Fidgeting in the Browser: An Empirical Study of a Virtual Self-Regulation Tool for ADHD

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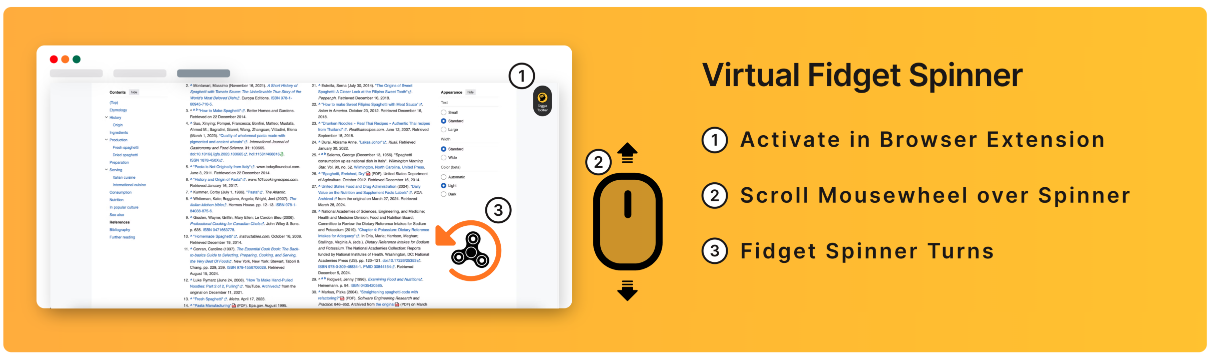

Figure 1: Interaction steps with virtual fidget spinner in a reading context.

Abstract

Individuals with ADHD often use self-regulation methods to stay focused, such as fidgeting with physical artifacts while interacting with web content. To support self-regulation, we designed a virtual fidget spinner as a browser overlay. The feature was developed through a participatory approach involving one author (diagnosed with ADHD) and an ADHD focus group (n=3), who contributed to the design phase. To understand existing fidgeting behaviors, we conducted online surveys with individuals with ADHD (n=25). Based on these insights, we designed a virtual fidget spinner, evaluated through interviews and think-aloud studies (n=12). Our findings offer insights into the fidgeting preferences of individuals with ADHD, providing key considerations for designing effective virtual fidgeting tools, particularly in terms of multimodality and ensuring a satisfactory user experience. Results show that these tools need to strike a balance between distraction that helps to focus and accommodating user preferences for effective self-regulation.

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CCS Concepts

• **Human-centered computing** → **Accessibility systems and tools**; **Accessibility technologies**.

Keywords

Accessibility, ADHD, Fidget, Browser, Participatory Design

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1 Introduction

Attention-deficit/hyperactivity disorder (ADHD) is characterized by difficulties in attention regulation, impulsivity, and executive function [3, 7]. Since self-regulation is essential for individuals with ADHD [5, 7], many develop strategies to manage attention and cognitive load, with fidgeting (engaging in small, repetitive movements) being a widely recognized approach [11].

While prior research indicates that fidgeting can enhance cognitive engagement and support working memory by offering a channel for excess energy and aiding attentional control [22, 33], the use of conventional physical fidget tools (e.g., spinners, cubes, stress balls) presents several limitations. First, such behaviors are often perceived as disruptive or socially inappropriate in professional and educational environments, which potentially leads to stigma or exclusion [27]. Second, the necessity to carry physical objects may pose a challenge for individuals with ADHD, who frequently experience difficulties related to object permanence and misplacement [8, 11]. Finally, physical tools are typically not personalized, requiring users to experiment with multiple devices, which results in physical clutter and increased frustration before they identify one or more tools that meet their individual sensory preferences and regulatory needs.

Despite the widespread adoption of physical fidgets, limited research has explored whether digital fidgeting can provide similar cognitive benefits through supported self-regulation and how such tools could seamlessly integrate with existing digital content. Our aim was to understand both the facilitators (e.g., usability and engagement) and potential drawbacks (e.g., distraction) of on-screen fidget tools. All our contributions, and the artifact in particular, are aimed at addressing the **following goals:**

- For user and surrounding non-disruptive self-regulation.
- Providing an instantly available solution within web content.
- Allowing for customization and adaptability across contexts.

To explore this, we developed a virtual fidget spinner designed to visually and interactively replicate the simplicity and effectiveness of physical fidget spinners in a non-intrusive manner to address the research question (RQ):

RQ: How can a virtual fidget spinner support self-regulation in web reading tasks for users with ADHD?

Our study identified five key themes in user experiences with the virtual fidget spinner, which we discuss in detail: visual clarity, customization, engagement and distraction dynamics, usability, and preferences between virtual and physical fidgeting. These themes reflect the diverse ways users with ADHD interact with digital fidgeting tools and the specific design requirements needed to support effective self-regulation without introducing new distractions.

To address these challenges and advance the field of ADHD support tools, **we contribute:**

(1) a virtual fidget spinner
(2) the design insights from our ADHD focus group (n=3)
(3) an exploratory evaluation through surveys (n=25) of existing fidgeting behaviors and interviews (n=12) with people with ADHD on their interaction with our virtual fidget spinner.

Paper structure. This article is organized as follows: Section 2 offers a comprehensive review of existing literature and systems relevant to our study. Section 3 outlines the virtual fidget spinner based on the insights from the focus group and the developed features. Section 4 presents the methods, findings, and discussion of our two part evaluation study with its survey and the think-aloud sessions. Section 5 discusses potential limitations and threats to the validity of our findings. Section 6 describes future directions for how our findings can be applied to extend this research stream. Finally, Section 7 offers concluding remarks.

2 Related Work

In this section, we first outline the characteristics of our user group (individuals with ADHD) who rely on self-regulation to manage distractions that can significantly impact their daily lives. We discuss existing research solutions and workarounds, alongside research on self-regulation and fidgeting. Insights into effective fidgeting strategies inform the development of our digital fidgeting tool.

2.1 ADHD and Self-Regulation

An estimated 5% of the global population is diagnosed with ADHD [7, 19, 43, 55], though many cases remain undiagnosed, as diagnoses are more common in children [7, 18, 20]. Despite lower reported prevalence in older age groups [26, 55], some countries face diagnostic backlogs spanning several years [46], likely underestimating the true affected population.

ADHD affects attention control, executive function, and impulse regulation, often necessitating the use of self-regulation strategies to manage cognitive demands [5, 7]. Brown identifies executive functions as cognitive processes coordinating goal-directed behavior, clustering them into six domains: (1) Activation, (2) Focus, (3) Effort, (4) Emotion, (5) Memory, and (6) Action [7]. Fidgeting serves as a self-regulation mechanism [5], particularly aiding Activation, Focus, and Effort to sustain attention [7].

A distinction must be made between self-regulation and co-regulation. Self-regulation refers to an individual's autonomous strategies for managing executive function challenges, whereas co-regulation involves external support from individuals (e.g., parents, teachers, doctors) or tools (e.g., timers, reminders) [52]. Fidget tools align with self-regulation, empowering users to decide when and how to engage with them and fostering independence.

Various technological interventions have been developed to support users with ADHD, focusing on time and task management (e.g., Pomodoro apps [34], time visualizers [49]) or behavioral interventions (e.g., gamified self-monitoring apps [50], co-working apps with accountability partners [35]). Prior HCI studies have explored ADHD self-regulation without incorporating fidgeting mechanisms. For instance, *Chillfish* [56] promotes focus through a respiration-based game, while *Bubble Beats* [25] pairs breathing exercises with music. *MoodGems* [58] facilitates emotional regulation and well-being communication in ADHD families. Additionally, McLaren and Antle [38] evaluated sound-based neurofeedback (e.g., white noise, binaural beats) as a tool for self-regulation.

While these digital interventions support different forms of self-regulation, they do not examine fidgeting, a widespread and pre-existing strategy, as an opportunity for digital self-regulation. Our work extends this research by exploring how digital fidgeting can serve as an self-regulation tool for individuals with ADHD.

2.2 Fidgeting as a Self-Regulation Strategy

For some individuals with ADHD, medication alleviates symptoms, often in combination with behavioral therapy [12], while others rely solely on behavioral strategies. Fidgeting has been shown to support sustained attention in cognitively demanding tasks while also reducing hyperactivity and anxiety by providing an outlet for restless energy and aiding emotional regulation [1, 5, 7].

In academic and professional environments, where sustained attention is crucial for daily success, median attention spans as short as 40 seconds have been observed in the general population [37]. Frequent interruptions in digital web environments in these settings underscore the need for individuals with ADHD to actively regulate their attention. While co-regulation strategies, such as parental or external support, exist [51, 52], overreliance on co-regulators may hinder the development of self-regulation skills [15].

Despite its benefits, fidgeting as a behavior has a controversial history, sometimes perceived as disruptive in social and educational settings [36] or reported by others as the exact opposite [2, 53]. Stigma has contributed to an accessibility gap, where some individuals benefit from fidgeting but are unable to use fidget tools in restrictive environments. This is particularly pronounced in reading tasks, which are heavily influenced by executive function capabilities [5, 7]. Since reading often occurs in silent environments, any visible or audible distractions can be perceived as disruptive to others. Given this, we selected reading tasks for our evaluation to assess the potential of digital fidgeting tools to support sustained attention without causing disturbances to the user and environment.

2.3 Physical and Digital Fidgeting Tools

To address the general need for fidgeting, both analog and digital fidgeting tools have been developed. Analog fidgets (e.g., spinners, cubes) have been studied for their impact on attention and cognitive performance [23]. While these tools support self-regulation, digital alternatives remain underexplored. Digital fidgets could mitigate some of the limitations of physical fidgeting tools, as described in subsection 2.2, while also introducing new affordances.

Additionally, digital environments present unique challenges for individuals with ADHD, such as increased distractions, cognitive overload, and difficulties in maintaining focus [7]. Embedding fidgeting tools within these digital spaces could make them more accessible and adaptable while leveraging the successful interaction patterns of physical fidgeting devices.

The concept of digital fidgeting already exists, but with varying use cases and regulation mechanisms. While Karlesky and Isbister [29] identified tangentiality, playfulness, digitality, and tangibility as essential properties, digital fidgeting tools encompass a range of forms, from hardware-based solutions to purely software-driven interventions. Some employ additional hardware, such as AR glasses that display calming visual elements activated via virtual touch [28], or small robotic systems consisting of interactive modular cubes for tactile engagement [44]. Handheld digital devices incorporating gesture or biosignal analysis demonstrate potential for interactive fidgeting, analyzing existing fidgeting behaviors in individuals with ADHD [10, 39, 59].

Karlesky and Isbister [30] developed a virtual bubble wrap for smartwatches that combines tactile engagement with visual and auditory stimuli; however, it has not yet been evaluated with users who have ADHD. Ross et al. [47] evaluated screen-based fidgeting tools in combination with online lectures, exploring three different fidgeting mechanisms that were sometimes not chosen by the participants for unknown reasons, relied on co-regulation, or introduced new distractions.

While these approaches explored digital fidgeting, they did not fully replicate the physical experience. This informed our work to leverage physical interaction principles, supporting self-regulation, and investigating whether digital fidgets can: (1) provide similar benefits as physical fidgets, (2) avoid the social and logistical limitations of physical tools, (3) and seamlessly integrate into digital, web-based reading workflows where ADHD users often face distractions.

3 The Virtual Fidget Spinner

3.1 Focus Group

The development process began with identifying key attention-related pain points faced by users with ADHD, followed by the proposal of targeted, lightweight interventions. One of the authors, who has a formal ADHD diagnosis, contributed experiential insights throughout the development process, grounding early decisions in lived experience. From the outset, we adopted a participatory design approach [6, 16, 57], collaborating with three individuals with ADHD who were known to the development team. They provided requirements and needs across iterations, contributing to decisions around system features, interaction mechanics, and visual presentation. Their involvement helped ensure the tool reflected practical, real-world self-regulation needs.

The spinner was designed with a clear goal: **to support attention in a web context without introducing additional distractions.** Achieving this balance proved nontrivial, given ADHD's characteristic need for stimulation alongside difficulties with impulse control [5]. The author and focus group translated their sensory needs and usage preferences into foundational requirements, reaching consensus that the proposed features are essential to the tool and either actively supported or tolerated by all participants.

Focus-Group Requirements:

- Enable interaction using the mouse scroll wheel, without scrolling the webpage.
- Prioritize mouse-based input over keyboard interaction, aligning with existing fidgeting behavior.
- Allow the spinner and tool menu to be repositioned freely on the screen.
- Include an option to toggle the spinner on or off at any time.
- Activate the spinner on a per-tab basis, recognizing that fidgeting needs vary across tasks.
- Use visual representations drawn from physical fidget spinners for familiarity.
- Employ a minimal color scheme (e.g., black and white) to reduce visual distraction.
- Provide brief, optional guidance on how to use the feature.

The focus group directly informed the visual simplicity of the spinner, achieving a smooth rotational quality and placement on the browser interface to avoid visual overload. Participants also highlighted difficulties in maintaining tactile-like feedback and control over activation, which contributed to the addition of customization settings. This foundation ensured that the tool aligned with common attentional strategies, fidgeting preferences, and usability needs in everyday browsing contexts.

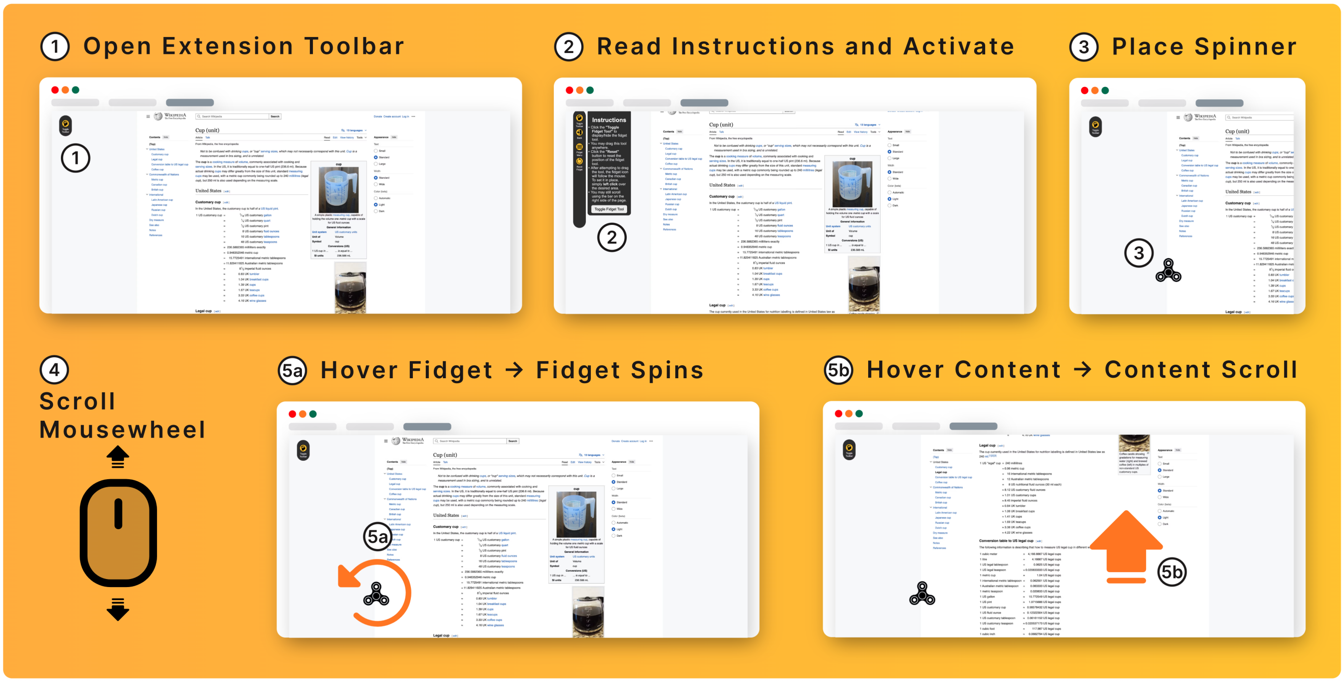

Figure 2: Detailed user flow of interaction with the fidget spinner.

3.2 Feature Description

Based on the focus group requirements, we developed a virtual fidget spinner to support attentional regulation through digital fidgeting (for a high-level overview, see Figure 1). This browser overlay extension offers a non-disruptive outlet for users who benefit from movement-based or sensory feedback during cognitive tasks, a need frequently reported by individuals with ADHD and corroborated by our focus group. Unlike physical tools, the digital spinner requires no additional hardware and can be seamlessly integrated into the user's browsing environment.

Although other feature concepts (e.g., audio interaction) were explored, the first version focused on implementing the above requirements as a lightweight, optional overlay. Users can activate and interact with the spinner directly within their current browsing context, providing personalized and situational support for attention regulation across various digital tasks. A detailed overview of the user interaction flow is presented in Figure 2. These steps integrate a lightweight interactive layer into the browsing interface.

Step 1 Users initiate the spinner by opening the extension toolbar.

Step 2 Upon activation, users are provided with usage instructions via an on-screen guide to ensure toggling of the spinner is communicated before use. Our tool introduces a real-time, user-initiated interaction, unlike existing virtual fidget tools that rely on pre-defined animation loops [48] or time-driven feedback [41].

Step 3 Users are prompted to drag and place the spinner anywhere on the screen, ensuring perceptual customization [42]. The design of our tool differs from prior digital fidget tools in that they often use fixed placements or global overlays [48]. This approach allows users to place the fidget tool in unused "margins" of their current web content, as similarly identified in doodling mechanisms [30].

Step 4 The system captures scroll wheel input as the primary mode of interaction as wished by the focus group. This allows easy interaction through familiar device behavior, avoiding any need for manual mode-switching or extra clicks. Our tool facilitates the users with two context-sensitive behaviors based on cursor hover:

Step 5a Hovering over the spinner activates its rotation in direct response to scroll input.

Step 5b Hovering away from the spinner returns scroll behavior to default, allowing users to engage in reading or task execution seamlessly.

The virtual fidget spinner combines real-time responsiveness with input modality awareness, avoiding the passive loops of earlier virtual tools and the disruptions of physical devices. It offers an in-situ, non-intrusive, user-activated channel that supports attention without disrupting task engagement or digital flow.

This paper focuses on the **three primary benefits**, as listed in section 1, targeted by the virtual fidget spinner:

- **Self-Regulation:** The virtual fidget spinner aims to provide a sensory outlet for managing restlessness by allowing users to interact with the tool using their mouse or trackpad while being optimized for the physical sensation of the mouse wheel to leverage the kinematic similarities with the physical fidget spinners. This digital adaptation of a physical fidget tool allows users to redirect restless energy without disrupting their browsing experience, while still providing a physical interaction. By offering an interactive and visually engaging, yet to black and white reduced element, the spinner helps users maintain focus on their primary tasks while fulfilling their need for movement or sensory input.

- **Instant Availability:** As a browser overlay, the virtual fidget spinner is just one click away, minimizing barriers to use and allowing quick, almost instinctive activation, similar to picking up a physical fidget tool.
- **Customization and Adaptability:** The virtual fidget spinner offers two essential customization options: toggling the spinner's visibility and adjusting its on-screen position. These features enable users to customize the spinner according to their specific workflow and preferences. For instance, users can activate the spinner during periods of heightened restlessness and position it in a convenient spot to minimize interference with ongoing tasks. While this puts the burden on the user to actively position the tool, the development team concluded that this has the highest utility across pages.

4 Evaluation Study

Building on the participatory design process described in section 3, where experiential insights were gathered from one of the authors (who has ADHD) and a small focus group, we translated early feedback into the initial design and interaction logic of the virtual fidget spinner. Participants in the participatory design process self-identified common attentional difficulties during web browsing and discussed their sensory preferences for fidgeting through open-ended discussions and exploratory use cases.

To evaluate the virtual fidget spinner (presented in section 3) developed for individuals with ADHD, we employed a mixed-methods approach combining a quantitative online survey (n=25) with qualitative think-aloud interviews (n=12). This exploratory two-stage study design allowed us to examine both general patterns of user behavior and in-depth experiential perspectives on the tool's perceived effectiveness in supporting focus during web-based tasks. The study was reviewed and approved by the institutional review board of the first author's institution.

Recruitment: Participants for both study components were recruited through email outreach and announcements shared in ADHD-focused self-help groups and online communities. This targeted recruitment approach aimed to ensure that our evaluation was grounded in the lived experiences of users who actively manage attentional challenges, thereby strengthening the relevance and validity of our findings [45]. Importantly, all design components, including participatory design sessions, surveys, and interviews, were conducted individually. Each participant engaged in a one-on-one setting to intentionally mitigate the risk of cross-participant influence on their responses and design input.

4.1 Study (1): Survey with Evaluation

To broaden our understanding beyond the initial focus group, we conducted an online survey exploring users' general fidgeting behaviors, web-based attention challenges, and reactions to digital tools designed to promote self-regulation. Although the survey participants were not directly involved in the tool's development, their responses helped validate and expand upon earlier design decisions, providing a more generalizable basis for evaluation. The survey also identified user expectations and emergent needs, which directly informed the structure and focus of the next phase.

4.1.1 Method. A total of 28 participants initially responded to the online survey. However, only 25 participants completed it in full and were therefore included in the final analysis. Of these, 8 participants (34.8%) reported having received a formal ADHD diagnosis from a healthcare professional, while 11 participants (47.8%) identified as self-diagnosed. The remaining 17.4% had no formal diagnosis but still identified with attention-related challenges. This participant breakdown reflects the broader trend of increasing recognition of both self-diagnosed [24] and undiagnosed [21] ADHD among the general population, especially within digitally engaged and younger demographics. Notably, four participants were currently undergoing treatment for their ADHD symptoms, indicating active management of their condition.

Demographically, the survey sample was relatively young, with the majority of participants (52.2%) aged between 18 and 24 years. The gender distribution skewed predominantly male, with 69.6% identifying as male and 30.4% as female. The educational background of participants was diverse, suggesting the relevance of the tool across different levels of academic engagement: 43.5% of respondents were high school students or had a high school–level education, 34.8% were currently attending college, 17.4% were pursuing a Bachelor's degree, and 4.3% were enrolled in a Master's program. These demographics illustrate a potential applicability of the virtual fidget spinner across a broad spectrum of users and educational settings.

To ensure usability and consistency in participation, the inclusion criteria required that participants be at least 18 years old and have access to either a laptop or a desktop computer, as the browser extension and survey were optimized for these platforms. All respondents had to be fluent in English and sampled from an English-speaking country, ensuring that the questionnaire content was clear and accessible. The survey was created using *Google Forms* and distributed online, allowing participants to complete it at their convenience.

The survey was structured into three distinct sections. The first section included five demographic questions to establish age, gender, educational level, diagnosis status, and treatment. The second section explored participants' attention-related needs during digital activities, specifically within the context of web browsing and digital work. The third section focused on fidgeting behaviors and self-regulation strategies, using six targeted items to better understand how individuals with ADHD engage in physical and sensory self-regulation while performing online tasks. The following fidgeting-related questions directly informed the design decisions for later iterations of the virtual fidget spinner.

(1) Do you use objects to fidget? (Fidget Spinner, Pencils, etc.) - Yes or No
(2) If you fidget, what objects do you use to fidget? - Open-ended Question
(3) If you fidget, in what scenarios do you fidget? - Reading, Writing, Watching Videos, Working, In Meetings, (Free Text)
(4) Have you used digital objects for fidgeting? (Scrollbar, Mouse Cursor, ...) - Yes or No
(5) If you digitally fidget, with what and how? - Yes, No, Maybe

Before starting the survey, which was designed to take approximately five minutes, participants were shown a detailed information sheet outlining the study's goals, procedures, voluntary nature, and data privacy practices. Informed consent was obtained via a mandatory checkbox that participants had to select before accessing the survey questions. They were informed in advance, via email, that there would be no monetary compensation for their participation. However, all participants were invited to keep the browser extension on their personal devices after the study, thereby providing them with continued access to the tool. They had surveyed responses that provided crucial insights into real-world fidgeting behaviors, attention regulation strategies, and tool techniques, and tool usage preferences among individuals with ADHD. These findings not only validated the initial design of the virtual fidget spinner but also guided further refinement of the tool and supported its alignment with the diverse needs of its intended users. These insights also directly informed the design of our interview protocol, allowing us to build on emerging themes through more targeted, experience-driven questions during the think-aloud sessions. In this way, the survey served as a critical bridge between early design assumptions and in-depth user evaluation, reinforcing the iterative, layered structure of our methodology.

4.1.2 Findings. When asked whether the participants use physical objects to fidget, 23 out of 25 participants affirmed this habit, suggesting a strong baseline reliance on tangible stimuli for attention regulation. This finding highlights a potential design opportunity for incorporating digital fidgeting mechanisms into systems designed to support users with ADHD.

Participants reported a diverse range of fidgeting objects, typically favoring small and easily accessible items. Pens and pencils were among the most frequently mentioned tools, often used for clicking, spinning, or tapping. Additional objects included stress balls, fidget spinners, fidget cubes, detachable phone grips, mouse wheels, and multi-tools. Some participants mentioned fidgeting with personal items such as rings, bracelets, hair ties, or clothing. Others reported interacting with whatever was immediately available, such as water bottles, wires, wallets, or earbud cases. A few participants noted fidgeting behaviors involving their own body, including foot tapping, knuckle popping, or fingernail manipulation.

Participants were also asked to indicate the situations in which they most frequently fidget. The most commonly reported situations were *Working* (n=17) and *Reading* (n=16), followed by *Writing* (n=13), *Watching Videos* (n=12), and *In Meetings* (n=11). The in the free-text field cited scenarios included introspective moments (e.g., "*When I'm deep in thought*") and generalized responses such as *"All the time."* These findings showcase the ubiquity of fidgeting across a variety of cognitively demanding or passive contexts.

When asked about their experience with digital objects for fidgeting, most participants (n=20) reported that they had never used such tools for this purpose, while five participants had prior experience. Those with experience described a range of digital interactions that served a fidgeting function. These included interacting with the mouse, such as aimless clicking, using the scroll wheel, or moving the cursor without intent, as well as playing low-complexity games such as Tetris or Minesweeper. Visual UI elements such as the scrollbar or cursor highlight were also noted as serving a fidgeting purpose. Some mentioned the *Google Spinner*, a virtual fidget spinner accessible on a Google search site[1], but pointed out that it does not operate as an overlay and instead introduces other visual distractions by replacing their main content or increasing the need for tab switching. Additionally, some participants mentioned that switching between browser tabs functioned as a form of fidgeting, though it risked fragmenting their attention.

We also gauged participants' openness to the idea of using digital fidgeting tools. Of the 25 respondents, 37.9% (n=11) indicated "Yes," 51.7% (n=15) selected "Maybe," and only 10.3% (n=3) responded "No." These results suggest a generally positive or at least curious disposition toward digital fidgeting solutions, with the majority of participants willing to consider such tools as viable alternatives or supplements to physical fidgeting practices.

4.1.3 Discussion. Our findings underscore the potential value of incorporating fidgeting functionalities into digital systems designed to support self-regulation in individuals with ADHD. Although the majority of participants had never used digital objects for fidgeting, nearly all reported using physical items, indicating a well-established behavioral strategy for managing attention and self-regulation. Notably, participants who used digital tools for fidgeting described using both physical and digital tools similarly, suggesting that digital fidgeting can be used in a comparable way to physical fidgeting when thoughtfully designed. Among those who had not used digital fidgeting tools, the lack of engagement appeared to stem less from disinterest than from a lack of awareness or availability, an observation substantiated by the interviews and think-aloud sessions.

The wide variety of objects used and the diverse contexts in which fidgeting occurs highlight the importance of flexibility and personalization in the design of digital fidget tools. We opted to emulate familiar physical objects, such as pens, stress balls, or, in our case, spinners, in the hopes of increasing comfort, familiarity, and usability. This was validated as the participants did not need instructions on how this type of tool would be fidgeted with in general. Moreover, given the frequency of fidgeting during cognitively demanding activities such as reading, writing, working, and attending meetings, there is a clear opportunity for digital fidgeting aids that function as unobtrusive overlays within web content and in spaces with others. Because fidgeting was also reported during passive activities, such as watching videos, these tools could be beneficial across both work-related and leisure contexts, reinforcing their relevance in day-to-day digital interactions.

The limited prior use of digital fidgeting tools suggests a largely untapped space for innovation. Features such as interactive cursors, manipulable scroll bars, or customizable virtual spinners can offer alternatives to physical fidgeting objects while maintaining accessibility and engagement. To be effective, these tools must strike a balance between providing sensory stimulation and minimizing potential distractions. Options for customizing the intensity or temporarily disabling features can help users modulate their interaction based on task demands. In addition, integrating lightweight game-like elements, such as simple puzzles or interactive visual

[1]Google Inc. - Google Fidget Spinner - n.d.. Retrieved 11. April 2025 on https://www.google.com/search?q=google+fidget+spinner

Table 1: Demographics of interview participants.

Participant	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Formally Diagnosed	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No
Taking ADHD Treatment	No	Yes	Yes	No	No	No	Yes	No	No	Yes	Yes	No
Age	21	38	28	24	26	29	22	22	21	32	24	18
Gender (Male / Female)	M	F	F	F	M	M	M	M	M	F	M	F
Education Level (High School / Bachelor)	H	B	B	B	H	H	H	H	H	H	H	H

feedback, could support sustained attention without overwhelming cognitive resources and leverage features not possible with physical fidget spinners. Given participants' general openness toward digital fidgeting, our findings suggest that the concept of a virtual fidget spinner holds considerable promise as a supportive feature in attention-sensitive digital environments. Based on this, we propose further investigating different types of digital fidgeting tools.

4.2 Study (2): Interview and Think-Aloud Session

Following the survey, we conducted a think-aloud interview study to gain a deeper understanding of how users interacted with the spinner in real time. Participants were given a brief tutorial on how to install and start the browser extension with the virtual fidget spinner on their own device. They then used the tool during a browsing task while verbalizing their thoughts and interactions. This allowed us to capture nuanced feedback about the spinner's usability, engagement potential, and its role in facilitating focus.

4.2.1 Method. We conducted the online interviews and think-aloud sessions with a subset of 12 out of the 25 survey participants. Table 1 presents the demographic information of these individuals, who were invited based on availability rather than through stratified sampling. Of the 12 interviewees, eight had been formally diagnosed with ADHD by a healthcare professional, while the remaining four either self-identified as having ADHD or were awaiting formal diagnosis. Participants' ages ranged from 18 to 38 years, with a gender distribution of seven males and five females. Variation in their educational backgrounds was limited, ranging from high school to bachelor's degrees.

Insights from earlier phases influenced the interview questions and the interaction context, ensuring that participants engaged with the spinner in ways that reflected authentic attentional needs and fidgeting behaviors. While participatory feedback guided the initial design of the tool, and the survey confirmed its relevance across a wider population, the interviews provided a space for participants to articulate their thoughts, preferences, and approaches to using the tool. This phase enabled us to capture the lived, moment-to-moment experience of using the spinner, illuminating how it supported focus, reduced distraction, or introduced new challenges.

Unlike traditional usability testing, which often relies on structured tasks and time-based metrics [4], our interview approach emphasized open-ended exploration. For the fidget spinner part of the interview, participants were asked to read a *Wikipedia* article of their choice while using the virtual fidget spinner. Reading was chosen as the primary activity because it demands a moderate level of sustained attention and cognitive engagement [54] and is recognised as a challenging task for people with ADHD [5, 7]. This setup offered a naturalistic yet consistent interaction context, enabling us to observe user behavior and tool usage in a scenario closely resembling real-life web engagement. The open-ended nature of the task allowed participants to use the tool freely and express their thoughts in real time, offering deeper insights into personal preferences and needs related to attention and self-regulation.

The interview and think-aloud session lasted approximately 20–25 minutes. All interviews were audio-recorded with participants' consent to ensure accuracy, and subsequently transcribed verbatim to preserve participants' language and expressions.

To analyze the qualitative data, we employed thematic analysis [13] following the guidelines by Klooster et al. [31]. One author performed the initial open coding using an inductive approach, reading and re-reading the transcripts to develop a close familiarity with the data. As patterns and recurring ideas emerged, codes were grouped and compared across participants to identify commonalities and variations. Candidate themes were developed and iteratively refined through continued engagement with the dataset, ensuring they reflected both the breadth and depth of participant responses. These emerging themes were subsequently reviewed and discussed with two other authors from the research team to enhance analytical validity and ensure a multi-perspective interpretation. In the final phase, the themes were synthesized into a coherent narrative supported by representative participant quotations.

Theoretical saturation was deemed reached when no new insights or themes emerged in the final interview sessions. This approach aligns with established guidance on achieving theoretical sufficiency in qualitative studies [9, 14]. To further ensure the credibility of the analysis, we assessed inter-rater agreement, which yielded a consensus level of 98% and a Cohen's Kappa coefficient of 0.89, indicating high agreement and coding consistency.

4.2.2 Findings. Each participant's response was carefully reviewed and coded for underlying meaning using an open coding approach. Example excerpts include:

P1: "If it were more transparent, I'd be able to see what's behind it…" Codes generated: *Transparency*, *Screen Real Estate*, *Visual Clarity.*

P2: "You might consider changing it [(app color)] to a light green instead of the yellow…" Codes generated: *Color Customization*, *Personalization.*

Similarly, other participants' responses yielded codes such as *Usability*, *Toolbar Flexibility*, *Accessibility*, *Fidgeting Tool Distraction*, and *Physical Fidgeting Comparison.* Following the open coding stage, codes were iteratively grouped into broader conceptual categories using constant comparison techniques and discussed between the authors until reaching full agreement. Through this process of refinement and reorganization, the following five themes emerged:

Table 2: Fidget Tool Thematic Map: Emergent themes with example quotes by participants during the think-aloud sessions.

Emergent Theme	Sub-theme/Code	Citation (Example Quote)
Visual Clarity & Transparency	Screen Real Estate, Visual Clarity, Transparency	"If it were more transparent, I'd be able to see what's behind it. That way, it's more passively on the screen..." (P1)
	Subdued Color Schemes	"[The] colors are good, so I don't like a lot of color because it's very distracting... when I'm trying to do stuff like this." (P3)
Customization & Personalization	Color Customization, Personalization	"You might consider changing it [app color] to a light green instead of the yellow, because blues and greens are calming..." (P2)
Engagement & Distraction Dynamics	Game-like Motivation, Toggle Options	"It's like a fake distraction just because of the visualization... I like it, but it makes me want to make a game of it." (P3)
	Fidgeting Tool Distraction	"I feel that I'm getting slightly more distracted with it... I guess I'm paying more attention to the fidget spinner than the actual article itself." (P12)
Usability	Toolbar Flexibility, Setup Guidance	"A user startup guide could be useful, maybe a prompt that says, 'Do you need help?'..." (P6)
	Accessibility, Consistency	"It's convenient to have the toolbar available whenever I need it." (P7)
Fidgeting Preferences	Physical Fidgeting Comparisons	"I do fidget a lot with rings or a bracelet I'm wearing." (P5)

(1) **Visual Clarity & Transparency:** Combines observations on transparency and minimal visual interference. Emerged clearly from comments such as P1's note about transparency. This theme emphasizes the user's need for an unobtrusive visual experience.
(2) **Customization & Personalization:** Captures feedback on color choices, toggle options, and customization of UI elements (e.g., toolbar icons). Focused on the individual's desire for control over the tool's appearance, demonstrated in P2's color suggestion and P3's desire for toggle options.
(3) **Engagement & Distraction Dynamics:** Captured the complexity and dual role of how fidgeting can both enable focus and cause distraction. Conflicting views (e.g., "helping me focus" versus "it distracts me") were grouped.
(4) **Usability:** Reflected comments on the utility of the toolbar, ease-of-use features (P6, P7, and P8), and suggestions for better setup guidance (e.g., instructional popups).
(5) **Fidgeting Preference:** Highlighted nuances in how users compare the digital tool to tangible objects used for fidgeting.

A comprehensive overview of the thematic structure, including sub-themes and representative example quotes from participants, is provided in Table 2. In the following, we elaborate on these themes through detailed qualitative findings. Participants shared a diverse range of reactions to the on-screen fidget spinner, including both enthusiastic and critical responses.

Several participants appreciated the element of engagement and enjoyment that the fidget spinner introduced into their browsing experience. Participants P10 and P11, for instance, described using the virtual spinner as a satisfying and enjoyable activity. Similarly, P8 highlighted the spinner as a particularly fun and engaging feature.

The feature's effectiveness appeared to hinge on context, as reflected in the theme *Engagement & Distraction Dynamics*. For some, the spinner served as a helpful aid for maintaining focus. P1, for example, reported that it supported concentration during reading tasks, while P6 expected it to be useful during phone calls or conversations, providing a tactile-like outlet for idle hand activity. However, this same feature was also flagged by others as a potential source of distraction. Participants P5, P6, P7, P8, and P12 all noted that the fidget spinner could interrupt concentration, especially when they were engaged in cognitively demanding tasks such as reading or writing.

Some of this friction stemmed from initial usability hurdles. Because the spinner required hover focus to activate (see Figure 2 — Step 5a), it did not permit completely passive or "mindless" interaction in the first interactions, a quality often associated with physical fidgeting tools. While participants generally accepted this mechanic after becoming familiar with it, some, such as P3, suggested the addition of an introductory guide or instructional pop-up to help users understand how to activate and interact with the spinner to help their *Usability*. The hover-to-spin mechanism was intentionally implemented by the development team and discussed with the focus group to prevent unintended scrolling of web content, but it introduced a short learning curve. In some cases, such as P5s, the novelty of the spinner drew more attention than intended, disrupting focus rather than supporting it. P1 recommended towards this to implement a translucent overlay mode, so that background content would remain visible even when the fidget spinner was active, reinforcing the desire for a less obtrusive presence.

Another prominent theme was participants' *Fidgeting Preferences*. While P11 appreciated the concept of the virtual fidget spinner and believed others could benefit from it. P5 and P12 were hesitant and expressed a strong preference for physical fidgeting tools, such as rings, bracelets, or textured objects, which they are accustomed to and find more intuitive and effective. In discussing physical alternatives, participants often mentioned the multisensory aspects of those experiences, particularly auditory feedback, which they felt was lacking in our virtual fidget spinner. This need did not come up in our focus group. To enhance the sense of personalization, P3 recommended broadening interaction modes, such as enabling clicking as an alternative to scrolling on the spinner, thus contributing to the theme *Customization & Personalization*.

One notable advantage of the browser overlay compared to a separate interface, was its flexibility. Participants could freely move both the spinner and its associated toolbar across the screen without the need to switch tabs or disrupt web content. This aspect was praised for maintaining workflow continuity.

4.2.3 Discussion. The interviews with participants offered valuable insights into how digital fidgeting tools might support self-regulation for individuals with ADHD, while also revealing tensions that challenge straightforward design assumptions. These discussions underscore the need for nuanced and adaptable design strategies that take into account attentional variability, sensory needs, and the social and cognitive contexts in which these tools are used. In general, the participants reported positively about the tool and introduced topics of critique on their own. Still, some issues with the current implementation of the virtual fidget spinner were only identified in the think-aloud sessions through questions by the researchers after unexpected behavior by the participants. For example, the aforementioned call for tutorial content at the beginning of the tool setup can be traced back to struggles with initial interaction with the fidget tool, as seen in some participants, which were only revealed through direct observation of their interactions with the tool and subsequent questioning.

A central takeaway is that digital fidgeting tools also hold potential as externalized self-regulation aids, echoing psychological models of diverse executive functioning in ADHD [5, 7]. The fidget spinner served as a structured outlet for physical restlessness for several participants during the sustained cognitive engagement while reading. In these cases, it functioned much like physical fidget tools do: as a low-effort, low-stakes background activity that supports task persistence without requiring focused attention. In this sense, the spinner can be seen as a compensatory mechanism that scaffolds attention in a similar way to external time management or planning tools that support individuals with ADHD.

However, participants also described instances where the spinner acted not as a support but as a competing stimulus, diverting attention rather than stabilizing it. This imbalance of *Engagement and Distraction Dynamics* reflects a central paradox in attention support of people with ADHD: the very features that make a system stimulating and engaging can also make it overwhelming or intrusive. Some participants found that the spinner's visibility or movement pulled them away from their primary task, a finding consistent with Barkley [5] emphasis on impaired response inhibition. For these users, the spinner became another "open loop" demanding cognitive resources, rather than helping them manage the existing ones. This challenges us to rethink how and when stimulation is helpful, suggesting a design opportunity for adaptive systems that adjust stimulation based on task demands or user state. Potentially, the deployment of this system longitudinally might already decrease the distraction compared to the first time use, based on effects such as the power law of practice [40] or novelty effect [32]. Still, concrete measures are needed to help users control (and reduce) the level of distraction the tool provides. Allowing to modify size, shape, color, sounds, and movement speed of the virtual fidget spinner would be integral extensions to the current ability to choose the timing and placement of the fidget spinner. Extending on user activated changes through context driven changes (e.g., text-based) provides further opportunity for modular distraction levels.

Moreover, the fact that some users had difficulty engaging with the hover-to-spin mechanic suggests that the design placed subtle demands on working memory and action sequencing. Brown's executive functioning model [7] posits that individuals with ADHD often struggle with multi-step interactions, especially those requiring temporal coordination. A hover-based interaction may seem low-effort, but it demands a kind of sustained spatial attention that isn't always accessible to users with attentional variability. Here, even minor cognitive friction becomes a barrier to tool adoption, underscoring the importance of *Usability* in such designs. Explicit, lightweight instructional support, as requested by some users, could serve as a form of external scaffolding that helps users internalize how and when to use the tool effectively.

The theme of *Customization & Personalization* also emerged as a strong design imperative. Participants expressed a clear desire to adapt the visual style, interaction method, and even presence of the spinner to suit their sensory preferences and cognitive needs. ADHD is a highly heterogeneous condition, and what soothes or grounds one user may overstimulate another. As such, one-size-fits-all approaches to digital fidgeting are unlikely to succeed. Offering configurable parameters (e.g., color, size, interactivity, placement) could allow users to shape the tool to fit both their environment and their internal state. This is not merely a convenience feature, but a question of accessibility and agency.

As for *Visual Clarity & Transparency*, this shows that digital fidgeting tools must coexist harmoniously with primary tasks. Several participants emphasized that the spinner should not obscure or compete with surrounding content, especially during reading. This concern echoes longstanding insights from interface design: secondary tools should blend into the user's environment rather than asserting themselves as focal points. In this context, transparency is not just about visual aesthetics, but about cognitive ergonomics and the ability to use a tool peripherally and subconsciously.

Participants' reflections on their *Fidgeting Preferences* further complicate the design space. While digital spinners offer convenience, especially in remote or professional contexts, many users still prefer the multisensory feedback and embodied nature of physical fidget tools. This preference speaks to a core limitation of our current digital implementations: the lack of haptic or kinesthetic engagement. In contrast to digital spinners, a physical object provides a rich stream of sensory input (e.g., sound, texture, resistance, weight) that supports regulation through multisensory integration. While digital tools cannot replicate this entirely, there may be room for hybrid approaches or more tactile interactions (e.g., haptic feedback via trackpads or game controllers). That said, one promising feature of digital fidgeting is its non-disruptiveness in shared or social settings. Unlike physical fidgeting, which can be noisy or visually distracting to others, virtual tools provide a more private channel of self-regulation, particularly relevant in shared-screen environments such as video calls or open-plan offices.

The interviews highlighted the broader social and ethical context in which digital self-regulation tools operate. Historically, fidgeting has been framed as disruptive or immature and thus something to be suppressed (see section 2). In contrast, participants reported a sense of legitimacy and usefulness in their fidgeting practices, suggesting a shift in how such neurodivergent behaviors are perceived. Notably, none expressed concern that their fidgeting might disturb others, which might reflect the normalization of remote work, reduced social stigma, or limited awareness of peer perceptions. Designing digital tools that validate rather than stigmatize fidgeting may therefore help reframe it as a legitimate support strategy.

In summary, our findings suggest that digital fidgeting tools, such as spinners, represent a promising yet complex opportunity space for inclusive interface design. Success in this space will depend not only on thoughtful interaction design but also on an understanding of ADHD as a dynamic condition that requires flexibility and respect for individual differences. Future systems might incorporate adaptive, user-configurable, and even sensor-aware fidgeting elements that serve not only to regulate attention but to affirm the legitimacy of neurodivergent ways of engaging with technology. Drawing from our thematic findings, we can provide **five design guidelines** on how to implement virtual fidget tools:

(1) **Visual Clarity & Transparency:** Ensure that fidget elements remain unobtrusive to primary tasks while positioned to minimize context switching.
(2) **Customization & Personalization:** Allow users to customize colors and interaction methods, as these can lower the barrier to adoption.
(3) **Engagement & Distraction Dynamics:** New digital fidget tools need to navigate the underlying engagement-distraction struggle, avoiding overstimulation that could fragment attention.
(4) **Usability:** Basic usability and accessibility, as with good onboarding, are essential to the experience.
(5) **Fidgeting Preferences:** To increase acceptance of virtual fidgeting, these tools may need to simulate multisensory aspects of physical fidgeting to meet diverse user needs.

Together, these guidelines frame virtual fidgeting as a modifiable, context-sensitive attentional aid, and offer a starting point for broader application and empirical testing.

5 Limitations

This section presents the main limitations of our study. The limitations are grouped into three categories: design and scope, participant sampling, and contextual validity.

Design and Scope. The virtual spinner primarily provides visual stimulation and does not replicate the tactile or auditory richness of physical fidgeting devices [17]. To mitigate this, we focused on minimal visual interference and fine-grained interaction control to support attentional regulation, while explicitly documenting unmet sensory needs to inform future designs. Although optimized for mouse-wheel input, we ensured compatibility across standard browsers and input devices, and we framed our findings as design insights rather than performance claims. While the usage of the mouse-wheel was intended to mimic the kinetic mechanisms behind analog fidget spinners, we could not control for specific mouse hardware in the think-aloud sessions, which might have influenced the perceived kinetic and auditory feedback of our system.

Participant and Sampling. The sample was relatively small and demographically narrow, limiting generalizability. To mitigate this, we recruited participants with confirmed ADHD diagnoses and used complementary methods (survey and think-aloud) to capture converging perspectives. The recruitment materials did not explicitly mention fidgeting to reduce expectation bias.

Contextual and Temporal. The study focused on short-term use in reading tasks, which limits claims about long-term adoption or use in collaborative contexts. To address this, we positioned our findings as formative and design-oriented, emphasizing perceived usefulness, barriers, and variability rather than long-term efficacy. We also explicitly avoided framing virtual fidgeting as a socially "acceptable" substitute, presenting it instead as an optional, private support for attention regulation.

6 Future Directions

Extending Use Across Tasks and Platforms. Future work should examine digital fidgeting beyond reading tasks, including video conferencing, writing, and programming, and investigate its integration into mobile and tablet workflows rather than treating mobile devices as parallel interaction channels.

Longitudinal and Large-Scale Evaluation. Long-term and large-sample studies are needed to assess sustained engagement, learning effects, habituation, and potential risks such as overreliance or reduced effectiveness, while isolating key design factors without think-aloud interference and varying hardware.

Interaction Design, Learnability, and Multisensory Support. Future designs should incorporate participant-requested features, explore alternative fidgeting interactions (e.g., sliders, toggles, or freeform scribble zones), evaluate structured onboarding to reduce cognitive friction, and investigate multisensory or hardware-supported designs, such as programmable haptic feedback, to address limitations of purely visual interactions.

Adaptation, Generalizability, and Social Context. Adaptive systems that respond to user behavior, attention states, or task progression may enable more personalized support, while evaluations across broader populations, cultures, and professional or educational settings can clarify generalizability and the social acceptability of virtual fidgeting compared to physical fidgeting.

7 Conclusion

This paper investigated the potential of digital fidgeting as a self-regulation mechanism for individuals with ADHD in web-based reading contexts. While fidgeting is commonly supported through physical objects, its integration into digital environments remains underexplored. To address this gap, we designed and evaluated a virtual fidget spinner implemented as a browser overlay. Using a participatory design process, we conducted a focus group (n=3), followed by a survey (n=25) and think-aloud sessions (n=12) with individuals with ADHD. We examined how such a tool fits within real-world web interactions without disrupting primary task performance.

Our findings reveal that the effectiveness of digital fidgeting depends on careful design trade-offs related to visual transparency, customization, usability, and individual differences in engagement and distraction. While some participants found the tool supportive for maintaining focus, others experienced it as distracting, highlighting the heterogeneous nature of ADHD and the risks of one-size-fits-all solutions. These results suggest that digital fidgeting tools must remain unobtrusive, highly configurable, and cognitively lightweight to be effective. As web-based work and learning environments continue to expand, thoughtfully designed digital self-regulation tools can contribute to more accessible and inclusive web experiences, while also opening opportunities for future multimodal and adaptive designs.

References

[1] American Psychiatric Association. 2013. *Diagnostic and Statistical Manual of Mental Disorders* (fifth edition ed.). American Psychiatric Association. doi:10.1176/appi.books.9780890425596

[2] Kathleen B. Aspiranti and David M. Hulac. 2022. Using Fidget Spinners to Improve On-Task Classroom Behavior for Students With ADHD. *Behavior Analysis in Practice* 15, 2 (June 2022), 454–465. doi:10.1007/s40617-021-00588-2

[3] American Psychological Association. 2018. attention-deficit/hyperactivity disorder (ADHD). https://dictionary.apa.org/

[4] Marie T. Banich. 2009. Executive Function: The Search for an Integrated Account. *Current Directions in Psychological Science* 18, 2 (April 2009), 89–94. doi:10.1111/j.1467-8721.2009.01615.x

[5] R. A. Barkley. 1997. Attention-deficit/hyperactivity disorder, self-regulation, and time: toward a more comprehensive theory. *Journal of developmental and behavioral pediatrics: JDBP* 18, 4 (Aug. 1997), 271–279.

[6] Susanne Bødker, Christian Dindler, Ole S Iversen, and Rachel C Smith. 2022. What is participatory design? In *Participatory design*. Springer, 5–13.

[7] Thomas E. Brown. 2005. *Attention deficit disorder: the unfocused mind in children and adults*. Yale Univ. Press, New Haven, Conn.

[8] Thomas E Brown. 2006. Executive functions and attention deficit hyperactivity disorder: Implications of two conflicting views. *International journal of disability, development and education* 53, 1 (2006), 35–46.

[9] Kelly Caine. 2016. Local Standards for Sample Size at CHI. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, San Jose California USA, 981–992. doi:10.1145/2858036.2858498

[10] Laura Cang, Paul Bucci, and Karon E. MacLean. 2015. CuddleBits: Friendly, Low-cost Furballs that Respond to Touch. In *Proceedings of the 2015 ACM on International Conference on Multimodal Interaction*. ACM, Seattle Washington USA, 365–366. doi:10.1145/2818346.2823293

[11] CDC. 2024. Symptoms of ADHD. https://www.cdc.gov/adhd/signs-symptoms/index.html

[12] CDC. 2024. Treatment of ADHD. https://www.cdc.gov/adhd/treatment/index.html

[13] AL Chapman, M Hadfield, and CJ Chapman. 2015. Qualitative research in healthcare: an introduction to grounded theory using thematic analysis. *Journal of the Royal College of Physicians of Edinburgh* 45, 3 (2015), 201–205.

[14] Kathy Charmaz. 2008. Grounded theory as an emergent method. *Handbook of emergent methods* 155 (2008), 172.

[15] Franceli L. Cibrian, Kimberley D. Lakes, Arya Tavakoulnia, Kayla Guzman, Sabrina Schuck, and Gillian R. Hayes. 2020. Supporting Self-Regulation of Children with ADHD Using Wearables: Tensions and Design Challenges. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. ACM, Honolulu HI USA, 1–13. doi:10.1145/3313831.3376837

[16] Bronwyn Cumbo and Neil Selwyn. 2022. Using participatory design approaches in educational research. *International Journal of Research & Method in Education* 45, 1 (2022), 60–72.

[17] Suzanne B. Da Câmara, Rakshit Agrawal, and Katherine Isbister. 2018. Identifying Children's Fidget Object Preferences: Toward Exploring the Impacts of Fidgeting and Fidget-Friendly Tangibles. In *Proceedings of the 2018 Designing Interactive Systems Conference*. ACM, Hong Kong China, 301–311. doi:10.1145/3196709.3196790

[18] Tessa Eagle and Kathryn E. Ringland. 2023. "You Can't Possibly Have ADHD": Exploring Validation and Tensions around Diagnosis within Unbounded ADHD Social Media Communities. In *The 25th International ACM SIGACCESS Conference on Computers and Accessibility*. ACM, New York NY USA, 1–17. doi:10.1145/3597638.3608400

[19] Stephen V. Faraone, Philip Asherson, Tobias Banaschewski, Joseph Biederman, Jan K. Buitelaar, Josep Antoni Ramos-Quiroga, Luis Augusto Rohde, Edmund J. S. Sonuga-Barke, Rosemary Tannock, and Barbara Franke. 2015. Attention-deficit/hyperactivity disorder. *Nature Reviews Disease Primers* 1, 1 (Aug. 2015), 15020. doi:10.1038/nrdp.2015.20

[20] National Center for Health Statistics. 2024. Attention-Deficit/Hyperactivity Disorder in Children Ages 5–17 Years. doi:10.15620/cdc/148043

[21] Sina Gerhand and Christopher WN Saville. 2022. ADHD prevalence in the psychiatric population. *International journal of psychiatry in clinical practice* 26, 2 (2022), 165–177.

[22] Paulo A Graziano, Alexis M Garcia, and Taylor D Landis. 2020. To fidget or not to fidget, that is the question: A systematic classroom evaluation of fidget spinners among young children with ADHD. *Journal of attention disorders* 24, 1 (2020), 163–171.

[23] Paulo A. Graziano, Alexis M. Garcia, and Taylor D. Landis. 2020. To Fidget or Not to Fidget, That Is the Question: A Systematic Classroom Evaluation of Fidget Spinners Among Young Children With ADHD. *Journal of Attention Disorders* 24, 1 (Jan. 2020), 163–171. doi:10.1177/1087054718770009

[24] Jacqueline Hesson and Ken Fowler. 2018. Prevalence and correlates of self-reported ADD/ADHD in a large national sample of Canadian adults. *Journal of Attention Disorders* 22, 2 (2018), 191–200.

[25] Yajing Hu, Yijun Zhao, Yaping Shao, Can Zhu, Jiayan Chen, Tianlei Shi, Zili Zhou, Fangtian Ying, Guanyun Wang, and Cheng Yao. 2021. Bubble Beats: A Breathing Exercise Game Based on Music Rhythm for Children. In *Interaction Design and Children*. ACM, Athens Greece, 588–592. doi:10.1145/3459990.3465207

[26] Rakesh Jain, Saundra Jain, and C. Brendan Montano. 2017. Addressing Diagnosis and Treatment Gaps in Adults With Attention-Deficit/Hyperactivity Disorder. *The Primary Care Companion For CNS Disorders* 19, 05 (Sept. 2017). doi:10.4088/PCC.17nr02153

[27] Sumeet M Jaswal, Drake Levere, and Todd C Handy. 2024. I struggle with your fidgeting: A qualitative study of the personal and social impacts of misokinesia. *PloS one* 19, 12 (2024), e0313169.

[28] Chen Ji and Katherine Isbister. 2022. AR Fidget: Augmented Reality Experiences that Support Emotion Regulation through Fidgeting. In *CHI Conference on Human Factors in Computing Systems Extended Abstracts*. ACM, New Orleans LA USA, 1–4. doi:10.1145/3491101.3519874

[29] Michael Karlesky and Katherine Isbister. 2013. Fidget widgets: secondary playful interactions in support of primary serious tasks. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems*. ACM, Paris France, 1149–1154. doi:10.1145/2468356.2468561

[30] Michael Karlesky and Katherine Isbister. 2016. Understanding Fidget Widgets: Exploring the Design Space of Embodied Self-Regulation. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction*. ACM, Gothenburg Sweden, 1–10. doi:10.1145/2971485.2971557

[31] E Klooster, N Koenders, J Vermeulen-Holsen, L Vos, PJ Van Der Wees, and TJ Hoogeboom. 2022. Healthcare professionals feel empowered by implementing a hospital-based multifaceted intervention: a qualitative study using inductive thematic analysis. *BMC Health Services Research* 22, 1 (2022), 903.

[32] Michael Koch, Kai von Luck, Jan Schwarzer, and Susanne Draheim. 2018. The Novelty Effect in Large Display Deployments – Experiences and Lessons-Learned for Evaluating Prototypes. (2018). doi:10.18420/ECSCW2018_3

[33] Naomi Langerock, Klaus Oberauer, Elena Throm, and Evie Vergauwe. 2025. The cognitive load effect in working memory: Refreshing the empirical landscape, removing outdated explanations. *Journal of Memory and Language* 140 (2025), 104558.

[34] Inc Llama Life. 2025. Llama Life: calm, focused productivity. https://llamalife.co

[35] Eudaimonia Labs Ltd. 2025. Accountability Partner App | ADHD Accountability Buddy | Deepwrk. https://www.deepwrk.io/accountability-partner-app

[36] Mei Yee Lui, Lok Yiu Wong, Ho Yin Mak, and Yi-Teng Shih. 2022. TOY DESIGN: IMPROVING LEARNING EFFECTIVENESS FOR ADHD STUDENTS. In *DS 117: Proceedings of the 24th International Conference on Engineering and Product Design Education (E&PDE 2022), London South Bank University in London, UK. 8th - 9th September 2022*. The Design Society. doi:10.35199/EPDE.2022.46

[37] Gloria Mark, Shamsi T. Iqbal, Mary Czerwinski, Paul Johns, and Akane Sano. 2016. Neurotics Can't Focus: An *in situ* Study of Online Multitasking in the Workplace. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, San Jose California USA, 1739–1744. doi:10.1145/2858036.2858202

[38] Elgin-Skye McLaren and Alissa N. Antle. 2017. Exploring and Evaluating Sound for Helping Children Self-Regulate with a Brain-Computer Application. In *Proceedings of the 2017 Conference on Interaction Design and Children*. ACM, Stanford California USA, 393–398. doi:10.1145/3078072.3084299

[39] Nahid Nasiri, Katherine Isbister, Julie B Schweitzer, Jared Borden, Peter S Cottrell, and Daniel Goodman Shapiro. 2024. Extracting the Affective Content of Fidgeting in Adults with ADHD via Machine Learning and a Hand-held Soft Tangible Device. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems*. ACM, Honolulu HI USA, 1–8. doi:10.1145/3613905.3650856

[40] A. Newell and Paul Rosenbloom. 1993. Mechanisms of skill acquisition and the law of practice. *Cognitive Skills and Their Acquisition* Vol. 1 (Aug. 1993).

[41] V Oliveira. 2020. Using a reed switch to measure the angular speed of a fidget spinner. *Physics Education* 55, 2 (2020), 023007.

[42] Seonwook Park, Christoph Gebhardt, Roman Rädle, Anna Maria Feit, Hana Vrzakova, Niraj Ramesh Dayama, Hui-Shyong Yeo, Clemens N Klokmose, Aaron Quigley, Antti Oulasvirta, et al. 2018. Adam: Adapting multi-user interfaces for collaborative environments in real-time. In *Proceedings of the 2018 CHI conference on human factors in computing systems*. 1–14.

[43] Guilherme Polanczyk, Maurício Silva De Lima, Bernardo Lessa Horta, Joseph Biederman, and Luis Augusto Rohde. 2007. The Worldwide Prevalence of ADHD: A Systematic Review and Metaregression Analysis. *American Journal of Psychiatry* 164, 6 (June 2007), 942–948. doi:10.1176/ajp.2007.164.6.942

[44] Samira Pulatova and Lawrence H Kim. 2024. Co-Designing Programmable Fidgeting Experience with Swarm Robots for Adults with ADHD. In *The 26th International ACM SIGACCESS Conference on Computers and Accessibility*. ACM, St. John's NL Canada, 1–14. doi:10.1145/3663548.3675614

[45] Fatemeh Rabiee. 2004. Focus-group interview and data analysis. *Proceedings of the nutrition society* 63, 4 (2004), 655–660.

[46] Christine Ro. 2024. Why an ADHD diagnosis can be a mixed blessing. https://www.bbc.com/future/article/20241003-the-pros-and-cons-of-an-adult-diagnosis-with-adhd

[47] Sam H Ross, Nicole Sullivan, and Jina Aris Yoon. 2023. Virtual Fidgets: Opportunities and Design Principles for Bringing Fidgeting to Online Learning. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*. ACM, Hamburg Germany, 1–6. doi:10.1145/3544549.3585729

[48] Sam H Ross, Nicole Sullivan, and Jina Aris Yoon. 2023. Virtual Fidgets: Opportunities and Design Principles for Bringing Fidgeting to Online Learning. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*. 1–6.

[49] Rahel Mirijam Schneider, Hauke Steffen Wendt, and Alexander Kuon. 2022. AID-Watch - Smartwatch for People with Cognitive Impairments. In *Mensch und Computer 2022*. ACM, Darmstadt Germany, 622–624. doi:10.1145/3543758.3547513

[50] Seekrtech. 2025. Forest - Stay focused, be present. https://www.forestapp.cc

[51] Lucas M. Silva, Franceli L. Cibrian, Clarisse Bonang, Arpita Bhattacharya, Aehong Min, Elissa M Monteiro, Jesus Armando Beltran, Sabrina Schuck, Kimberley D Lakes, Gillian R. Hayes, and Daniel A. Epstein. 2024. Co-Designing Situated Displays for Family Co-Regulation with ADHD Children. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*. ACM, Honolulu HI USA, 1–19. doi:10.1145/3613904.3642745

[52] Lucas M. Silva, Franceli L. Cibrian, Elissa Monteiro, Arpita Bhattacharya, Jesus A. Beltran, Clarisse Bonang, Daniel A. Epstein, Sabrina E. B. Schuck, Kimberley D. Lakes, and Gillian R. Hayes. 2023. Unpacking the Lived Experiences of Smartwatch Mediated Self and Co-Regulation with ADHD Children. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. ACM, Hamburg Germany, 1–19. doi:10.1145/3544548.3581316

[53] Ha Min Son, Catrina Andaya Calub, Boyang Fan, J. Faye Dixon, Shahbaz Rezaei, Jared Borden, Julie B. Schweitzer, and Xin Liu. 2024. A quantitative analysis of fidgeting in ADHD and its relation to performance and sustained attention on a cognitive task. *Frontiers in Psychiatry* 15 (July 2024), 1394096. doi:10.3389/fpsyt.2024.1394096

[54] Ha Min Son, Catrina Andaya Calub, Boyang Fan, J Faye Dixon, Shahbaz Rezaei, Jared Borden, Julie B Schweitzer, and Xin Liu. 2024. A quantitative analysis of fidgeting in ADHD and its relation to performance and sustained attention on a cognitive task. *Frontiers in psychiatry* 15 (2024), 1394096.

[55] Peige Song, Mingming Zha, Qingwen Yang, Yan Zhang, Xue Li, and Igor Rudan. 2021. The prevalence of adult attention-deficit hyperactivity disorder: A global systematic review and meta-analysis. *Journal of Global Health* 11 (Feb. 2021), 04009. doi:10.7189/jogh.11.04009

[56] Tobias Sonne and Mads Møller Jensen. 2016. ChillFish: A Respiration Game for Children with ADHD. In *Proceedings of the TEI '16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction*. ACM, Eindhoven Netherlands, 271–278. doi:10.1145/2839462.2839480

[57] Clay Spinuzzi. 2005. The methodology of participatory design. *Technical communication* 52, 2 (2005), 163–174.

[58] Evropi Stefanidi, Jonathan Luis Benjamin Wassmann, Paweł W. Woźniak, Gunnar Spellmeyer, Yvonne Rogers, and Jasmin Niess. 2024. MoodGems: Designing for the Well-being of Children with ADHD and their Families at Home. In *Proceedings of the 23rd Annual ACM Interaction Design and Children Conference*. ACM, Delft Netherlands, 480–494. doi:10.1145/3628516.3655795

[59] Karen Vanderloock, Vero Vanden Abeele, Johan A.K. Suykens, and Luc Geurts. 2013. The skweezee system: enabling the design and the programming of squeeze interactions. In *Proceedings of the 26th annual ACM symposium on User interface software and technology*. ACM, St. Andrews Scotland, United Kingdom, 521–530. doi:10.1145/2501988.2502033