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Inhibitory control ability moderates the relationship between internet addiction and inattention in ADHD in a community sample

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ABSTRACT

Internet addiction (IA) has been related to psychiatric problems such as ADHD. However, it is not known exactly how this relationship operates, although most research shows that both people with ADHD and IA have inhibitory control (IC) deficit. This study aimed to investigate whether IC mediates or moderates the relationship. 76 non-clinically diagnosed participants were recruited. They performed the Stroop task and completed the Young's Internet Addiction Test, Adult ADHD Self-Report Scale Symptom Checklist and a Demographic Information Form. Consistent with previous research, the results show that while total ADHD/inattention was correlated with IA, hyperactivity/impulsivity was not. In contrast with some previous research, Stroop task performance (measured via reaction times and pupil dilation) did not differ between low and high IA groups, nor low and high inattention groups. Despite neither inattention nor IA between associated with IC impairments, the relationship between inattention and IA was shown to be moderated by Stroop task performance in that the relationship was present mainly in those who experience high and moderate IC deficits. This finding could have implications for both ADHD and IA at higher levels of severity and could help guide prevention and treatment options in those most vulnerable to IA.

1. Introduction

Internet is an indispensable part of life for people of all ages and is used in all areas of life such as in entertainment, education, work, social networking, and information sharing (Dogruer, Eyyam, & Menevis, 2011). Although it provides many advantages, excessive and uncontrolled use can lead to several adverse effects, including decreased quality of life, and social, cognitive, and psychiatric problems (Sun et al., 2023), as well as physical health problems (Güzel, Kahveci, Solak, Cömert, & Turan, 2018). Furthermore, global pooled prevalence of internet addiction was determined as 14.22 % by Meng et al., 2022. Thus, it is important to understand the mechanisms underlying problematic internet use. In the literature, the excessive and uncontrolled use of the internet is referred to variously as internet addiction (IA), pathological internet use, problematic internet use, excessive internet use, internet dependence, compulsive computer uses or virtual addiction (Kandre, Patel, & Mehta, 2020). Here we use the former term IA.

Young, Pistner, O'Mara, and Buchanan (1999) proposed IA consists of five sub-categories: cybersex, cyber-relationships, online stock trading or gambling, information surfing, and computer games. However, IA is not included in DSM V due to insufficient peer-reviewed research (Potenza, 2014) despite evidence indicating its adverse effects. Therefore, further research is required to develop diagnostic criteria. In this context, psychological or psychiatric factors that can render people more prone to IA are being investigated, including depression, anxiety (Gudlavallety, Radham, & Gurnule, 2023), and Attention Deficit and Hyperactivity Disorder (ADHD) (Zhang, Jiang, Yang, & Zhu, 2022).

ADHD is considered as a neurodevelopmental disorder affecting school children (Kian, Samieefar, & Rezaei, 2022) and adults (Rosso, Portaluppi, Teobaldi, Di Salvo, & Maina, 2023). Whilst ADHD has traditionally been considered a categorical disorder, more recent evidence suggests that it is more appropriately understood as existing along a continuum of inattention and hyperactivity/impulsivity (HI) traits within the general population (Norman, Sudre, Price, Shastri, & Shaw, 2023). Sometimes individuals do not meet the diagnostic criteria for ADHD, but can show distinct impairments (Arildskov, Sonuga-Barke, Thomsen, Virring, & Østergaard, 2022) with impairments in executive functions (EF) being one of them (Barkley, 2022).

EF is a blanket term referring to the collection of higher-order cognitive skills required to explore and accomplish a goal. It

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encompasses a broad range of cognitive abilities such as inhibitory control, cognitive flexibility, working memory, planning, problem solving, and reasoning; (Cristofori, Cohen-Zimerman, & Grafman, 2019). EFs have significant implications across various aspects of life, including mental health, physical health, quality of life, as well as success in education, employment, and relationships. Therefore, it is important to understand the role of EFs in mental disorders (Diamond, 2013).

As with ADHD, EF impairments are associated with IA (Dong, DeVito, Du, & Cui, 2012; Dong, Zhou, & Zhao, 2011). Furthermore, it is clear from the literature that ADHD and IA are related (Zhang et al., 2022). According to an analysis, inattention is the symptom most associated with IA among ADHD symptoms (Wang, Yao, Zhou, & Liu, 2017). In a recent study examining the relationship between ADHD symptoms and different technology addictions (include IA), researchers found IA, unlike the other addictions, was uniquely predicted by inattention (Aydin, Parris, Arabaci, Kilintari, & Taylor, 2023). Given that people with ADHD (Barkley, 2022) and IA (Dong et al., 2011; Dong et al., 2012) have impaired EFs, the present experiment was designed to investigate whether EFs mediate or moderate the relationship between IA and inattention.

Various tasks can be employed to assess EFs (e.g., Arabaci & Parris, 2018; Elisa, Balaguer-Ballester, & Parris, 2016), with the Stroop task (see Parris, Hasshim, Wadsley, Augustinova, & Ferrand, 2022 for reviews) being one of the most used (e.g., Dong et al., 2011). Thus, we employed the Stroop task in the present study as our measure of inhibitory control. It evaluates the capacity to prevent interference from an irrelevant word whilst naming the font color of that word. In the task, there are usually three conditions: congruent, incongruent, and a control condition to enable measurement of interference and facilitation. The difficulty in suppressing the more automated process is called "the Stroop Effect" which can refer to the difference between incongruent and control stimuli, known as Stroop interference, and the difference between the control and congruent stimuli, which is known as Stroop facilitation (Parris et al., 2022).

In addition to response times and accuracy as a measure of performance on the Stroop task, in more recent literature, pupillometry has been used as a measure of performance because it permits the measurement of effort expenditure (Hasshim & Parris, 2015; Laeng, Ørbo, Holmlund, & Miozzo, 2011; Parris, Hasshim, & Dienes, 2021). One theory of ADHD holds that it results, not from an impairment in executive control, but instead from an impairment in the cognitive-energetic pools of arousal, activation, and effort (Sergeant, 2005). One implication of this is that executive control performance might not differ between those with inattention / ADHD, but self-regulation of performance might, indicating a different amount of effort required for the same level of performance. Indeed, it might be this regulatory deficiency in ADHD that leads to its association with IA.

2. Method

2.1. Participants

Seventy-nine participants with normal or corrected-to-normal vision were recruited. The inclusion criteria were: 1) being above 18 years old; 2) being fluent in English, and 3) currently not receiving psychological or neurological treatment. The data from three of the participants were excluded because of later divulging they did not fulfil these criteria. 76 participants (62 females/14 males) between 18 and 40 years old remained (M_{age} = 22.24; SD = 6.61). Based on inattention symptom scores and IA scores, participants were divided into low (n = 33) and high inattention groups (n = 43), and low (n = 36) and high (n = 40) IA groups.

Participants were recruited from a University's Experiment Participation Scheme (SONA), where students were offered 0.5 course credit as compensation for their participation, and via social media adverts, where participants did not receive any compensation. The study was approved by the Ethics committee of a University (ID: 46038). The Helsinki Declaration of 1975, as amended in 2013, and the ethical guidelines of the relevant committee on human testing (both national and institutional) were followed throughout all processes (World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects, 2013). Informed consent was obtained from all patients for being included in the study.

2.2. Design

The experiment had a 2 (inattention: high, low) x 2 (IA: high, low) x 3 (Stroop conditions: congruent, incongruent, and neutral) mixed design.

2.3. Procedure

Initially, the Participant Information Sheet and Participant Agreement Form were given to all participants. Once consent was given, the participants were seated in front of the computer screen. Calibration and validation processes for eye recording were done. Then, they read the instructions of the Stroop task and when they were ready, they completed the practice block. After the end of the practice session, participants were informed that the test session would start, and the same procedures would be followed. After they completed the test session, participants were asked to complete a Demographic Information Sheet, the Internet Addiction Test, and the Adult ADHD Self-Report Scale (ASRS). The order of questionnaire administration was counterbalanced.

2.4. The Stroop task

There were three trial types: congruent trials (e.g., the word "blue" written in blue ink), incongruent trials (e.g., the word "blue" written in red ink) and neutral trials (e.g., the word "flower" written in red ink). Eight practice trials of each trial type were given to each participant at the beginning. After the practice session, participants completed 280 randomly presented trials (120 neutral, 120 incongruent and 40 congruent trials). They were told to ignore the meaning of the word and reply as quickly and accurately as they could to the color of each stimulus. Each trial began with a fixation cross for 1000 ms. The stimuli were then presented for 1000 ms (includes time for a response). After that, a blank screen for 1000 ms was presented. Completion of the task took approximately 16 min. The Stroop interference effect, calculated as the RT difference between incongruent and neutral trials, was used as a dependent variable to measure interference control (Parris et al., 2022).

2.5. Pupil size recording

A standard PC running Experiment Builder software (SR Research Ltd) was used to present stimuli. Stimuli appeared on a color monitor that ran at 120 Hz. Pupils were recorded with an Eyelink 1000 (SR Research Ltd) video-based pupil/CR tracker. A 1000 Hz monocular sampling rate was applied. Offline Eyelink Data Viewer software (SR Research Ltd) was used to extract pupil parameters. Pupil size was measured in pixels. Pupil size was continuously sampled except for when blinks occurred; when blinks did occur pupil sizes 100 ms either side of the blink were removed without interpolation and therefore did not contribute to the mean pupil size values. Pupil sizes were sampled at two phases of the task: (a) intra-trial response phase: the average pupil size within the period from stimulus onset to response completion; (b) a 1000 ms pre-trial period (just before stimulus onset) which was subtracted from the intra-trial phase to provide a baseline-corrected measure of performance as recommended by Mathôt, Fabius, Van Heusden, and Van der Stigchel (2018), and is a method used to show pupillometric Stroop effects (Laeng et al., 2011).

2.6. Questionnaires

Young's Internet Addiction Test (IAT).

IAT assesses the presence and severity of technology and IA in adulthood (Young, 2009). It consists of 20 questions rated from "0 = not applicable" to "5 = always". A score between 0 and 30 points is a normal amount of internet usage, whereas 31 to 49 points indicates mild IA, 50 to 79 points indicates moderate IA, and 80 to 100 points indicates severe IA (Islam et al., 2023).

Adult ADHD Self-Report Scale Symptom (ASRS-v1.1) Checklist.

ASRS-v1.1 assesses ADHD symptoms and consists of 18 items meeting the DSM-IV-TR criteria. It has two domains, inattention, and HI. Each item is rated from "0 = never" to "4 = very often" (Greenblum, 2023). The scores to be taken from the scale vary between 0 and 72. High scores on this scale indicate severe ADHD symptoms. Total score of ≥4 in a six-item Part A scale is used as the cutoff point for a positive screening test result and "Very often" or "often" responses are seen as positive (shown by shaded boxes on the questionnaire) (Dunlop, Wu, & Helms, 2018). Twenty-seven participants had exceeded the ASRS cutoff. The mean of the ASRS was used in the analysis with those below the average classified as low, those above the average classified as high.

2.7. Statistical analysis

JASP 0.16.2.0 and IBM SPSS Statistics 28 programs were used for analysis. To assess normality, normality plots, the Kolmogorov-Smirnov test, skewness, and kurtosis were examined. Data exhibiting skewness and kurtosis values within the range of −1 and + 1 were considered to follow a normal distribution (Mishra et al., 2019). The relations among ADHD symptoms and IA were analyzed using Pearson correlation. Mixed ANOVA was used to analyze group differences. A moderation analysis to investigate a potential mediating role for inhibitory control in the relationship between inattention and IA was run using PROCESS Version 3.0 (Hayes, 2013) and employing Bootstrapping was performed to determine 95 % confidence intervals around using 1000 resampling method.

3. Results

3.1. The relationship between inattention and internet addiction

A Pearson's Correlation indicated a moderately strong, positive relationship between inattention and IA, $r\ (74) = 0.403$, $R^2 = 0.16$, $p < .001$. See Table 1 for correlations between all self-report variables.

3.2. Internet addiction and inhibitory control

Previous research has reported a link between IA and Stroop task performance, two separate two-way mixed ANOVAs were performed with RT and pupil dilation as dependent variables. In both ANOVAs, Stroop condition (congruent/incongruent/neutral) was the within-subjects factor and Group (low and high Internet addicted groups) was the between-subjects factor.

The two-way mixed ANOVA for RTs revealed there was not a statistically significant interaction between Stroop conditions and Group [$F(1,74) = 0.405$, $p = .14$, partial $\eta^2 = 0.005$]. The two-way mixed ANOVA for PDs also revealed no interaction [$F(1,74) = 1.539$, $p = .79$, partial $\eta^2 = 0.019$](Fig. 1).

3.3. Inattention and inhibitory control

Two separate two-way mixed ANOVAs were performed with RT and pupil dilation as dependent variables and Stroop conditions (congruent/incongruent/neutral) as the within-subjects factor and Group (low and high inattention) as the between-subjects factor. The two-way mixed ANOVA for RT revealed there was not a statistically significant interaction between Stroop conditions and Group [$F(1,74) = 1.639$, $p = .20$, partial $\eta^2 = 0.022$]. Likewise, the two-way mixed ANOVA for PDs revealed no interaction [$F(1,74) = 0.181$, $p = .47$, partial $\eta^2 = 0.002$] (Fig. 2).

3.4. Moderation analysis

The normality was checked with Q-Q Plot of Stroop Interference Effect (Z scores); outliers (four data points) were removed. While inattention and IA has been shown to be linked, inattention and IA did not correlate with interference inhibition (See Table 1). Therefore, our data did not meet the assumptions of mediation analysis (VanderWeele, 2016). To further investigate if the relationship between inattentive traits and IA varies among different levels of inhibitory control, the moderation analysis was performed to assess the moderating role of inhibitory control on the relationship between inattention and IA using PROCESS Version 3.0 (Hayes, 2013) using Bootstrapping to calculate a 95 % confidence interval around the indirect effect using 1000 resamples (See Fig. 3).

The model explained 28 % of the variation, [$F(4, 67) = 6.64$, $p < .01$] and revealed inattention predicted an increase IA only for those with moderate (β *moderate* = 0.41, $p < .01$) and high interference inhibition (β *high* = 0.82, $p < .01$). HI scores were not a significant predictor ($p = .65$). Therefore, when controlling for HI, inhibitory control scores moderated the relationship between inattention and IA (See Table 2).

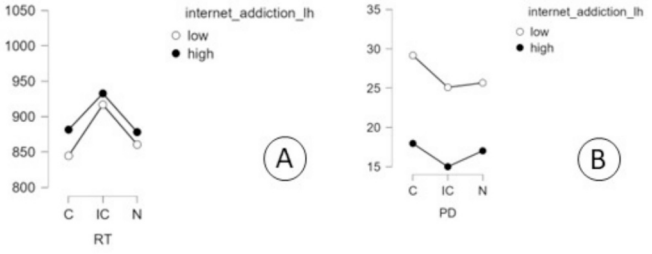

Fig. 1. . Reaction times and pupil dilations of internet addiction groups in Stroop task

Note: A: Reaction times (RT) of low and high internet addiction groups in congruent (C), incongruent (IC), and neutral (N) trials. B: Pupil dilations (PD) of low and high internet addiction groups in congruent (C), incongruent (IC), and neutral (N) trials.

Table 1
Correlation between ADHD symptoms and IA.

Variable	M	SD	1	2	3	4	5	6
1. Total_ADHD	39.68	11.75	–					
2. IAT	37.16	11.85	0.317**	–				
3. Inattention	22.51	6.49	0.912***	0.403***	–			
4. Hyperactivity_Impulsivity	17.17	6.41	0.910***	0.172	0.660***	–		
5. Interference_Inhibition_RT	55.35	44.12	0.182	0.151	0.320	0.395	–	
6. Interference_Inhibition_PD	−1.33	12.37	0.638	0.914	0.451	0.526	0.933	–

* $p < .05$, ** $p < .01$, *** $p < .001$.

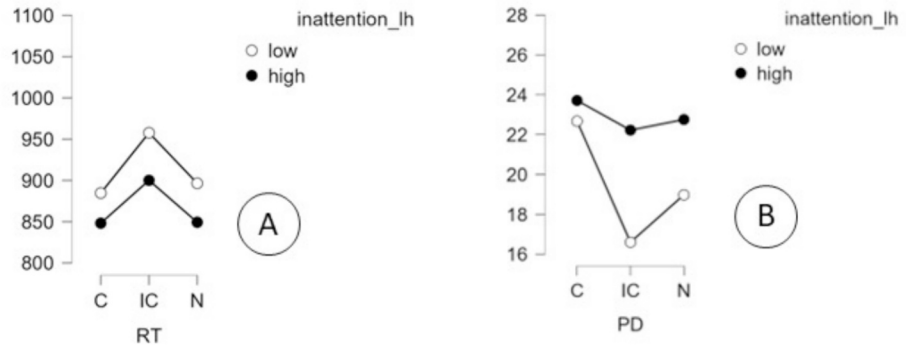

Fig. 2. Reaction times and pupil dilations of inattention groups in Stroop task
Note: A: Reaction times (RT) of low and high inattention groups in congruent (C), incongruent (IC), and neutral (N) trials. B: Pupil dilations (PD) of low and high inattention groups in congruent (C), incongruent (IC), and neutral (N) trials.

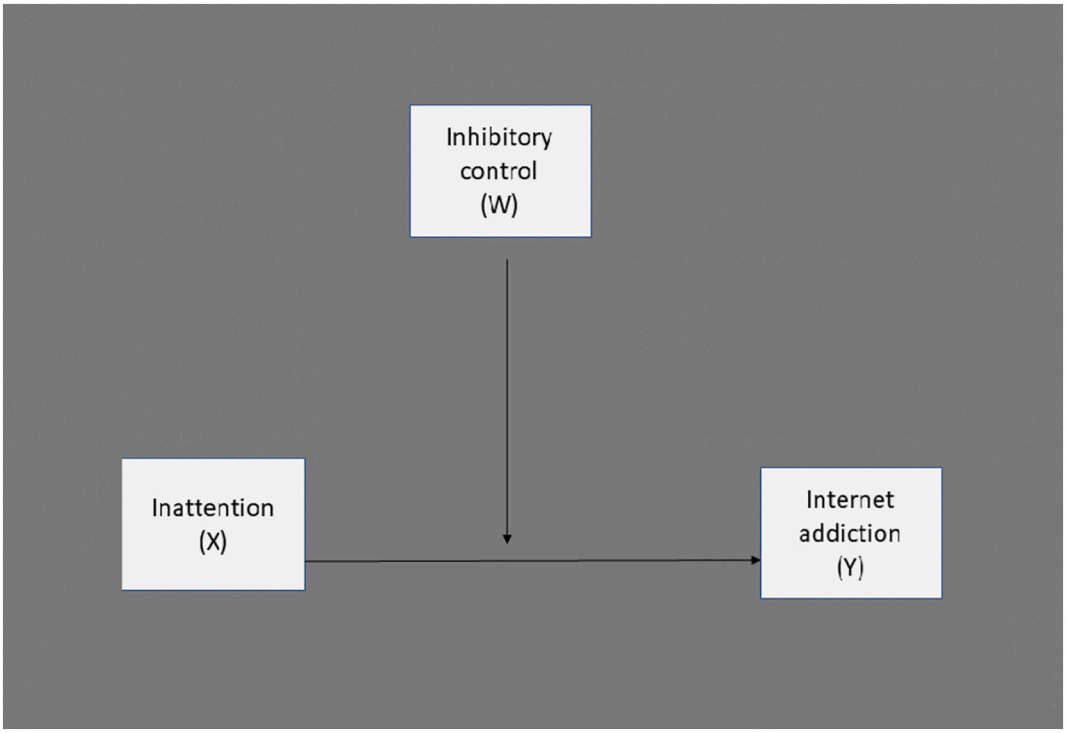

Fig. 3. Schematic of the moderation model.

Table 2
The moderation effect of inhibitory control when ADHD traits are predicting internet addiction.

Effect	β	*SE*	95 % Confidence Interval		*p*
			Lower Bound	*Upper Bound*	
Intercept	0.069	0.010	−0.136	0.275	0.50
Inattention	0.486	0.013	0.217	0.755	<0.01
Inhibitory control	0.022	0.013	−0.231	0.276	0.86
Inattention*Inhibitory control	0.427	0.014	−0.001	0.711	0.004
Hyperactivity/ impulsivity	−0.063	0.014	−0.336	0.210	0.65

Note: The coefficient here represents the standardized beta.

4. Discussion

The present study investigated the role of inhibitory control ability in IA and its association with ADHD symptoms in a community sample. Behavioral results showed there were no significant group differences in inhibitory control between low and high IA groups. Furthermore, inhibitory control was not different in low and high inattention groups. However, moderation analysis revealed inhibitory control moderated the observed relationship between inattention and IA in those with moderate and high inhibitory control impairments. The findings help us to understand how inhibitory control plays a role in IA.

4.1. Correlations between ADHD symptoms and IA

We found both total ADHD score and inattention score were correlated with IA. The result is in line with the current literature reporting similar relationships (Panagiotidi & Overton, 2018; Zhang et al., 2022). In contrast to the previous findings (Aydin et al., 2023), HI was not

correlated with IA. There are many studies in the current literature suggesting relationship between HI and IA (Dundar & Karabicak, 2022; Panagiotidi & Overton, 2018). The fact that our sample consisted of individuals who have low ADHD symptom scores (Mean = 39.68) and mild IA (range from 12 to 64), may be a factor in obtaining a different results from the existing literature; previous studies consisted of individuals with higher ADHD symptom scores (e.g., Mean = 51.16; Kim, Lee, Lee, Namkoong, & Jung, 2017) and more severe IA scores (e.g., range 5 to 81; Panagiotidi & Overton, 2018). Another reason may be that impulsivity decreases from childhood to adulthood, while inattention persist with age (Yen, Yen, Chen, Tang, & Ko, 2009). Considering that our aim was to address the relationship between IA and the trait level of ADHD in the general population as opposed to the clinical population, our study once again supports the conclusion that inattention symptoms in non-clinically diagnosed individuals can be related to IA severity.

4.2. RTs and PDs differences between low and high IA groups

The behavioral and pupillometry data revealed inhibitory control performance did not differ between high and low subclinical levels of IA. As with many previous studies (Dong et al., 2011;Dong et al., 2012 ; Shafiee-Kandjani et al., 2019), our study used the Stroop task to measure inhibitory control. Previous research has also reported IA is not related to performance on the Stroop Task (Dong et al., 2012; Shafiee-Kandjani et al., 2019), but IA seems to be related to significant performance deficits in Backward Digit Span and Letter Number Sequencing Task (Shafiee-Kandjani et al., 2019), the Stop signal task (Zhou, Zhang, Li, Xue, & Zhang-James, 2020), the Trail-Making Tests-B (Tekin, Yetkin, Adıgüzel, & Akman, 2018), and Go/NoGo task (Qi et al., 2022; Zhou, Zhu, Li, & Wang, 2014). However, it has also been reported IA is associated with better performance in the Go/NoGo task (Qi et al., 2022) in contrast to another studies finding performance deficits (Zhou et al., 2014) or no performance difference (Vargas et al., 2019) and importantly for present purposes those with IA exhibited worse performance (longer RTs) in the Stroop task (Dong et al., 2011; Tekin et al., 2018). Thus, there seems to be inconsistency in the relationship between IA and inhibitory control in the current literature.

4.3. RTs and PDs differences between inattention groups

The behavioral and pupillometry data indicated there were no performance difference between high and low subclinical levels of inattention. Consistently, in a community sample, researchers did not find any significant differences between low and high ADHD symptomology groups based on results of behavioral or neural correlates in a new hybrid Flanker Go/NoGo task (Hislop, 2022). However, the results (Çelik, Küçükgöncü, Erdoğan, & Özerdem, 2023) appear to be different in those with clinically diagnosed ADHD. However, to highlight inconsistencies in the literature, another study using the Stop-signal task and Stroop task found while adults with ADHD have worse performance in the Stop-signal task compared to controls, there was no performance difference on Stroop task (Çelik et al., 2023). The result from the present study is consistent with other studies considering subclinical levels of ADHD symptoms (Hislop, 2022) indicating inhibitory control problems are present in clinical but not non-clinical, trait-level ADHD. Nonetheless, it should not be forgotten cognitive impairments are not always seen at the clinical level (Mattfeld et al., 2016).

4.4. The moderating role of inhibitory control in the relation between inattention and IA

Contrary to research indicating decreased inhibitory control in IA (Dong et al., 2011; Tekin et al., 2018) and ADHD (Silva et al., 2013), this study indicated that inhibitory control does not have a direct relationship with either inattention or IA. Research investigating whether motivational or executive dysfunction in ADHD predicts IA concluded motivational but not executive dysfunction in ADHD is predictor of IA (Zhou et al., 2020). Importantly however the present data revealed a moderating role of inhibitory control in the relation between inattention and IA in which IA and inattention are related only in adults who experience high and moderate inhibitory control deficits but not those who do not.

The Implications of Future Research

Considering that the participants in the study were from a non-clinically diagnosed sample, it is recommended this relationship be examined those with clinical diagnosed ADHD. Furthermore, since most of the participants in the present study were females, the study should be replicated with a male participant group especially given that males with ADHD might show greater deficiencies in attention functioning (Bálint et al., 2009). Moreover, in this study, internet addiction was investigated as a broad concept and not at the level of granularity at which other studies have considered i.e., at the actual activity level. It has been shown that each of the core symptoms of ADHD may show a distinct relationship with different kinds of online activity (Zhang et al., 2022). Therefore, it is recommended that future research investigates the relationship between internet addiction, inattention symptoms, and the more fine-grained level of online activities in adults.

Inhibition has been argued to include at least two discrete but connected functions: response inhibition and interference control (Diamond, 2013). Whilst we attempted to measure response conflict and the more cognitive, non-behavioral semantic conflict, it could be argued we examined only the interference control component using the Stroop task (Nigg, 2000, 2017). Therefore, future research should employ tasks that more clearly target these two different functions.

The novel finding of a role for inhibitory control in this relationship between the ADHD symptom of inattention and IA could indicates new treatment strategies for both disorders. Furthermore, by examining the relationship between trait level inattention and severe IA from an inhibitory control perspective, precautions could be taken to prevent the development of severe IA in healthy adults.

5. Conclusion

This study is first study to examine the relation between inattention and IA from an inhibitory control perspective. Despite neither inattention nor IA being associated with inhibitory control impairments, the relationship between inattention and IA was shown to be moderated by inhibitory control performance.

CRediT authorship contribution statement

Tuba Aydin: Conceptualization, Data curation, Methodology, Formal analysis, Writing – original draft. **Gizem Arabaci:** Conceptualization, Data curation, Methodology, Project administration, Supervision, Writing – review & editing. **Marina Kilintari:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Jacqui Taylor:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Benjamin A. Parris:** Conceptualization, Methodology, Project administration, Supervision, Writing – review & editing.

Data availability

Data will be made available on request.

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Declaration of interest

None.

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Ethics

Ethical approval was received from Bournemouth University Ethic Committee (ID:46038).

References

Arabaci, G., & Parris, B. A. (2018). Probe-caught spontaneous and deliberate mind wandering in relation to self-reported inattentive, hyperactive and impulsive traits in adults. *Scientific Reports, 8*(1), 4113. https://doi.org/10.1038/s41598-018-22390-x

Arildskov, T. W., Sonuga-Barke, E. J. S., Thomsen, P. H., Virring, A., & Østergaard, S. D. (2022). How much impairment is required for ADHD? No evidence of a discrete threshold. *Journal of Child Psychology and Psychiatry, 63*(2), 229–237. https://doi.org/10.1111/jcpp.13440

Aydin, T., Parris, B. A., Arabaci, G., Kilintari, M., & Taylor, J. (2023). Trait-level non-clinical ADHD symptoms in a community sample and their association with technology addictions. *Current Psychology*. https://doi.org/10.1007/s12144-023-05203-x

Bálint, S., Czobor, P., Komlósi, S., Meszaros, A., Simon, V., & Bitter, I. (2009). Attention deficit hyperactivity disorder (ADHD): Gender-and age-related differences in neurocognition. *Psychological Medicine, 39*(8), 1337–1345.

Barkley, R. A. (2022). Improving clinical diagnosis using the executive functioning—Self-regulation theory of ADHD. *The ADHD Report, 30*(1), 1–9. https://doi.org/10.1521/adhd.2022.30.1.1

Çelik, H. E. A., Küçükgöncü, S., Erdoğan, A., & Özerdem, A. (2023). Response inhibition and interference control in adult attention deficit hyperactivity disorder. *Noro Psikiyatri Arsivi, 60*(1), 3–8. https://doi.org/10.29399/npa.28192

Cristofori, I., Cohen-Zimerman, S., & Grafman, J. (2019). *Executive functions. Handbook of clinical neurology, 163*, 197–219. https://doi.org/10.1016/b978-0-12-804281-6.00011-2

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*, 135. https://doi.org/10.1146/annurev-psych-113011-143750

Dogruer, N., Eyyam, R., & Menevis, I. (2011). The use of the internet for educational purposes. *Procedia-Social and Behavioral Sciences, 28*, 606–611. https://doi.org/10.1016/j.sbspro.2011.11.115

Dong, G., DeVito, E. E., Du, X., & Cui, Z. (2012). Impaired inhibitory control in 'internet addiction disorder': A functional magnetic resonance imaging study. *Psychiatry Research: Neuroimaging, 203*(2–3), 153–158. https://doi.org/10.1016/j.pscychresns.2012.02.001

Dong, G., Zhou, H., & Zhao, X. (2011). Male internet addicts show impaired executive control ability: Evidence from a color-word Stroop task. *Neuroscience Letters, 499*(2), 114–118. https://doi.org/10.1016/j.neulet.2011.05.047

Dundar, C., & Karabicak, C. (2022). Problematic internet use associated with attention deficit hyperactivity disorder in Turkish college students. *Erciyes Medical Journal, 44*(2), 143–148. https://doi.org/10.14744/etd.2021.58159

Dunlop, B. W., Wu, R., & Helms, K. (2018). Performance of the adult ADHD self-report scale-v1.1 in adults with major depressive disorder. *Behav Sci (Basel), 8*(4). https://doi.org/10.3390/bs8040037

Elisa, R. N., Balaguer-Ballester, E., & Parris, B. A. (2016). Inattention, working memory, and goal neglect in a community sample. *Frontiers in Psychology, 7*, 1428. https://doi.org/10.3389/fpsyg.2016.01428

Greenblum, M. (2023). *The impact of ADHD on quality of life and peer relations in college students.* [Bachelor's thesis, Oregon State University]. https://ir.library.oregonstate.edu/concern/honors_college_theses/6h441256n.

Gudlavallety, P., Radham, R., & Gurnule, S. R. (2023). Prevalence of internet addiction and associated psychiatric comorbidities in medical students. *Swiss Archives of Neurology, Psychiatry and Psychotherapy, 174*(01), 9–13. https://doi.org/10.4414/sanp.2023.03289

Güzel, N., Kahveci, İ., Solak, N., Cömert, M., & Turan, F. N. (2018). Internet addiction and its impact on physical health. *Turkish medical student journal, 5*(2), 32–36. https://doi.org/10.4274/tmsj.2018.05.03.0002

Hasshim, N., & Parris, B. A. (2015). Assessing stimulus–stimulus (semantic) conflict in the Stroop task using saccadic two-to-one color response mapping and preresponse pupillary measures. *Attention, Perception, & Psychophysics, 77*, 2601–2610. https://doi.org/10.3758/s13414-015-0971-9

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach.* New York, NY: Guilford Press.

Hislop, I. M. (2022). *ERP correlates of interference and inhibitory control in adults with high and low-level subclinical ADHD symptoms* (Doctoral dissertation,. University Of Tasmania.

Islam, M. R., Apu, M. M. H., Akter, R., Tultul, P. S., Anjum, R., Nahar, Z., … Bhuiyan, M. A. (2023). Internet addiction and loneliness among school-going adolescents in Bangladesh in the context of the COVID-19 pandemic: Findings from a cross-sectional study. *Heliyon, 9*(2). https://doi.org/10.1016/j.heliyon.2023.e13340

Kandre, D., Patel, A., & Mehta, P. I. (2020). Analytical study of adult attention deficit hyperactivity disorder symptoms and internet addiction among medical students. *Neuropsychiatria i Neuropsychologia/Neuropsychiatry and Neuropsychology, 15*(1), 7–12. https://doi.org/10.5114/nan.2020.97398

Kian, N., Samieefar, N., & Rezaei, N. (2022). Prenatal risk factors and genetic causes of ADHD in children. *World Journal of Pediatrics, 18*(5), 308–319. https://doi.org/10.1007/s12519-022-00524-6

Kim, D., Lee, D., Lee, J., Namkoong, K., & Jung, Y.-C. (2017). Association between childhood and adult attention deficit hyperactivity disorder symptoms in Korean young adults with internet addiction. *Journal of Behavioral Addictions, 6*(3), 345–353. https://doi.org/10.1556/2006.6.2017.044

Laeng, B., Ørbo, M., Holmlund, T., & Miozzo, M. (2011). Pupillary stroop effects. *Cognitive Processing, 12*, 13–21. https://doi.org/10.1007/s10339-010-0370-z

Mathôt, S., Fabius, J., Van Heusden, E., & Van der Stigchel, S. (2018). Safe and sensible preprocessing and baseline correction of pupil-size data. *Behavior Research Methods, 50*, 94–106. https://doi.org/10.3758/s13428-017-1007-2

Mattfeld, A. T., Whitfield-Gabrieli, S., Biederman, J., Spencer, T., Brown, A., Fried, R., & Gabrieli, J. D. E. (2016). Dissociation of working memory impairments and attention-deficit/hyperactivity disorder in the brain. *NeuroImage: Clinical, 10*, 274–282. https://doi.org/10.1016/j.nicl.2015.12.003

Meng, S. Q., Cheng, J. L., Li, Y. Y., Yang, X. Q., Zheng, J. W., Chang, X. W., … Shi, J. (2022). Global prevalence of digital addiction in general population: A systematic review and meta-analysis. *Clinical Psychology Review, 92*, Article 102128. https://doi.org/10.1016/j.cpr.2022.102128

Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., & Keshri, A. (2019). Descriptive statistics and normality tests for statistical data. *Annals of Cardiac Anaesthesia, 22*(1), 67–72. https://doi.org/10.4103/aca.ACA_157_18

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin, 126*(2), 220.

Nigg, J. T. (2017). Annual research review: On the relations among self-regulation, self-control, executive functioning, effortful control, cognitive control, impulsivity, risk-taking, and inhibition for developmental psychopathology. *Journal of Child Psychology and Psychiatry, 58*(4), 361–383.

Norman, L. J., Sudre, G., Price, J., Shastri, G. G., & Shaw, P. (2023). Evidence from "big data" for the default-mode hypothesis of ADHD: A mega-analysis of multiple large samples. *Neuropsychopharmacology, 48*(2), 281–289. https://doi.org/10.1038/s41386-022-01408-z

Panagiotidi, M., & Overton, P. (2018). The relationship between internet addiction, attention deficit hyperactivity symptoms and online activities in adults. *Comprehensive Psychiatry, 87*, 7–11. https://doi.org/10.1016/j.comppsych.2018.08.004

Parris, B. A., Hasshim, N., & Dienes, Z. (2021). Look into my eyes: Pupillometry reveals that a post-hypnotic suggestion for word blindness reduces Stroop interference by marshalling greater effortful control. *European Journal of Neuroscience, 53*(8), 2819–2834. https://doi.org/10.1111/ejn.15105

Parris, B. A., Hasshim, N., Wadsley, M., Augustinova, M., & Ferrand, L. (2022). The loci of Stroop effects: A critical review of methods and evidence for levels of processing contributing to color-word Stroop effects and the implications for the loci of attentional selection. *Psychological Research, 86*(4), 1029–1053. https://doi.org/10.1007/s00426-021-01554-x

Potenza, M. N. (2014). Non-substance addictive behaviors in the context of DSM-5. *Addictive Behaviors, 39*(1), 1–2. https://doi.org/10.1016/j.addbeh.2013.09.004

Qi, Y., Liu, Y., Yan, Z., Hu, S., Zhang, X., Zhao, J., … He, Q. (2022). Slow-wave EEG activity correlates with impaired inhibitory control in internet addiction disorder. *International Journal of Environmental Research and Public Health, 19*(5), 2686. https://doi.org/10.3390/ijerph19052686

Rosso, G., Portaluppi, C., Teobaldi, E., Di Salvo, G., & Maina, G. (2023). Assessing adult ADHD through objective neuropsychological measures: A critical overview. *Journal of Attention Disorders, 27*(7), 786–794. https://doi.org/10.1177/10870547231167564

Sergeant, J. A. (2005). Modeling attention-deficit/hyperactivity disorder: A critical appraisal of the cognitive-energetic model. *Biological Psychiatry, 57*(11), 1248–1255. https://doi.org/10.1016/j.biopsych.2004.09.010

Shafiee-Kandjani, A. R., Mohammadzadeh, Z., Amiri, S., Asghar, A., Sarbakhsh, P., & Salman, S. (2019). Attention, working memory and executive functions in patients with internet addiction disorder. *Journal of Injury and Violence Research, 11*(4 Suppl 2).

Silva, K. L., Guimarães-da-Silva, P. O., Grevet, E. H., Victor, M. M., Salgado, C. A. I., Vitola, E. S., … Picon, F. A. (2013). Cognitive deficits in adults with ADHD go beyond comorbidity effects. *Journal of Attention Disorders, 17*(6), 483–488. https://doi.org/10.1177/1087054711434155

Sun, J.-T., Hu, B., Chen, T.-Q., Chen, Z.-H., Shang, Y.-X., Li, Y.-T., … Wang, W. (2023). Internet addiction-induced brain structure and function alterations: A systematic review and meta-analysis of voxel-based morphometry and resting-state functional connectivity studies. *Brain Imaging and Behavior, 17*(3), 329–342. https://doi.org/10.1007/s11682-023-00762-w

Tekin, A., Yetkin, A., Adıgüzel, S., & Akman, H. (2018). Evaluation of Stroop and trail-making tests performance in university students with internet addiction. *Anatolian Journal of Psychiatry, 19*(6), 593–598. https://doi.org/10.5455/apd.292389

VanderWeele, T. J. (2016). Mediation analysis: A practitioner's guide. *Annual Review of Public Health, 37*, 17–32. https://doi.org/10.1146/annurev-publhealth-032315-021402

Vargas, T., Maloney, J., Gupta, T., Damme, K. S. F., Kelley, N. J., & Mittal, V. A. (2019). Measuring facets of reward sensitivity, inhibition, and impulse control in individuals with problematic internet use. *Psychiatry Research, 275*, 351–358. https://doi.org/10.1016/j.psychres.2019.03.032

Wang, B.-q., Yao, N.-q., Zhou, X., Liu, J., & Lv, Z.-t. (2017). The association between attention deficit/hyperactivity disorder and internet addiction: A systematic review and meta-analysis. BMC Psychiatry, 17(1), 1–12. doi:https://doi.org/10.1186/s12888-017-1408-x.

World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. (2013). *Jama, 310*(20), 2191–2194. https://doi.org/10.1001/jama.2013.281053

Yen, J.-Y., Yen, C.-F., Chen, C.-S., Tang, T.-C., & Ko, C.-H. (2009). The association between adult ADHD symptoms and internet addiction among college students: The gender difference. *Cyberpsychology & Behavior, 12*(2), 187–191. https://doi.org/10.1089/cpb.2008.0113

Young, K., Pistner, M., O'Mara, J., & Buchanan, J. (1999). Cyber disorders: The mental health concern for the new millennium. *Cyberpsychology & Behavior, 2*(5), 475–479. https://doi.org/10.1089/cpb.1999.2.475

Young, K. S. (2009). *Internet addiction test* (Center for on-line addictions).

Zhang, W., Jiang, X., Yang, L., & Zhu, W. (2022). Adult attention deficit and hyperactivity disorder symptoms and internet addiction in college students: Prevalence and differential associations. *European Journal of Psychology and Educational Research, 5*(1), 33–43. https://doi.org/10.12973/ejper.5.1.33

Zhou, B., Zhang, W., Li, Y., Xue, J., & Zhang-James, Y. (2020). Motivational but not executive dysfunction in attention deficit/hyperactivity disorder predicts internet addiction: Evidence from a longitudinal study. *Psychiatry Research, 285*, Article 112814. https://doi.org/10.1016/j.psychres.2020.112814

Zhou, Z., Zhu, H., Li, C., & Wang, J. (2014). Internet addictive individuals share impulsivity and executive dysfunction with alcohol-dependent patients. *Frontiers in Behavioral Neuroscience, 8*, 288. https://doi.org/10.3389/fnbeh.2014.00288