However, the available evidence is heterogeneous. The effects depend largely on the content, the structure of the stimuli, the duration of use, the child's stage of development, and the context of use. Passive, excessive, and age-inappropriate forms of use are more frequently associated with adverse consequences, whereas interactive, age-appropriate, and socially supported activities show more mixed and context-dependent associations. As a large proportion of the research to date is based on observational studies, causal conclusions can only be drawn to a limited extent. Digital sensory overload should therefore be regarded as a relevant, yet context-dependent, factor associated with children's information processing.

Keywords: digital media; attention; perception; information processing; cognitive overload

INTRODUCTION

Attention, perception and information processing are key prerequisites for children's learning and developmental processes. Attention enables the selection of

relevant information, the maintenance of focus, and the suppression of irrelevant stimuli. A distinction is made between stimulus-driven bottom-up processes and controlled top-down processes. Controlled top-down processes are particularly important for the targeted selection and processing of information (Reynolds, Romano, 2016).

During childhood, the systems involved in attention, perception, and cognitive control are still developing. At the same time, children are increasingly exposed through digital media to rapidly changing, visually and auditorily salient stimuli. Perception can be understood as an active process of selecting, organising, and interpreting sensory information. This presents particular challenges for children, as they must distinguish relevant from irrelevant information and process new content in an organized manner (Barr, 2019).

Against this background, this study investigates the extent to which a high density of rapidly changing digital stimuli influences children's attentional control and auditory and visual perceptual processes, and whether digital sensory overload hinders the age-appropriate organisation and processing of information. This leads to the following hypotheses:

H1: A high density of rapidly changing digital stimuli is associated with reduced attentional control and altered auditory and visual perceptual processing in children.

H2: Digital sensory overload is associated with difficulties in the age-appropriate organisation and processing of information because it may reinforce stimulus-driven bottom-up processes and place greater strain on controlled, goal-directed top-down information selection and processing

RESEARCH METHODOLOGY

Search strategy

The literature review was developed based on the key elements of the research question. The focus was on studies concerning children as a target group, digital exposure in the form of screen-based media and rapidly changing stimuli, as well as cognitive and perceptual outcome variables. As this work is not an intervention study but rather a structured evaluation of the current state of research, the search strategy was based on the core thematic concepts of the research question. The aim was to identify studies relating to attention control, auditory and visual perception, sensory processing, and information-related processing in the context of digital media use. The results were combined across databases, checked for duplicates, and subsequently screened at the title, abstract, and full-text levels in a multi-stage process.

Databases

The search was conducted in the international databases PubMed, Web of Science and PsycINFO. These databases were selected on the basis of their relevance to issues in developmental psychology, medicine, cognitive science and neuroscience. This approach enabled us to identify a wide range of relevant publications that were both interdisciplinary and thematically focused.

Keywords and truncation

The search terms were selected in English, as the research relevant to the topic is predominantly published internationally. Terms were used from the fields of population, digital exposure, stimulus characteristics and outcome variables. The keywords were digital media, attention, perception, information processing, cognitive overload. The terms were organized into thematic blocks and linked using the Boolean operators AND and OR. Where supported by the respective databases, truncations such as screen* or child* were also used to include different word forms and conceptual variants. The search strategy was designed to capture both broader studies on digital media use and more specific works on stimulus density, rapid stimulus switching and cognitive load.

Inclusion and exclusion criteria

The analysis included peer-reviewed publications from 2021 onwards in German or English. Systematic reviews, experimental studies, and cross-sectional and longitudinal studies were considered. A prerequisite for inclusion was that the studies examined samples of children and assessed variables relevant to the research question. These included, in particular, attention, perception, sensory processing, information processing, cognitive performance, and aspects of digital sensory overload. Non-peer-reviewed works and studies whose primary outcomes lay outside the thematic focus were excluded. This applied in particular to publications on health, psychological development, motor skills or language development, provided there was no discernible link to attention, perception or information processing. Older studies were considered only if they served to provide a theoretical foundation for key concepts; however, they were not included in Appendix A (Table 1. Study matrix) as included studies.

The selection of the included studies was based on the relevance of their content to the research question. Priority was given to studies examining the effects of digital stimuli on attention, perceptual processing or the cognitive organisation of information in childhood. In addition to primary studies, systematic reviews were also included in order to take into account both individual findings and overarching trends in the research. Fourteen studies were included in the study matrix. Further theoretical or conceptual publications were used for conceptual classification but were not listed as included studies. The selection was carried out in a multi-stage process based on title, abstract and full text. Duplicates were removed. Studies that did not meet the inclusion criteria were excluded during the screening process.

RESULTS

The effects of digital stimuli on attention

Several of the studies included demonstrate links between exposure to digital media and changes in children's attention. In their systematic review, Santos et al. show that the majority of the included studies associated longer screen time with attention problems, whilst only one study reported improved attention performance. Given the heterogeneous nature of the findings, the authors emphasize the need for

further long-term studies (Santos et al., 2022). Jourdren et al. also conclude that high screen exposure during the pre-school years is associated with attention problems. All the included cross-sectional studies reported significant associations, and some of the longitudinal studies showed that early screen exposure was linked to later attention problems (Jourdren et al., 2023). In their review, Rizzo et al. show that passive and excessive digital use, in particular, is more frequently associated with attention problems, sleep disturbances, emotional dysregulation and neurobiological abnormalities. One of the fNIRS studies included in the review described reduced inhibitory control and reduced activation of the prefrontal cortex (Rizzo et al., 2025). In their systematic review, Presta et al. also highlight that increased use of digital devices during childhood is associated with various health and developmental issues, including behavioral problems, academic and socio-emotional difficulties, as well as reduced physical activity and sleep problems (Presta et al., 2024). Wetzel et al. provide experimental evidence of increased distractibility. In their EEG study, children reacted more strongly to irrelevant noises whilst playing on a tablet than during face-to-face interaction. The authors interpret this as heightened stimulus processing and increased attentional focus on auditory information irrelevant to the task, suggesting that it is more difficult to distinguish relevant stimuli from irrelevant ones (Wetzel et al., 2021). In addition, Nustad and Abrahamsson report that active screen time is associated with improved bottom-up and orientational attention, but at the same time with weaker executive and top-down attention. They interpret this as an indication that digital use may favor rapid, stimulus-driven attentional processes (Nustad, Abrahamsson, 2026). Vedeckina and Borgonovi also conclude that fast, conspicuous and highly stimulating media stimuli can reinforce bottom-up processes and thereby hinder the targeted top-down control of attention (Vedeckina, Borgonovi, 2021).

Strain on information processing

Several studies suggest that high-stimulus digital media can also place a strain on executive functions. Information is often taken in more quickly, but processed in a less organized manner. Clemente-Suárez et al. describe cognitive overload within the framework of Cognitive Load Theory as a consequence of limited working memory capacity, which can be exceeded by multiple streams of information presented simultaneously. Digital devices can contribute to such overload when parallel stimuli, constant shifts in attention and large amounts of information hinder children's processing, learning and memory formation (Clemente-Suárez et al., 2024). Namazi and Sadeghi demonstrate that fast-paced and fantasy-based television programmes can have differing effects on attention and executive functions in pre-school children. Evidence is found primarily for effects on bottom-up attention, as well as for an adverse influence of fantasy content on inhibitory control. At the same time, the authors take a critical view of the evidence, as the results remain inconsistent due to methodological differences between the studies and therefore do not allow for clear conclusions (Namazi, Sadeghi, 2024). Hinten et al. conducted two meta-analyses with moderator analyses using robust variance estimation

(RVE). A total of 21 studies were included, comprising 19 studies involving 1,431 children on media pace and 16 studies involving 1,297 children on fantasy content. Theoretically, the study is based on assumptions of limited cognitive resources. The results show that media pace had no consistent short-term effect on attention and executive functions, whilst fantasy content was associated with poorer cognitive performance after viewing. The authors attribute this to the fact that fantasy content can be particularly cognitively demanding, as it draws less on existing knowledge of real-world events and therefore requires more processing resources (Hinten et al., 2025).

Perception, sensory processing and neurobiological correlates

In addition to attention and executive functions, several studies also provide evidence of changes in perceptual processing. Wetzel et al. show that children using tablets reacted more strongly to irrelevant auditory stimuli than during analogue social interaction, suggesting altered sensory selection and increased distractibility (Wetzel et al., 2021). Hutton et al. report that higher levels of digital media use in pre-school children are associated with structural differences in the occipital, parietal, temporal and fusiform regions of the brain, which support primary visual and higher-order processing (Hutton et al., 2022). Furthermore, Rizzo et al. point to neurobiological abnormalities associated with excessive digital screen use, including reduced activation of the prefrontal cortex (Rizzo et al., 2025). Taken together, these findings suggest that digital stimuli can influence not only perception but also the depth and organisation of processing.

Information processing and cognitive overload

Another key focus of the findings concerns the extent to which digital information overload hinders the orderly processing of information. Parra-Medina and Álvarez-Cervera define information overload as a state in which the volume or intensity of information exceeds limited cognitive processing capacity. They cite confusion, delayed decision-making, a lack of critical evaluation, loss of control, stress and anxiety as possible consequences (Parra-Medina, Álvarez-Cervera, 2021). Within the framework of Cognitive Load Theory, Clemente-Suárez et al. describe how digital devices can contribute to cognitive overload when parallel stimuli, frequent shifts in attention and large amounts of information make processing, learning and memory formation more difficult (Clemente-Suárez et al., 2024). Vedeckina and Borgonovi, as well as Nustad and Abrahamsson, also point out that digital use can become problematic when stimulus-driven bottom-up processes are reinforced and controlled top-down processes are weakened. This makes it more difficult to prioritize relevant information and places a strain on the organisation of information processing (Vedeckina, Borgonovi, 2021; Nustad, Abrahamsson, 2026).

DISCUSSION

The available findings suggest that digital sensory overload has a significant impact on children's information-processing abilities. Correlations are particularly evident in the areas of attention, perceptual processing and executive control. Overall,

the studies indicate that children in digital environments are more strongly oriented towards conspicuous and immediate stimuli, whilst controlled, goal-directed processing is impaired.

H1 can thus be largely confirmed on the basis of a predominantly supportive, albeit not entirely consistent, body of evidence, particularly with regard to attention and visual perception. H2 is supported somewhat more clearly, especially in the areas of executive control, information selection and organized information processing.

At the same time, the findings show that digital media should not be viewed as inherently negative. Rather, it is the content, structure and context of use that are decisive. Whilst passive, excessive and developmentally inappropriate use is more frequently associated with adverse cognitive and attention-related outcomes, interactive, educational and socially embedded forms of use point to more nuanced and, in some cases, more favorable associations (Arabiat et al., 2023; Bal et al., 2024; Mallawaarachchi et al., 2024; Zosh et al., 2023). It should be noted, however, that a large proportion of the existing evidence is based on observational, cross-sectional and longitudinal studies. It is therefore difficult to draw causal conclusions. Furthermore, differences in the operationalisation of screen time, media content and outcome measures make it difficult to compare the studies. The results should therefore be interpreted with caution and highlight the need for more methodologically consistent longitudinal and experimental studies.

CONCLUSION

Digital sensory overload appears to be a relevant, context-dependent factor associated with attention, perception, and structured information processing in childhood. Rapid, intensive, and unsupervised media use, as well as passive and poorly structured formats, appear to be particularly problematic (Bal et al., 2024; Mallawaarachchi et al., 2024; Massaroni et al., 2023). The findings show that the effects of digital media depend largely on content, stimulus structure, context of use, and developmental appropriateness. Under favorable conditions, interactive and age-appropriate content can also be associated with positive cognitive outcomes (Arabiat et al., 2023). This highlights the need for both research and practice to take a nuanced approach to assessing children's use of digital media and to place greater emphasis on developing high-quality, child-friendly content.

Appendix A Table 1. Study matrix

Title/Author	Type of study / Year	Variable	Methodology	Results
The Association between Screen Time and Attention in Children: A Systematic Review. Santos et al.	Systematic review (2022)	Screen time, attention/attention problems in childhood	Systematic search; 498 hits, 41 full-text articles reviewed, 11 studies included	Most studies showed an association between higher screen time and attention problems.
The Impact of Screen Exposure on Attention Abilities in Young Children: A Systematic Review Jourdren et al.	Systematic review (2023)	Screen exposure in pre-school children; attention abilities	15 studies: 5 cross-sectional and 10 longitudinal studies involving children under 7 years of age	High screen exposure in cross-sectional studies consistently associated with attention problems (significant). 6 out of 10 longitudinal studies found negative long-term effects of early exposure. 7 out of 8 studies suggest a bidirectional relationship.
Molecular and Neurobiological Imbalance from the Use of Technological Devices During Early Child Development Stages Rizzo et al.	Systematic review (PRISMA) (2025)	Digital device use; age; motor skills, cognition, language, sleep, behaviour, emotional regulation	PRISMA review: literature search in PubMed, Scopus, Web of Science; age-stratified analysis	Passive and excessive use was more frequently associated with negative consequences such as attention problems, language delays, sleep disorders, emotional dysregulation and neurobiological abnormalities.
The Impact of Digital Devices on Children's Health: A Systematic Literature Review Prestia et al.	Systematic literature review (2024)	Exposure to digital devices; physical and mental health outcomes; physical activity, obesity, motor skills, sleep, behaviour, vision; COVID-19/lockdown	PROSPERO-registered; PRISMA; PICO; JBI Critical Appraisal Tool; SWiM synthesis 40 studies; a total of 75,540 children, aged 2–12 years	During the COVID-19 pandemic, exposure continued to increase and was associated with additional adverse effects. Lower academic performance, socio-emotional dysregulation and lower cognitive development were also reported
Tablet PC use directly affects children's perception and attention. Wetzel et al.	Experimental EEG study (2021)	Interaction mode (tablet vs. human interaction); auditory distraction, perception, attention	37 children performed the same memory task either on a tablet or with a person; parallel auditory oddball paradigm with EEG	Under tablet conditions, children responded more strongly to irrelevant sounds – indicating increased processing of task-irrelevant stimuli and heightened distractibility
Passive and active screen time relate differently to attention in preschool children Nustad & Abrahamsson	Review (2026)	Passive vs. active screen time; bottom-up/orientational attention vs. executive/top-down attention	Literature review: 13 relevant publications (10 empirical studies, 3 reviews).	Passive screen time detrimental to attention vs. active screen time more favourable associations with bottom-up and orientational attention, weaker associations with executive/top-down attention.
A Review of Evidence on the Role of Digital Technology in Shaping Attention and Cognitive Control in Children Vedchikina & Borgonovi	Review (2021)	Digital media stimuli; attention, cognitive control, bottom-up vs. top-down processes	Literature on television, video games and digital multitasking	Fast, eye-catching media stimuli can reinforce stimulus-driven bottom-up processes and thereby hinder controlled top-down regulation; effects vary depending on the medium and context of use.

Title/Author	Type of study / Year	Variable	Methodology	Results
Digital Device Usage and Childhood Cognitive Development: Exploring Effects on Cognitive Abilities Clemente-Suárez et al.	Review (2024)	Digital device use; cognitive development, attention, learning, memory, cognitive load	Peer-reviewed publications in PubMed, Embase, Scopus, SciELO, ScienceDirect and Web of Science; PRISMA flow chart; incorporation of theoretical frameworks from cognitive development and media psychology	Cognitive overload, reduced attention, executive and social impairments, effects dependent on content, context, duration and parental supervision; structured use and parental involvement as protective factors.
The immediate impacts of TV programs on preschoolers' executive functions and attention: a systematic review Namazi & Sadeghi	Systematic review (2024)	Media pace, fantastical content; attention and executive functions in pre-school children	15 experimental studies involving 1,855 children aged 2–7 years.	Effects on bottom-up attention; fantastical content ⊂ associated with weaker inhibitory control. Findings inconsistent due to methodological differences
Meta-Analytic Review of the Short-Term Effects of Media Exposure on Children's Attention and Executive Functions Hinten et al.	Meta-analyses with moderator analyses (RVE) (2025)	Media speed and fantasy content; short-term effects on attention and executive functions	Two meta-analyses – moderator analyses – RVE – 21 studies in total - Speed: 19 studies / 1,431 children - Fantasy: 16 studies / 1,297 children	Speed: no significant overall effect - Fantasy: significant negative effect - high heterogeneity
Associations between digital media use and brain surface structural measures in preschool-aged children Hutton et al.	Cross-sectional study (MRI) (2022)	Digital media use; brain structure in areas involved in visual and higher-order processing	Parent questionnaire, structural MRI, whole-brain and ROI analyses 52 children, aged 3–5 years	Higher media use was associated with structural differences in occipital, parietal, temporal and fusiform regions, which support primary visual and higher-order processing.
Examining the relationship between language development, executive function, and screen time: A systematic review Bai et al.	Systematic review (2024)	Language development, executive functions and screen time in early childhood	14 included articles; focus on children aged 0–78 months	Passive screen time was more frequently associated with adverse language and executive function outcomes; interactive content and parental involvement were assessed in a more nuanced manner.
Early Childhood Screen Use Contexts and Cognitive and Psychosocial Outcomes: A Systematic Review and Meta-analysis Mallawaarachchi et al.	Systematic review and meta-analysis (2024)	Context of screen use (content, co-use, background TV, parental use); cognitive and psychosocial outcomes	100 studies 176,742 participants including 64 observational studies in meta-analyses	Greater programme use and background TV were associated with poorer cognitive outcomes; shared use with caregivers showed more favourable cognitive associations
The Relationship between Language and Technology: How Screen Time Affects Language Development in Early Life - A Systematic Review Massaroni et al.	Systematic review (2024)	Screen time; passive/active use; TV; age at exposure; parent-child interaction; attention; executive functions	PRISMA-P; literature search in PubMed and Scopus; narrative review 18 studies; 32,274 pre-school children, 414 school-age children	high screen time associated with attention problems early TV exposure; background TV interferes with concentration on environmental stimuli - reduced parent-child interaction impairs attention control

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ВЛИЯНИЕТО НА ПРЕНАСИЩАНЕТО С ДИГИТАЛНИ СТИМУЛИ ВЪРХУ ВНИМАНИЕТО, ВЪЗПРИЯТИЕТО И ОБРАБОТКАТА НА ИНФОРМАЦИЯ ПРИ ДЕЦАТА

Резюме: Дигиталните медии все повече излагат децата на бързо променящи се визуални и слухови стимули, както и на голяма концентрация от информация, достъпна едновременно. На този фон настоящото проучване изследва до каква степен дигиталното сензорно претоварване влияе върху контрола на вниманието, зрителното и слуховото възприятие, както и върху подбора, обработката и организирането на информацията в детска възраст. Освен това то проучва дали силно стимулиращите цифрови среди благоприятстват стимулирано ориентираните процеси от долу нагоре, като едновременно с това поставят по-големи изисквания към контролираните, целенасочени процеси от горе надолу. Проучването се основава на структурирано проучване на литературата в базите данни PubMed, Web of Science и PsycINFO. Включени са рецензирани публикации на немски и английски език, издадени от 2021 г. насам. Анализът обхваща систематични прегледи и литературни прегледи, както и експериментални,

напречни и проследяващи проучвания с участието на извадки от деца. Общо 14 проучвания бяха обединени в матрица на проучванията и оценени по отношение на вниманието, възприятието, изпълнителния контрол, сензорната обработка и когнитивното претоварване. Резултатите показват, че интензивното и свободно структурирано използване на дигиталните медии може да бъде свързано с повишена разсеяност, проблеми с вниманието и по-голяма обработка на стимули, които не са свързани с текущата задача. Освен това има данни за нарушения в изпълнителния контрол и затруднения при целенасочения подбор и организираната обработка на адекватна информация. Отделни проучвания сочат също така промени в слуховата и зрителната перцептивна обработка, както и невробιологични корелации. Като цяло резултатите сочат, че средите с дигитални стимули могат да усилят процесите „от долу нагоре“, като същевременно наточават повече процесите „от горе надолу“, като инхибиране, устойчиво внимание и целенасочен подбор на информация. Резултатите обаче не са еднозначни. Ефектите зависят до голяма степен от съдържанието, структурата на стимулите, продължителността на употребата, етапа на развитие на детето и контекста на употреба. Пасивните, прекомерните и неподходящи за възрастта форми на употреба по-често се свързват с неблагоприятни последици, докато интерактивните, подходящи за възрастта и подкрепяни от социалната среда дейности изискват по-нюансирана оценка. Тъй като голяма част от проведените досега изследвания се основава на наблюдателни проучвания, причинно-следствени заключения могат да се правят само в ограничена степен. Следователно дигиталното сензорно претоварване трябва да се разглежда като значим, но зависим от контекста фактор, влияещ върху обработката на информация при децата.

Ключови думи: дигитални медии; внимание; възприятие; обработка на информация; когнитивно претоварване

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