

A preliminary study into internet related addictions among adults with dyslexia
 --Manuscript Draft--

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Short Title:	Internet related addictions among adults with dyslexia
Corresponding Author:	Sophie Jackson, Ph.D Birmingham City University Birmingham, UNITED KINGDOM
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Abstract:	In recent decades, studies have investigated associations between learning disorders such as Autism Spectrum Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD), and the various types of internet addictions, ranging from general internet addiction (GIA) to specific internet addictions such as social media addiction (SMA) and internet gaming disorder (IGD). However, to date, no study has investigated such internet addictions among persons with dyslexia. The present study aimed to investigate whether differences exist between adults with dyslexia and controls in terms of GIA, SMA and IGD. A total of 141 adults with dyslexia and 150 controls (all UK based) were recruited. Controlling for age, gender, marital status, employment, and income levels, it was found that adults with dyslexia had higher levels of GIA and IGD compared to controls. However, these participants did not show any significant difference in terms of SMA. The results indicate that internet addictions may have a larger ambit for learning disorders beyond just ASD and ADHD and could be a hidden problem for these individuals.
Order of Authors:	Sophie Jackson, Ph.D Suresh Kumar, MSc Dominic Petronzi, PhD
Opposed Reviewers:	
Response to Reviewers:	<p>We would like to thank the reviewers for their comments, which have helped improve the manuscript. Please see our categorical responses in red to the comments from both the reviewers. Please note in addition to these changes suggested by the reviewers we have also made some grammar and proof reading amendments.</p> <p>Response set 1 1.0 Reviewer #1: The manuscript describes a technically sound piece of scientific research with data that supports almost all conclusions. The data provided supports almost all conclusions, as noted in the review, data considering age is required from Authors. The manuscript is presented in an intelligible fashion and written in standard English. We thank the reviewer for their kind comments. Age is now included see lines 284-285.</p> <p>Response set 2 Introduction 2.1 Page 3: "There are several reasons to suspect that dyslexia might be associated with these types of additions." The authors should further explain in the manuscript what they mean by several reasons. This has been edited in order to make it clear that reason the link is likely is because research shows this relationship in other similar populations, please see lines 76-78.</p> <p>2.2 Page 4, paragraph 2: The Authors explain how mental health issues as consequences of ASD and ADHD may lead to internet addictions. In order to do so,</p>

they line up articles about anxiety, depression and low self-esteem in children with ASD and ADHD, and depression and anxiety as antecedent factors for internet related addictions. Importantly, the Authors base their hypotheses on these associations, as they imply that there is a similar association between dyslexia and internet related addictions. A more thorough explanation of how learning disabilities and internet related addictions might be associated is necessary, especially that the current data focuses on adults and some of the literature is about children.

We thank the reviewer for this comment and believe the changes we have made in order to address this have strengthened this section of the manuscript. See lines 82 to 94 and 96 to 109.

2.3 Page 4, paragraph 3: A thorough and well written explanation about how SMA and dyslexia might be associated is presented. This would be necessary in the previous paragraph as well.

We believe that the changes that we have made to address the previous point have also addressed this. Additionally, we have now made some changes including a re-ordering of paragraphs in order to make our arguments clearer (see lines 183 to 229).

2.4 Page 6, paragraph 1: "Yet coping strategies may help mitigate the challenges and therefore research is needed to identify if those with dyslexia are susceptible to SMA, in the same way that those with ADHD are." The Authors do not show literature or research on the comparison between ADHD and dyslexia, thus I suggest to take this comparison out.

This comparison has been removed.

2.5 Page 7, present study: Addiction is twice spelled as 'addition', please correct.

This has been corrected in lines 65, 67, 77, 85, 94, 242, 252, 253 and 577.

Methods

2.6 Page 8, participants: Authors state that all participants, including participants with dyslexia have no active mental health issues, however the assumption that dyslexia is relatable to internet addiction lies on the fact that people with dyslexia have higher levels of anxiety and depression. Was this controlled in the Prolific survey platform, and if so, how?

We acknowledge this point, which is a good one. Anxiety and depression may present as comorbid conditions with dyslexia but not always, and for this preliminary paper, to avoid confounding effects, we limited participation only to those who do not have active mental health. This said, it is certainly possible that in our sample anxiety and depression could be presenting at sub-clinical levels or be undiagnosed and therefore serve as partial mediators or moderators. However, as this is a preliminary study this goes beyond the scope of but paper. We do however, discuss this as potential areas for future research in the discussion and this section has been expanded for clarity see lines 579 to 583.

2.7 Page 9, sociodemographic characteristics of participants: Please provide age of participants as well.

Age is now included in lines 284- 285.

2.8 Page 9, sociodemographic characteristics of participants: Data is fitted according to marital status, income, education and employment, however gender is not balanced, as male participants are almost double (n=186) compared to female (n=100). If this is a general sociodemographic ratio, it would be important to mention this in the introduction and how it might effect the association between learning disabilities, mental health issues and internet addiction.

We agree with the reviewer. Gender/socio-demographics were already discussed in the introduction. However, this section has been expanded in light of this comment (see lines 239 – 246). Additionally, gender was controlled for in the study to ensure outcomes are not influenced by this

2.9 Page 11: Suggestion to use 'Analyses' instead of 'Analytical strategies' as subtitle.

Corrected to 'Analyses' (see line 350).

Results

2.10 Page 12, Descriptive statistics and data screening: Descriptive statistics show that both dyslexia and control group fall into the 'mild' IA category, and neither group falls into the pathological category in either IGD or SMA. This is problematic, because in later phases of the manuscript, Authors state that dyslexia is related to IGD and IA, however IA is only mild for both groups, and IGD doesn't reach pathological levels in neither of the two groups.

Although we agree with the reviewer's sentiment, here we are consistent with the approach in the literature, in that such addictions are not categorical (addicted vs not addicted) but rather that such addictions lie on a dimension/continuum. Hence it is the levels of addictions that are being compared. Thus, for both scales, the higher the score, the higher the addictive behavior. However, in order to acknowledge the reviewer's point we have added in a caveat to the discussion and toned our conclusion down somewhat (see lines 551-559).

2.11 The authors imply that the dyslexia group shows higher results in all three scales, however with the standard deviations in mind, the two groups are highly overlapping, differences are only statistically significant after square root transformations, which is explained later. These significant differences don't imply that participants with dyslexia have IGD. Other than the comment above, results are clearly written and well explained.

We agree with the reviewer's caution here. In addition to the above caveat, we have added a further caveat which we hope the reviewer feels addresses this point (line 565.)

2.12 Page 13, line 15: please correct 'score' to score

Amended in line 387.

Discussion

2.13 Page 19 paragraph 2: it is not clear from the manuscript what the Authors mean by 'hidden problem' particularly for people with learning disabilities. Please explain this a bit more in the introduction and the discussion of the manuscript.

We agree with the reviewer that phrasing was confusing, we have therefore changed it for clarity (see line 551).

2.14 Page 20, paragraph 2: IGD scores are higher for participants with dyslexia, however concerning the level of scores on the scales, it seems slightly far-fetched to state that it is related to an actual addiction.

Here we are arguing that there is a statistical difference in terms of levels of IGD between both groups, with the scales suggesting that higher scores are indicative of higher levels of addiction. For clarity on this we have added the word "levels" to line 565.

2.15 Page 20, paragraph 2: "Hence further attention is warranted because if significant relationships between dyslexia and GIA, SMA and IGD are detected early, then

interventions can be undertaken to manage such problems for this group.”. Importantly, this preliminary study SMA was not higher for participants with dyslexia, therefore it is suggested to exclude it from this assumption.

SMA has now been removed in line 599.

Response set 3

Introduction:

3.1. Introduction should include a clear definition of dyslexia.

We had already included a definition, but we have rewritten the sentence for clarity (see lines 71-74).

3.2 The authors state that there are diverse results on the relationship between SMA and ASD. Could it be due to the different age groups (and probably different severity of the condition) used in the cited studies (children vs adolescents vs adults), and that different age groups use social media for different purposes? Moreover, it seems to be reasonable that for adults with ASD using written online communication to connect others might be more convenient than for example a phone call or a personal contact. The section on ASD and SMA has now been expanded to address these comments (see lines 104-109).

Methods and results:

3.3. Did the authors check the presence of dysgraphia as well? As persons with dysgraphia might have also serious difficulties with typing in addition to the handwriting, one can hypothesize that this condition is also related to problematic internet and social media usage. Moreover, as authors argue that dyslexia affects writing and spelling skills, the simultaneous presence of dysgraphia (which is quite common) could enhance anxiety when using social media based on writing. This was outside of the scope of the current preliminary study. However, as the reviewer states, this certainly warrants future investigation. We have therefore added a discussion of this see lines 587-592.

3.4. Page 9, Table 1: how can be the percentage of the widowed/divorced participants 829% of the sample? I think that this might be a typo.

This was a typo error it now reads 8 (see Table 1 in line 299).

3.5 Page 12: What was the reason that SMA and IGD ($r=.49$) were submitted into the MANOVA while there was a stronger correlation between GIA and SMA ($r=.77$)? Does IA and GIA refer to the same construct? If yes, these abbreviations should be consistent.

Pallant, (2020)'s recommendation is that “correlations up around .8 and .9” are reason for concern and that when this is the case you need to consider removing one variable. Hence, we felt that .77 was approaching .8 and it would be better to isolate GIA from SMA and IGD. We have made this decision clearer in the manuscript see lines 375-379.

In relation to the abbreviations. Indeed, IA and GIA are the same construct, and this was a consistency error. Changes have now been made to address this in lines 305, 375, 378.

3.6 - Page 13: $p = .05$ and $p = .11$ are not significant results of normality tests, suggesting that the distribution of the data met normality.

Here we meant after transformation. We agree with the reviewer that the previous wording was confusing and have therefore edited for clarity (see the paragraph beginning on line 388).

3.7 Do beta values reflect the differences between groups or do they reflect something else? The authors should clarify.

They reflect between groups; this has now been clarified in lines 403-405.

3.8 There are many inconsistencies in reporting results. When reporting p values, instead of $p = .00$ authors should report either the exact p value or $p < .001$.

This has been correct throughout the manuscript.

Similarly, authors either use partial ETA square or eta or partial eta in the manuscript. I think that the authors should be more consistent (especially if these expressions are the same), and that would be simpler and more parsimonious to use η^2p .

We agree and have changed to η^2p throughout.

3.9 - The authors argue that the lack of predicted effects might be due to the low level of statistical power of the study. Indeed, calculating post-hoc sensitivity analysis could better underpin this statement.

While post-hoc power analysis could provide exact power, its computation is complex (not estimable with G-power) and beyond the scope of this paper. We believe the reader would accept our argument that a marginally significant p value could become more significant with more participants, which was what we explicitly stated when we wrote in lines 548-549 "Future studies could test this relationship again with larger samples".

Discussion

3.10 - The authors argue that participants with dyslexia might use compensational strategies when using social media. Although some strategies (e.g., spelling and grammar check) are mentioned in the Introduction, it would be helpful to reflect to these strategies again in a more exact way.

A reference to this has now been added to the discussion (see lines 514-519).

3.11 - The authors also state that the type of social media (visual such as Instagram or TikTok) or verbal (such as Twitter or Facebook) might influence results. As there is mentioned in the Introduction that persons with dyslexia prefer YouTube videos for learning, I think that the potential role of the dominating type of social media platforms in the null effect should be emphasized more in in the manuscript.

A reference to this and short discussion has now been added to the discussion (see lines 514-520).

Minor comments

3.12 - Page 5: "Google" should be written instead of "Goggle"
Corrected in line 206.

3.13 Page 13: authors wrote "sccore" instead of "score"

Corrected in line 297.

3.14 The number of decimals is not consistent across the manuscript.

This has now been correct so that we always round to 2 decimal places.

3.15 Interactions would be easier to read in the format e.g., "age x dyslexia status" instead of "age by dyslexia status".

This has been corrected in lines 467, 468, 475.

3.16 - I suggest to write "Wilk's" instead of "Wilk".

This has been corrected throughout.

3.17 - There should be a space between the two degrees of freedom in ANOVA results.

This has been corrected throughout.

3.18 - Why did the authors apply both Shapiro-Wilk and Kolmogorov-Smirnov tests for normality testing while only one of these should be efficient? Furthermore, the full name of the tests should be marked at the first appearance in the text before using abbreviations.

Shapiro-Wilk test was retained, and the Kolmogorov-Smirnov test was removed. Additionally, the full name of the test was given at the first appearance (see line 389–394).

3.19 - Page 15: there is a missing "b" in "lambda".

Lambda has been corrected in lines 444-445.

Response set 4 (journal requirements)

4.1. Please ensure that your manuscript meets PLOS ONE's style requirements, including those for file naming. The PLOS ONE style templates can be found at https://journals.plos.org/plosone/s/file?id=wjVg/PLOOne_formatting_sample_main_body.pdf and https://journals.plos.org/plosone/s/file?id=ba62/PLOOne_formatting_sample_title_authors_affiliations.pdf

	<p>We have made some formatting changes to the manuscript so that formatting is in line with the PLOS ONE style templates. This includes changes to headings and tables.</p> <p>2. Please change "female" or "male" to "woman" or "man" as appropriate, when used as a noun (see for instance https://apastyle.apa.org/style-grammar-guidelines/bias-free-language/gender).</p> <p>These changes have been made throughout.</p> <p>3. Thank you for stating the following financial disclosure: "The cost of recruiting the participants was sponsored by a donor." At this time, please address the following queries:</p> <p>a) Please clarify the sources of funding (financial or material support) for your study. List the grants or organizations that supported your study, including funding received from your institution.</p> <p>b) State what role the funders took in the study. If the funders had no role in your study, please state: "The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript."</p> <p>c) If any authors received a salary from any of your funders, please state which authors and which funders.</p> <p>d) If you did not receive any funding for this study, please state: "The authors received no specific funding for this work."</p> <p>Please include your amended statements within your cover letter; we will change the online submission form on your behalf.</p> <p>These have been addressed in the cover letter.</p> <p>4. Thank you for stating the following in your Competing Interests section: "No potential conflict of interest was reported by the authors." Please complete your Competing Interests on the online submission form to state any Competing Interests. If you have no competing interests, please state "The authors have declared that no competing interests exist.", as detailed online in our guide for authors at http://journals.plos.org/plosone/s/submit-now This information should be included in your cover letter; we will change the online submission form on your behalf.</p> <p>This have been addressed in the cover letter.</p> <p>5. We note that you have indicated that data from this study are available upon request. PLOS only allows data to be available upon request if there are legal or ethical restrictions on sharing data publicly. For more information on unacceptable data access restrictions, please see http://journals.plos.org/plosone/s/data-availability#loc-unacceptable-data-access-restrictions.</p> <p>In your revised cover letter, please address the following prompts:</p> <p>a) If there are ethical or legal restrictions on sharing a de-identified data set, please explain them in detail (e.g., data contain potentially sensitive information, data are owned by a third-party organization, etc.) and who has imposed them (e.g., an ethics committee). Please also provide contact information for a data access committee, ethics committee, or other institutional body to which data requests may be sent.</p> <p>b) If there are no restrictions, please upload the minimal anonymized data set necessary to replicate your study findings as either Supporting Information files or to a stable, public repository and provide us with the relevant URLs, DOIs, or accession numbers. For a list of acceptable repositories, please see http://journals.plos.org/plosone/s/data-availability#loc-recommended-repositories.</p> <p>We will update your Data Availability statement on your behalf to reflect the information you provide.</p> <p>There are no restrictions and therefore we will upload the data set as a supporting information file.</p> <p>6. We note that you have stated that you will provide repository information for your data at acceptance. Should your manuscript be accepted for publication, we will hold it until you provide the relevant accession numbers or DOIs necessary to access your data. If you wish to make changes to your Data Availability statement, please describe these changes in your cover letter and we will update your Data Availability statement to reflect the information you provide.</p> <p>As outlined above we will now upload the data set as a supporting information file and this is outlined in the cover letter.</p>
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Question	Response
Financial Disclosure	Our study was funded by a private funder (Mr Bobby Lim). The funder had no role in

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The research was conducted in compliance with APA ethical standards and appropriate institutional approval was obtained from the University of Derby (ETH2122-1830). All participants were over 18 years old. Participants who signed up for the survey were given a link to Qualtrics where they read the participant information sheet before providing online written informed consent. Participants were guided to click the consent button to proceed to the online survey. They also agreed to the GDPR statement before generating a unique user code.

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- Indicate the form of consent obtained (written/oral) or the reason that consent was not obtained (e.g. the data were analyzed anonymously)

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11th November 2022

The Editor

PLOS ONE

Dear Sir/Madam,

A preliminary study into internet related addictions among adults with dyslexia

(Authors: Kumar, S, Jackson, S & Petronzi, D)

We are very pleased to submit a revised version of our manuscript. We were very thankful for reviewers' positive feedback and have made the minor changes suggested by them.

We respond to each comment in turn, and adjustments are shown in track changes in the revised manuscript. We will now also upload the anonymous data set as a supporting information file. We believe that the revised manuscript addresses the reviewers' comments and should be now of significant interest to the readers of PLOS ONE.

Our study was funded by a private funder (Mr Bobby Lim). The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript and none of the authors receive a salary from this funder. In addition, the authors have declared that no competing interests exist.

Yours faithfully

A handwritten signature in black ink, appearing to read 'S. Jackson', written in a cursive style.

Dr Sophie Jackson

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1 A preliminary study into internet related addictions among
2 adults with dyslexia

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34 **Abstract**

35 In recent decades, studies have investigated associations between learning
36 disorders such as Autism Spectrum Disorder (ASD) and Attention Deficit
37 Hyperactivity Disorder (ADHD), and the various types of internet addictions, ranging
38 from general internet addiction (GIA) to specific internet addictions such as social
39 media addiction (SMA) and internet gaming disorder (IGD). However, to date, no
40 study has investigated such internet addictions among persons with dyslexia. The
41 present study aimed to investigate whether differences exist between adults with
42 dyslexia and controls in terms of GIA, SMA and IGD. A total of 141 adults with
43 dyslexia and 150 controls (all UK based) were recruited. Controlling for age, gender,
44 marital status, employment, and income levels, it was found that adults with dyslexia
45 had higher levels of GIA and IGD compared to controls. However, these participants
46 did not show any significant difference in terms of SMA. The results indicate that
47 internet addictions may have a larger ambit for learning disorders beyond just ASD
48 and ADHD and could be a hidden problem for these individuals.

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Introduction

56

57 The internet continues to be a popular platform for information seeking, education and
58 entertainment, in addition to social interaction and online games. However, there are
59 concerns over addictive usage among a minority of users, this includes those with
60 learning disabilities (1). Such an addiction has been defined as General Internet
61 Addiction (GIA) and includes a preoccupation with internet activities at the expense of
62 important daily activities such as schoolwork, occupation, relationships, and personal
63 health (2). These addictions can also be unique to social networking or social media
64 (named Social Media Addiction; SMA; 3), or exclusive to internet games, known as
65 Internet Gaming Disorder (IGD; 4). There is much literature suggesting that all these
66 forms of addictions are high in those with learning disorders but notably, much of this
67 literature has focused solely on those with Autism Spectrum Disorder (ASD) and
68 Attention Deficit Hyperactivity Disorder (ADHD) (5) Indeed, to date, no study has
69 investigated such internet addictions among persons with dyslexia, a condition
70 characterised by deficits in word decoding, spelling, reading fluency and
71 comprehension (7) and which accounts for 10-15% of the UK population (6).

72

73 It is likely that dyslexia might be associated with these types of addictions because a
74 growing body of evidence suggests that individuals with learning disabilities are
75 especially vulnerable to internet addictions compared to their typically developing
76 peers. For instance, studies have found a significant association between General
77 Internet Addiction (GIA) and both ASD (8) and ADHD (9). Similarly, Internet Gaming
78 Disorder (IGD) has also been associated with ASD (10) and ADHD (11). In ASD this
79 may be due to restricted and repetitive interests (a core symptom of ASD) leading to
80 difficulties in disengaging from video games or time spent on the internet and therefore

81 an addictions (10). In addition, the low social demands and audio-visual and structural
82 characteristics of the internet and games may further add to the appeal (11). In ADHD,
83 being bored easily and an aversion for delayed reward are two key symptoms and
84 therefore the internet and gaming may be especially appealing to these individuals,
85 and it provides a variety of activities, many with instant rewards (9). Additionally,
86 neurological research has found abnormal brain activities in both those with ASD and
87 ADHD which lead to impaired inhibition and lack of self-control ability (9; 12). Given
88 that those with dyslexia also show impairments on a range of executive functions,
89 including inhibition and self-control (13; 14), links to internet related addictions are
90 likely.

91

92 Research also shows a significant link between Social Media Addiction (SMA) and
93 ADHD (15), again perhaps because of the instant rewards social media can offer such
94 as 'likes' from peers and other users. Yet the relationships between SMA and ASD is
95 unclear; while one study (16) found that children with ASD (n = 202) spent less time
96 on social media than their typically developing siblings (n = 179), another study found
97 no difference in time spent on social media among adolescents with and without
98 ASD (ASD n = 24, control n = 26) (17). Meanwhile, another study found that the
99 majority of adults with ASD used social media to connect with others (18) perhaps
100 because they find social engagement through the written form more appealing and
101 less challenging than engaging with peers orally such as face-to-face or over the
102 phone, something that may not be the case for those with dyslexia. Yet, these
103 contrasting findings are perhaps due to age differences and the fact that children,
104 adolescents, and adults may use social media for different purposes.

105

106 Despite some contradictory findings regarding SMA and ASD, taken together these
107 research studies clearly highlight a link between ASD and ADHD and internet-based
108 addiction . In addition to the ones already discussed, another explanation for this link
109 may be due to ASD and ADHD triggering mental health conditions which are in turn a
110 risk factor for internet addictions. For instance, ASD has reportedly induced anxiety
111 (19), which is an antecedent for internet-related addictions (20, 21, 22). Similarly,
112 children with ADHD present with anxiety, depression, and poor self-esteem (23, 24,
113 25). As dyslexia also triggers similar mental health issues, such as anxiety and low
114 self-esteem (26), a similar relationship may exist between dyslexia GIA, IGD and SMA.

115

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117 The link between dyslexia and internet gaming seems likely. This is because online
118 games typically do not involve writing and thus have fewer spelling demands.. It is
119 logical to suggest therefore that such an environment would be highly appealing to
120 those with dyslexia. For instance, some studies aimed at using video games as
121 interventions for those with dyslexia have demonstrated that action video games
122 provide a rewarding experience that reinforces the engagement for users with dyslexia
123 (27, 28). However, if this leads to high prevalence of IGD in this population is
124 something which has yet to be explored. Hence this was akey aim of the present study.

125

126 On the other hand, the link between SMA and dyslexia is harder to explain as there is
127 some evidence that suggests barriers for usage of social media. For example, the
128 spelling deficits and comprehension difficulties associated with dyslexia may make

129 using social media extremely challenging. Indeed, a study on how students (n = 40)
130 used a library information system (without spelling support) showed that spelling
131 deficits hampered those with dyslexia as compared to typically developing peers, with
132 users with dyslexia spending more time searching compared to their peers (29).
133 Moreover, another study (30) reported that 48% of participants with dyslexia (n = 67)
134 received significantly more peer negative feedback on their social media posts as
135 compared to about 22% of controls (n = 404). They cited spelling as the main reason
136 why writing was harder than reading on social media sites (31). Similarly,
137 comprehending or integrating information when presented in various formats is a
138 common challenge for those with dyslexia and one that could create problems when
139 using social media. In a study of tenth-grade Norwegians (n = 44), it was found that
140 typically developing individuals outperformed participants with dyslexia on
141 synthesizing information across different web pages (32). Likewise, studies (e.g., 33)
142 have shown that when information is presented in different formats (text, images,
143 videos etc) on a page with use of cluttered spacing, variety of colours, multiple
144 columns, and lengthy sentences without bullet points, which can be common on social
145 media sites, this could be difficult for persons with dyslexia to follow (34, 35).

146 Nonetheless, while spelling deficits and information integration are major issues for
147 those with dyslexia, anecdotal evidence suggests some do employ coping strategies
148 when using the internet. One strategy for searching information is to use search
149 engines (such as Google) because they provide query suggestions and are tolerant of
150 spelling errors (36). This type of strategy was reported in a qualitative study where
151 participants with dyslexia talked positively about using Facebook and stated they
152 coped with their spelling deficits by using external resources such as MS word and
153 Google. Similarly, research with students has shown that despite struggling to

154 integrate academic information across multiple sources as compared to their peers (n
155 = 20), some undergraduates with dyslexia (n=13) went online to look for videos
156 (YouTube) instead of relying on their prescribed readings (37).

157

158 In summary, studies have shown that spelling deficits and information integration
159 difficulties are perhaps barriers to using social media for those with dyslexia
160 suggesting that those with dyslexia are not likely to be susceptible to SMA. Yet coping
161 strategies may help mitigate the challenges and therefore research is needed to
162 identify if those with dyslexia are susceptible to SMA. Therefore, the current study
163 aimed to shed light on this. On balance, given that those with ASD are not susceptible
164 to SMA - and because it is noted that spelling deficits and poor comprehension are
165 life-long challenges and hence permanent aspects of life for those with dyslexia, we
166 argue that it is likely that users with dyslexia would naturally avoid or at least have
167 lower levels of SMA as compared to controls. This is because social media platforms
168 such as Twitter or Facebook do not, in general, provide spell check functions that could
169 assist the writer when drafting a post for public viewing and while some to attempt to
170 use third party applications (e.g., Google Chrome, Microsoft Word) to check their
171 spelling before posting the fear of spelling remains a major deterrent. Hence exploring
172 whether this is the case will also be a key aim of this study.

173

174 Literature has suggested that some types of social demographics may be associated
175 with various internet related addictions, specifically, age and gender. In typically
176 developing populations, age has been shown to be negatively and significantly
177 associated with GIA (38) and SMA (39) with younger individuals showing higher levels

178 of addiction. However, findings are mixed for IGD (40, 41). Age is also shown to be
179 negatively and significantly related to these types of addiction in both ASD and ADHD
180 populations (42, 43, 44).

181

182 As for gender, literature suggests that woman are more likely to show SMA as opposed
183 to men (45), while men are more likely to have a GIA (46) and IGD (47). As for ASD
184 populations, these findings are shadowed with research showing that more men with
185 ASD than woman play video-action games (48). Given these links, it is important that
186 work into these internet addictions controls for such demographic factors.
187 Furthermore, given that dyslexia, and indeed ASD and ADHD, are reported to be more
188 prevalent in men (49), this further demonstrates the need for controlling for gender in
189 research in this area.

190

191 **The present study**

192

193 The present study aimed to investigate whether differences exist between a UK
194 sample of participants with dyslexia and controls in terms of GIA, SMA and IGD.
195 Despite much evidence showing links to these types of addiction and other forms of
196 learning disability no research has explored these forms of addiction in relation to
197 dyslexia. Such research is warranted because if significant links between dyslexia and
198 problematic internet usage are identified, early detection and targeted interventions
199 can be formulated to mitigate risks for such this group.

200

201 The following hypothesis were investigated. After controlling for age, gender, income
202 levels, marital status and educational levels: Adults with dyslexia will have significantly
203 higher levels of GIA as compared to controls without a dyslexia diagnosis (**Hypothesis**
204 **1**); adults with dyslexia will have significantly higher levels of IGD as compared to
205 controls without a dyslexia diagnosis (**Hypothesis 2**), and adults with dyslexia will
206 have significantly lower levels of SMA as compared to controls without a dyslexia
207 diagnosis (**Hypothesis 3**).

208 **Method**

209 **Design**

210
211 The study utilised a quantitative between-subjects design and used a convenience
212 sample of UK adults. The dependent variables were GIA, SMA and IGD. The
213 independent variable was dyslexia (Level 1 = no dyslexia diagnosis, Level 2 = dyslexia
214 diagnosis). The other fixed factors were gender, education level, marital status, and
215 income levels. The covariate was age. Details regarding the definitions and scoring of
216 the variables are provided in the materials sub-section.

217 **Participants**

218
219 Participants were recruited through Prolific (an online survey platform). In the first step,
220 participants with dyslexia were recruited; the inclusion criteria were a formal dyslexia
221 diagnosis and no other learning disorders and no active ill mental health. A total of
222 141 participants with dyslexia completed the survey. In the second step, controls were
223 recruited; the inclusion criteria were no dyslexia diagnosis, no other learning disorders
224 and no active ill mental health. A total of 150 controls completed the survey. All
225 participants were located in the UK and aged 18 and above. The mean age of controls

226 and participants with dyslexia diagnosis was 39.4 ($SD = 14.5$) and 43.2 ($SD = 11.0$)
 227 years old respectively. Participants were recruited between 22 and 25th February
 228 (2022) and were paid approximately £1 for their participation). See Table 1 for full
 229 demographics.

230

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240 **Table 1. Sociodemographic characteristics of participants**

241

	Control		Dyslexia		Full sample	
	n	%	n	%	n	%
Gender						
Female	36	24	64	45	100	34
Male	113	75	73	52	186	64
Others	1	1	4	3	5	2
Marital Status						
Married	73	49	53	38	126	43
Single	70	47	72	51	142	49
Divorced/Widow	7	5	16	11	23	8

Income							
Above 62,400	29	19	30	21	59	20	
64,200 to 29,900	74	49	58	41	132	45	
Below 13,800	32	21	30	21	62	21	
Education							
Primary/Sec.	21	14	22	16	43	15	
College/Diploma	42	28	35	25	77	26	
Degree	53	35	49	35	102	35	
Masters/PhD	34	23	35	25	69	24	
Employment							
Unemployed	5	3	8	6	13	4	
Not working	22	15	12	9	34	12	
Employed	87	58	91	65	178	61	
Self-Employed	15	10	17	12	32	11	
Studying	21	14	13	9	34	12	

242 Total sample is 291; Dyslexia diagnosis (141), Controls (150)

243

244 **Materials**

245

246 GIA was measured by the Internet Addiction Test (IAT; 50). The IAT is based on the
 247 DSM-IV criterion for pathological gambling diagnosis. There are 20 questions (e.g.,
 248 “*How often do you find that you stay on-line longer than you intended?*”) with six
 249 options ranging from Does Not Apply (0) to Always (5). The total score ranges from 0
 250 to 100, interpreted using the following cut-offs: severe (80 and above), moderate (50
 251 to 79), mild (31 to 49) and no addiction or normal usage (0 to 30) (51). An independent
 252 study reported Cronbach’s alpha (α) of .90, test-retest reliability of .83 and convergent
 253 validity range of .62–.84 (52). In the present study, $\alpha = .93$ indicating excellent internal
 254 consistency.

255

256 SMA was measured by the Bergen Social Media Addiction Scale (BSMAS; 39). The
 257 scale is based on the six core components model (salience, mood, modification,
 258 tolerance, withdrawal conflict and relapse) proposed by Griffiths to assess social

259 media addiction (53). The BSMAS is a modified version of the Bergen Facebook
260 Addiction Scale (BFAS; 54); questions were modified by using the word “social media”
261 instead of “Facebook”. There are six questions (e.g., “*How often during the last year*
262 *have you felt an urge to use social media more and more?*). Participants rate all items
263 on a 5-point Likert scale ranging from Very Rarely (1) to Very Often (5). The total score
264 ranges from 6 to 30. Higher scores indicate higher levels of addiction. Scores above
265 24 may be indicative of severe addiction and above 18, moderate addiction (55). The
266 internal consistency of the present study compared favourably ($\alpha = .91$) with the
267 original study ($\alpha = .88$; 35).

268

269 IGD was measured by the Internet Gaming Disorder Scale, Short-Form 9 (IGDS-SF9;
270 56). The measure includes 9 questions (e.g., “*Have you ever continued your gaming*
271 *activity despite knowing it was causing problems between you and other people?*)
272 rated on a five-point Likert scale, ranging from Never (1) to Very Often (5). The total
273 score ranges from 9 to 45. A higher score indicates a higher likelihood of IGD. A score
274 above 32 is indicative of pathological usage based on Qin (57) who suggested that
275 such a score was adequate to distinguish disordered and non-disordered gamers. A
276 recent study reported $\alpha = .91$ (58). Again, the present study demonstrated strong
277 internal reliability ($\alpha = .95$) in comparison to previous works.

278

279 **Procedure**

280

281 Participants who signed up for the survey were given a link to Qualtrics where they
282 read the participant information sheet before providing online written informed
283 consent. Participants were guided to click the consent button to proceed to the online

284 survey. They also agreed to the GDPR statement before generating a unique user
 285 code. Participants then completed the questions on internet addiction, social media
 286 addiction, and internet gaming disorder IGD before providing demographic information
 287 (e.g., age, gender, and household income). Lastly, they reaffirmed their consent and
 288 viewed the project debrief information. Ethical approval was granted by the University
 289 of Derby research ethics committee (ETH2122-1830).

290

291 **Analyses**

292

293 This study used a between-subjects analysis of covariance (ANCOVA) as well as
 294 multivariate analysis of covariance (MANCOVA). The continuous independent
 295 variable was dyslexia (Level 1: dyslexia diagnosis, Level 2: no dyslexia). For the
 296 ANCOVA, the continuous dependent variable was GIA. For MANCOVA, the
 297 continuous dependent variables were SMA and IGD. The study aimed to explore if
 298 there was a significant difference between the independent variable and the
 299 dependent variables, after controlling for the continuous covariate, age and the
 300 nominal covariates, gender, education levels, income levels, and marital status.

301

Results

302 **Descriptive statistics and data screening**

303

304 Table 2 shows descriptive statistics for all scales. As shown in Table 2, the
 305 participants with dyslexia had higher scores than controls on all measures.

306 **Table 2. *Adjusted Means and Standard Deviations of Scores***

Scale	Dyslexia Group	Controls
-------	----------------	----------

IAT	40.87 (4.21)	35.78 (4.36)
IGDS-SF9	19.82 (2.21)	16.55 (2.29)
BSMAS	15.41 (1.50)	14.23 (1.55)

307 *Standard deviations are presented in parenthesis. IAT = Internet Addiction Test;*
 308 *IGDS-SF9 = Internet Gaming Disorder Scale, Short Form (9); BSMAS = Bergen*
 309 *Social Media Addiction Scale.*
 310

311 A Pearson product-moment correlation was initially run to check for multicollinearity
 312 among the dependent variables. While the correlation between GIA and IGD was $r =$
 313 $.61$ and between SMA and IGD was $r = .49$, the correlation between GIA and SMA
 314 was $r = .77$. This was deemed to be too high, compared to the acceptable range of
 315 *around* $r = .8$ for multicollinearity (59). This suggested that general and specific internet
 316 addictions were not sufficiently independent. Hence it was decided that GIA would be
 317 isolated for an ANCOVA, while only SMA and IGD would be included in the
 318 MANCOVA.

319 **ANCOVA for GIA**

320
 321 A one-way between subjects ANCOVA was performed to investigate internet-related
 322 addictions among persons with and without dyslexia. The dependent variable was IA.
 323 The independent variable of interest was dyslexia diagnosis (no dyslexia vs dyslexia
 324 diagnosis). The covariates were age, gender, marital status, education, and income
 325 levels.

326

327 Initial screening of skewness for GIA (skewness = $.54$; $z = 3.78$) and GIA residuals
 328 (skewness = $.62$; $z = 4.34$) showed positive skewness a significant Shapiro-Wilk (S-
 329 W) test ($p < .001$). Visual inspection of the histograms suggested a moderate positive

330 skew. A square root transformation of IA resulted in an approximately normal
331 distribution of the residuals (skewness = $-.02$; $z = .15$) to within the ± 1.96 range and
332 produced a significant S-W ($p = .11$) tests and thus indicated normality. Visual
333 inspection of the histogram and Q-Q Plot indicated a normal distribution. The linearity
334 assumption was met. Levene's test of equality of error variance was also satisfactory
335 ($p = .69$), indicating homogeneity of variances. The adjusted mean GIA score
336 (untransformed) for the no dyslexia and dyslexia groups was 35.78 and 40.87
337 respectively. After square root transformation, this difference was statistically
338 significant, after controlling for age, gender, income levels, employment, and
339 education levels $F(1, 271) = 6.01, p = .02$. The partial ETA squared (η^2p) was $.02$,
340 thus a small effect. In terms of demographics, only age was negatively and significantly
341 associated with GIA, untransformed $b = -.39, p < .001$ with a η^2p of $.10$ (small effect).
342 For continuous variables like age, this beta is interpreted for every one year-increase
343 in age, GIA scores decrease by $.39$ units. The other demographics were not
344 significantly associated with GIA.

345

346 **MANCOVA for SMA and IGD**

347

348 A one-way between-subjects MANCOVA was performed to investigate SMA and IGD
349 addictions among persons with and without dyslexia. The dependent variables were
350 SMA and IGD. The independent variable of interest was dyslexia diagnosis (no
351 dyslexia vs dyslexia diagnosis). The covariates were age, gender, marital status,
352 education, and income levels.

353

354 The initial screening of SMA's residuals showed moderate positive skewness
355 (skewness = .31; $z = 2.16$) and significant S-W test ($p = .001$). Visual inspection of the
356 SMA residuals histogram suggested a slightly positive skew. A square root
357 transformation of the SMA reduced the skewness of the residuals (skewness = .08; z
358 = .53) to within the ± 1.96 range though the S-W ($p = .01$) test was still significant.
359 However visual inspection of the histogram and Q-Q plots suggested a normal
360 distribution. The linearity assumption was met. The initial screening of IGD residuals
361 showed moderate positive skewness (skewness = 1.01; $z = 7.06$) and a significant S-
362 W test ($p < .001$). Visual inspection of the histogram suggested a moderately positive
363 skew. An inverse transformation of the residuals improved the skewness of the
364 residuals (skewness = -.22; $z = 1.55$) although the S-W test was still significant ($p <$
365 $.001$). The transformed histogram showed a modest negative skew. The linearity
366 assumption was met.

367 Multivariate outliers and normality were assessed using Mahalanobis distance (MD).
368 Using the untransformed SMA and IGD, there was one multivariate outlier exceeding
369 the critical value of 13.82 for two dependent variables (60). However, using the
370 appropriately square root transformed SMA and inverse transformed IGD resulted in
371 no multivariate outliers. Homogeneity test was satisfactory; the Levene's Test of
372 Equality of Error Variance was insignificant for the square root SMA (.57) and the
373 inverse IGD (.08). The Box's Test of Equality of Covariance value was also
374 insignificant ($F = .98$, $p = .54$), thus suggesting that the observed covariance matrices
375 of the dependent variables are equal across groups.

376

377 After controlling for age, gender, income levels, employment, and education levels,
378 there was a statistically significant difference between no dyslexia and dyslexia
379 diagnosis on the combined appropriately transformed dependent variables, $F(2, 270)$
380 $= 5.62$, $p < .001$, Wilk's Lambda $= .96$. The η^2p was $.04$. suggesting a small effect. The
381 multivariate model also showed that age, $F(2, 270) = 13.58$, $p < .001$, Wilk's Lambda
382 $= .91$, $\eta^2p = .09$, and gender, $F(6, 540) = 5.76$, $p < .001$, $\eta^2p = .06$, Wilk's Lambda $= .88$,
383 were statistically significant on the combined appropriately transformed dependent
384 variables.

385

386 The adjusted mean SMA (untransformed) for the no dyslexia and dyslexia groups was
387 14.23 and 15.41 respectively. After square root transformation, this difference was not
388 statistically significant, $F(1, 271) = 3.48$, $p = .06$. The η^2p was $.01$, thus a small effect.
389 The adjusted mean IGD (untransformed) for the no dyslexia and dyslexia groups was
390 16.55 and 19.82 respectively. After inverse transformation, this difference was
391 statistically significant, $F(1, 271) = 10.9$, $p < .001$. The η^2p was $.04$, thus a small
392 effect.

393

394 The test between subjects effects also showed that gender was significant for SMA
395 only, $F(3, 271) = 6.03$, $p < .001$, $\eta^2p = .06$, such that men had significantly lower
396 mean SMA scores than woman (untransformed adjusted means 11.75 and 14.33,
397 respectively). The test between subjects effects also showed that age was negatively
398 and significantly associated with SMA, untransformed beta $= -.15$, $p < .001$, $\eta^2p = .08$
399 and IGD, untransformed beta $= -.14$, $p < .001$, $\eta^2p = .03$. All other demographic
400 variables were not significant.

401

402 **Interactions**

403

404 A gender x dyslexia status interaction was included in the ANCOVA for GIA. This
405 interaction was not statistically significant $F(1, 270) = .01, p = .94$. An age x dyslexia
406 status interaction was included in the ANCOVA for GIA. Consistent with literature that
407 older individuals have lower scores of GIA (Lozano-Blasco et al., 2020; MacMullin et
408 al., 2016) the older controls showed lower score for GIA (29.08) relative to the younger
409 controls (37.04). In contrast, the score for older participants did not seem to drop as
410 much (38.95) as compared to younger participants with dyslexia (40.84). However, the
411 statistical trend was not significant for the interaction, $F(1, 270) = 3.41, p = .07$. An
412 age x dyslexia status interaction was included in the MANCOVA for SMA and IGD.
413 This interaction was not statistically significant

414 $F(2, 269) = .52, p = .60, \text{Wilk's Lambda} = 1.00$

415

416

Discussion

417 This study aimed to examine if differences exist in General Internet Addiction (GIA),
418 Internet Gaming Disorder (IGD), and Social Media Addiction (SMA) between those
419 with and without dyslexia in a UK population after controlling for age, gender, marital
420 status, employment, and income levels. Findings showed a significant difference for
421 GIA and GD, but no significant difference was found for SMA.

422

423 The finding that adults with dyslexia had significantly higher levels of GIA as compared
424 to controls supports the first hypotheses. This finding is also supportive of studies

425 reporting a significant relationship between GIA and other learning disabilities such as
426 ASD (8, 10) and ADHD (9). The present study can extend this literature by showing
427 that dyslexia in addition to ASD and ADHD is associated with GIA, suggesting that this
428 may be a common factor in learning disabilities.

429

430 The second hypothesis was also supported as results showed that participants with
431 dyslexia had significantly higher levels of IGD than controls. Again, this finding is
432 supportive of studies which have shown a correlation between IGD and other learning
433 disabilities such as ASD (10) and ADHD (14). Hence the results in the present study
434 extend these findings to dyslexia, and again suggest this may be a common factor in
435 learning disabilities.

436

437 However, the third hypothesis was not supported by the results. It was expected that
438 those with dyslexia would score significantly lower on SMA than controls, however,
439 although it did not reach significance, participants with dyslexia scored slightly higher
440 than controls on SMA. There are several possible explanations for these findings. It
441 may be that those with dyslexia are effectively employing coping strategies (such as
442 using external resources like search engines for spell checking) when using social
443 media. This may have allowed them to mitigate their deficits in writing and reading and
444 still participate in social media activities meaningfully, such that having a dyslexia
445 diagnosis neither increases nor decreases the risk of SMA relative to controls. Hence
446 the results are supportive of studies hinting at such compensating strategies adopted
447 by these users (e.g., 61, 35, 36). Another explanation could be that the types of social
448 media used by the participants in this study is not largely written such as Twitter or

449 Facebook but could be picture or video based such as Instagram, TikTok or YouTube.
450 Indeed, research already shows that those with dyslexia use YouTube as a coping
451 strategy to learn new information (36). TikTok in particular has seen a large rise in
452 usership in recent years, especially amongst adolescents and younger adults (62),
453 and research into this area needs to reflect this change in how we use social media.
454 Thusuture studies could consider if there are differences in the different types of social
455 media used by those with dyslexia.

456

457 Given that SMA scores were not significantly higher in the dyslexia group, this
458 suggests that not all learning difficulties are associated with social media addiction.
459 Though ADHD may be correlated with SMA (61) studies show this is not necessarily
460 the case for ASD (16), and the results of this study indicate this may not be the case
461 for dyslexia either. This suggests that, unlike IGD and GIA, SMA might not be a
462 common factor across learning disabilities and instead it could depend on the
463 characteristics of the specific condition. For instance, it is perhaps the language
464 defects seen in ASD including challenges with learning to read (63) and spelling (64)
465 that may limit these individuals' social media usage in a similar way to those dyslexia.

466

467 In terms of social demographics, the univariate and multivariate results showed that
468 age was negatively and significantly associated with GIA, SMA, and IGD. This is in
469 line with literature that has suggested that age is significantly correlated with GIA (38),
470 SMA (39), and IGD (39). In this study, only gender and SMA showed statistical
471 significance, such that the female gender was significantly associated with SMA. This
472 is also in line with previous studies (45).

473

474 No interactions were found for gender by dyslexia for GIA, gender by dyslexia for SMA
475 and IGD, age by dyslexia for SMA and IGD. However, age by dyslexia for GIA showed
476 a statistical trend. Consistent with literature that older individuals have lower scores of
477 GIA, the older controls showed lower score for GIA relative to the younger controls. In
478 contrast, the score for older participants did not drop as much as compared to younger
479 participants with dyslexia. This appeared to suggest that age does not moderate GIA
480 levels among those with dyslexia, however the relationship approached but did not
481 reach statistical significance. It is possible that this study was not adequately powered
482 to test for such an interaction effect. Future studies could test this relationship again
483 with larger samples.

484 Taken together the main findings may suggest that internet addiction is more prevalent
485 in those with dyslexia. This said, it must be noted that although those with dyslexia
486 were found to have higher levels of GIA and IGD this did not fall within pathological
487 levels with group means suggesting only a mild addiction. Therefore, although those
488 with dyslexia might be more likely to show addictive behaviour this is not necessarily
489 a cause for concern. Moreover, it should also be noted that in all three scales, standard
490 deviations show that the two groups are highly overlapping, and differences are only
491 statistically significant after square root transformations therefore suggesting that,
492 although significant, these differences are small.

493

494 The current study was preliminary with the aim of exploring if differences exist
495 compared with controls. The findings suggest that this is an area that now warrants
496 further attention. It is possible that the widely reported challenges those with dyslexia

497 face at work, and the accompanying emotional disturbances (5) may be further
498 aggravated by levels of internet addictions or may be pushing them towards higher
499 levels of internet addictions. It is therefore important that future work explores the
500 mechanisms behind these relationships. Additionally, as age is believed to be
501 inversely related to such addictions, it is important for professionals working with
502 younger people who have dyslexia to consider such matters in their assessments and
503 interventions. Future studies could also focus on younger populations to see if the
504 findings extend to adolescents and children. Also, studies could examine more directly
505 the relationships between such addictions and spelling difficulties and information
506 integration.

507 A key limitation of this study is the cross-sectional nature which precludes conclusions
508 over causality and direction and does not tell us anything about how these
509 relationships operate. One possible explanation for the link between internet
510 addictions and learning disabilities is that learning disabilities may lead to mental
511 health issues, which in turn lead to internet addictions (see 26), or even that mental
512 health mediates the relationship. As this was a preliminary investigation exploring this
513 is beyond the scope of this study and here, to avoid confounding effects, we limited
514 participation only to those who did not have active mental health. This said, it is
515 certainly possible that in our sample, anxiety and depression presented at sub-clinical
516 levels or was undiagnosed. To explore this further, future research may wish to study
517 self-esteem and anxiety (commonly associated with dyslexia; 24) which may explain
518 a larger amount of variance related to levels of internet addictions or even play a
519 mediating role in the relationship. In doing this the research would be able to
520 understand further how these relationships operate. Additionally, we did not check for
521 the presence of dysgraphia (a writing disability that causes a person's writing to be

522 distorted or incorrect which can be co-morbid with dyslexia; 65) in our sample. A
523 comorbid diagnosis of dysgraphia could further complicate the relationship between
524 dyslexia and internet-based addictions, in particularly SMA, and this should therefore
525 be explored in future work.

526

527 Despite this limitation this study has made a notable contribution to this research area
528 showing that in addition to ASD and ADHD, dyslexia is also related to GIA and IGD.
529 This is important because these findings suggest that internet addictions (at least GIA
530 and IGD) are likely to impact a much larger ambit of people than previously assumed
531 (not just ASD and ADHD). Hence further attention is warranted because if significant
532 relationships between dyslexia and GIA and IGD are detected early, then interventions
533 can be undertaken to manage such problems for this group.

534

535 In conclusion, this study was a preliminary investigation into possible differences in
536 terms of GIA, IGD and SMA between those with and without dyslexia in a UK
537 population. Controlling for age, gender, marital status, employment, and income
538 levels, it was found that adults with dyslexia had higher levels of GIA and IGD as
539 compared controls. However, these participants did not show any significant
540 difference in terms of SMA. The results indicate that internet addictions may have a
541 larger ambit for learning disorders beyond just ASD and ADHD and is a hidden
542 problem for users with dyslexia.

543

544

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546

547

548

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Supporting Information

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1 A preliminary study into internet related addictions among
2 adults with dyslexia

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34 Abstract

35 In recent decades, studies have investigated associations between learning
36 disorders such as Autism Spectrum Disorders (ASD) and Attention Deficit
37 Hyperactivity Disorder (ADHD), and the various types of internet addictions, ranging
38 from general internet addiction (GIA) to specific internet addictions such as social
39 media addiction (SMA) and internet gaming disorder (IGD). However, to date, no
40 study has investigated such internet addictions among persons with dyslexia. The
41 present study aimed to investigate whether differences exist between adults with
42 dyslexia and controls in terms of GIA, SMA and IGD. A total of 141 adults with
43 dyslexia and 150 controls (all UK based) were recruited. Controlling for age, gender,
44 marital status, ~~employment~~employment, and income levels, it was found that adults
45 with dyslexia had higher levels of GIA and IGD compared to controls. However,
46 these participants did not show any significant difference in terms of SMA. The
47 results indicate that internet addictions may have a larger ambit for learning
48 disorders beyond just ASD and ADHD and could be a hidden problem for these
49 individuals.

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Introduction

57

58 The internet continues to be a popular platform for information seeking, education and
59 entertainment, in addition to social interaction and online games. However, there are
60 concerns over addictive usage among a minority of users, this includes those with
61 learning disabilities (1). Such an addiction has been defined as General Internet
62 Addiction (GIA) and includes a preoccupation with internet activities at the expense of
63 important daily activities such as schoolwork, occupation, relationships, and personal
64 health (2). These addictions can also be unique to social networking or social media
65 (named Social Media ~~Addition~~ Addiction; SMA; 3), or exclusive to internet games,
66 known as Internet Gaming Disorder (IGD; 4). There is much literature suggesting that
67 all these forms of addictions ~~addition~~ are high in those with learning disorders but
68 notably, much of this literature has focused solely on those with Autism Spectrum
69 Disorder (ASD) and Attention Deficit Hyperactivity Disorder (ADHD) (5) Indeed, to
70 date, no study has investigated such internet addictions among persons with dyslexia,
71 a condition characterised by deficits in word decoding, spelling, reading fluency and
72 comprehension (7) and which ~~that~~ accounts for 10-15% of the UK population (6). ~~and~~
73 ~~is characterised by deficits in word decoding, spelling, reading fluency and~~
74 ~~comprehension (7).~~

75

76 It is likely that ~~There are several reasons to suspect that~~ dyslexia might be associated
77 with these types of addictions ~~additions~~ because. ~~This includes~~ a growing body of
78 evidence suggests that ~~suggesting~~ individuals with learning disabilities are especially
79 vulnerable to internet addictions compared to their typically developing peers. For
80 instance, studies have found a significant association between General Internet
81 Addiction (GIA) and both ASD (8) and ADHD (9). Similarly, Internet Gaming Disorder

82 (IGD) has also been associated with ASD (10) and ADHD (11). In ASD this may be
83 due to restricted and repetitive interests (a core symptom of ASD) leading to difficulties
84 in disengaging from video games or time spent on the internet and therefore an
85 addition-addictions (10). In addition, the low social demands and -audio-visual and
86 structural characteristics of the internet and games may further add to the appeal (11)-.
87 In ADHD, being bored easily and an aversion for delayed reward are two key
88 symptoms and therefore the internet and gaming may be especially appealing to these
89 individualsindividuals, and it provides a variety of activities, many with instant rewards
90 (9). Additionally, neurological research has found abnormal brain activities in both
91 those with ASD and ADHD which lead to impaired inhibition and lack of self-control
92 ability (9; 12). Given that those with dyslexia also show impairments on a range of
93 executive functions, including inhibition and self-control (13; 14), links to internet
94 related addictions additions are likely.

95

96 Moreover, research also shows a significant link between Social Media
97 AdditionAddiction (SMA) and ADHD (152). again perhaps because of the instant
98 rewards social media can offer such as 'likes' from peers and other users. Yet the
99 relationships between SMA and ASD is unclear; while one study (163) found that
100 children with ASD (n = 202) spent less time on social media than their typically
101 developing siblings (n = 179), another study found no difference in time spent
102 on social media among adolescents with and without ASD (ASD n = 24, control n =
103 26) (174). Meanwhile, another study found that the majority of adults with ASD used
104 social media to connect with others (185) perhaps because they find social
105 engagement through the written form more appealing and less challenging than
106 engaging with peers orally such as face-to-face or over the phone, something that may

107 not be the case for those with dyslexia. Yet, these contrasting findings are perhaps
108 due to age differences and the fact that children, adolescents, and adults may use
109 social media for different purposes.

110
111 Despite some contradictory findings regarding SMA and ASD, taken together these
112 research studies clearly highlight a link between ASD and ADHD and internet-based
113 addiction ~~ditions~~. In addition to the ones already discussed, another explanation for
114 this link may be due to ASD and ADHD triggering mental health conditions which are
115 in turn a risk factor for internet addictions. For instance, ASD has reportedly induced
116 anxiety (196), which is an antecedent for ~~internet-related~~ internet-related addictions
117 (2047, 2148, 2249). Similarly, children with ADHD present with anxiety, depression,
118 and poor self-esteem (230, 244, 252). As dyslexia also triggers similar mental health
119 issues, such as anxiety and low self-esteem (263), a similar relationship may exist
120 between dyslexia GIA, IGD and SMA.

121
122 ~~With regards to SMA and dyslexia there is some evidence that suggests barriers for~~
123 ~~usage of social media. For example, the spelling deficits and comprehension~~
124 ~~difficulties associated with dyslexia may make using social media extremely~~
125 ~~challenging. Indeed, a study on how students (n = 40) used a library information~~
126 ~~system (without spelling support) showed that spelling deficits hampered those with~~
127 ~~dyslexia as compared to typically developing peers, with users with dyslexia spending~~
128 ~~more time searching compared to their peers (24). Moreover, another study (25)~~
129 ~~reported that 48% of participants with dyslexia (n = 67) received significantly more~~
130 ~~peer negative feedback on their social media posts as compared to about 22% of~~

131 controls (n = 404). They cited spelling as the main reason why writing was harder than
132 reading on social media sites (25). Similarly, comprehending or integrating information
133 when presented in various formats is a common challenge for those with dyslexia and
134 one that could create problems when using social media. In a study of tenth grade
135 Norwegians (n = 44), another study found that typically developing individuals
136 outperformed participants with dyslexia on synthesizing information across different
137 web pages (26). Likewise, studies (e.g., 27) have shown that when information is
138 presented in different formats (text, images, videos etc) on a page with use of cluttered
139 spacing, variety of colours, multiple columns and lengthy sentences without bullet
140 points, which can be common on social media sites, this could be difficult for persons
141 with dyslexia to follow (28, 29).

142
143 Nonetheless, while spelling deficits and information integration are major issues for
144 those with dyslexia, anecdotal evidence suggests some do employ coping strategies
145 when using the internet. One strategy for searching information is to use search
146 engines (such as GoogleGoggle) because they provide query suggestions and are
147 tolerant of spelling errors (30). This type of strategy was reported in a qualitative study
148 by Barden (2014) (n = 5) where participants with dyslexia talked positively about using
149 Facebook and stated they coped with their spelling deficits by using external resources
150 such as MS word and Google. Similarly, research with students has shown that
151 despite struggling to integrate academic information across multiple sources as
152 compared to their peers (n = 20), some undergraduates with dyslexia (n=13) went
153 online to look for videos (YouTube) instead of relying on their prescribed readings (31).

~~In summary, studies have shown that spelling deficits and information integration difficulties are perhaps barriers to using social media for those with dyslexia suggesting that those with dyslexia are not likely to be susceptible to SMA. Yet coping strategies may help mitigate the challenges and therefore research is needed to identify if those with dyslexia are susceptible to SMA, in the same way that those with ADHD are. Therefore, the current study aimed to shed light on this. On balance, given that those with ASD are not susceptible to SMA—and because it is noted that spelling deficits and poor comprehension are life-long challenges and hence permanent aspects of life for those with dyslexia, we argue that it is likely that users with dyslexia would naturally avoid or at least have lower levels of SMA as compared to controls. This is because social media platforms such as Twitter or Facebook do not, in general, provide spell check functions that could assist the writer when drafting a post for public viewing and while some do attempt to use third party applications (e.g. Google Chrome, Microsoft Word) to check their spelling before posting the fear of spelling remains a major deterrent (30, 25). Hence exploring whether this is the case will be a key aim of this study.~~

~~On the other hand, the link between dyslexia and internet gaming seems ~~more~~ likely. This is because online games typically do not involve writing and thus have fewer spelling demands, ~~than social media~~. It is logical to suggest therefore that such an environment would be highly appealing to those with dyslexia. For instance, some studies aimed at using video games as interventions for those with dyslexia have demonstrated that action video games provide a rewarding experience that reinforces the engagement for users with dyslexia (2732, 2833). ~~Taking all of this evidence together it seems likely that online gaming might be very appealing for someone with~~~~

179 ~~dyslexia but~~ However, if this leads to high prevalence of IGD in this population is
180 something which has yet to be explored. Hence this was ~~another~~ key aim of the
181 present study.

182
183 On the other hand, the link between SMA and dyslexia is harder to explain as there is
184 some evidence that suggests barriers for usage of social media. For example, the
185 spelling deficits and comprehension difficulties associated with dyslexia may make
186 using social media extremely challenging. Indeed, a study on how students (n = 40)
187 used a library information system (without spelling support) showed that spelling
188 deficits hampered those with dyslexia as compared to typically developing peers, with
189 users with dyslexia spending more time searching compared to their peers (29).
190 Moreover, another study (30) reported that 48% of participants with dyslexia (n = 67)
191 received significantly more peer negative feedback on their social media posts as
192 compared to about 22% of controls (n = 404). They cited spelling as the main reason
193 why writing was harder than reading on social media sites (31). Similarly,
194 comprehending or integrating information when presented in various formats is a
195 common challenge for those with dyslexia and one that could create problems when
196 using social media. In a study of tenth-grade Norwegians (n = 44), it was found that
197 typically developing individuals outperformed participants with dyslexia on
198 synthesizing information across different web pages (32). Likewise, studies (e.g., 33)
199 have shown that when information is presented in different formats (text, images,
200 videos etc) on a page with use of cluttered spacing, variety of colours, multiple
201 columns, and lengthy sentences without bullet points, which can be common on social
202 media sites, this could be difficult for persons with dyslexia to follow (34, 35).

203 Nonetheless, while spelling deficits and information integration are major issues for
204 those with dyslexia, anecdotal evidence suggests some do employ coping strategies
205 when using the internet. One strategy for searching information is to use search
206 engines (such as Google) because they provide query suggestions and are tolerant of
207 spelling errors (36). This type of strategy was reported in a qualitative study where
208 participants with dyslexia talked positively about using Facebook and stated they
209 coped with their spelling deficits by using external resources such as MS word and
210 Google. Similarly, research with students has shown that despite struggling to
211 integrate academic information across multiple sources as compared to their peers (n
212 = 20), some undergraduates with dyslexia (n=13) went online to look for videos
213 (YouTube) instead of relying on their prescribed readings (37).

214
215 In summary, studies have shown that spelling deficits and information integration
216 difficulties are perhaps barriers to using social media for those with dyslexia
217 suggesting that those with dyslexia are not likely to be susceptible to SMA. Yet coping
218 strategies may help mitigate the challenges and therefore research is needed to
219 identify if those with dyslexia are susceptible to SMA. Therefore, the current study
220 aimed to shed light on this. On balance, given that those with ASD are not susceptible
221 to SMA - and because it is noted that spelling deficits and poor comprehension are
222 life-long challenges and hence permanent aspects of life for those with dyslexia, we
223 argue that it is likely that users with dyslexia would naturally avoid or at least have
224 lower levels of SMA as compared to controls. This is because social media platforms
225 such as Twitter or Facebook do not, in general, provide spell check functions that could
226 assist the writer when drafting a post for public viewing and while some to attempt to
227 use third party applications (e.g., Google Chrome, Microsoft Word) to check their

spelling before posting the fear of spelling remains a major deterrent. Hence exploring whether this is the case will also be a key aim of this study.

Literature has suggested that some types of social demographics may be associated with various internet related addictions, specifically, age and gender. In typically developing populations, age has been shown to be negatively and significantly associated with GIA (384) and SMA (395) with younger individuals showing higher levels of addiction. However, findings evidence are mixed for IGD (4036, 4137). Age is also shown to be negatively and significantly related to these types of addiction in both ASD and ADHD populations (4238, 4339, 440).

As for gender, literature suggests that ~~woman females~~ are more likely to show SMA as opposed to ~~men males~~ (454), while ~~men males~~ are more likely to ~~be~~ have a GIA (462) and IGD (473). As for ASD populations, these findings are shadowed with research showing that more ~~men males~~ with ASD than ~~woman females~~ play video-action games (484). Given these links, it is important that work into these internet addictions ~~additions~~ controls for such demographic factors. Furthermore, given that dyslexia, and indeed ASD and ADHD, are reported to be more prevalent in men (49), this further demonstrates the need for controlling for gender in research in this area.

The present study

The present study aimed to investigate whether differences exist between a UK sample of participants with dyslexia and controls in terms of GIA, SMA and IGD.

252 Despite much evidence showing links to these types of ~~addiction~~ ~~addition~~ and other
253 forms of learning disability no research has explored these forms of ~~addiction~~ ~~addition~~
254 in relation to dyslexia. Such research is warranted because if significant links between
255 dyslexia and problematic internet usage are identified, early detection and targeted
256 interventions can be formulated to mitigate risks for such this group.

257

258 The following hypothesis were investigated. After controlling for age, gender, income
259 levels, marital status and educational levels: Adults with dyslexia will have significantly
260 higher levels of GIA as compared to controls without a dyslexia diagnosis (**Hypothesis**
261 **1**); adults with dyslexia will have significantly higher levels of IGD as compared to
262 controls without a dyslexia diagnosis (**Hypothesis 2**), and adults with dyslexia will
263 have significantly lower levels of SMA as compared to controls without a dyslexia
264 diagnosis (**Hypothesis 3**).

265

Method

Design

267

268 The study utilised a quantitative between-subjects design and used a convenience
269 sample of UK adults. The dependent variables were GIA, SMA and IGD. The
270 independent variable was dyslexia (Level 1 = no dyslexia diagnosis, Level 2 = dyslexia
271 diagnosis). The other fixed factors were gender, education level, marital status, and
272 income levels. The covariate was age. Details regarding the definitions and scoring of
273 the variables are provided in the materials sub-section.

274

275 Participants

276 Participants were recruited through Prolific (an online survey platform). In the first step,
277 participants with dyslexia were recruited; the inclusion criteria ~~was~~ were a formal
278 dyslexia diagnosis and no other learning disorders and no active ill mental health. A
279 total of 141 participants with dyslexia completed the survey. In the second step,
280 controls were recruited; the inclusion criteria ~~was~~ were no dyslexia diagnosis, no other
281 learning disorders and no active ill mental health. A total of 150 controls completed the
282 survey. All participants were located in the UK and aged 18 and ~~above~~ The above.
283 The mean age age (standard deviation) of controls and participants with dyslexia
284 diagnosis ~~was~~ ere 39.4 (*SD* = 14.5) and 43.2 (*SD* = 11.0) years old respectively.
285 Participants were recruited between 22 and 25th February (2022) and were paid
286 approximately £1 for their participation). See Table 1 for full demographics.
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Table 1. Sociodemographic characteristics of participants

	Control		Dyslexia		Full sample	
	n	%	n	%	n	%
Gender						
Female	36	24	64	45	100	34
Male	113	75	73	52	186	64
Others	1	1	4	3	5	2
Marital Status						
Married	73	49	53	38	126	43
Single	70	47	72	51	142	49
Divorced/Widow	7	5	16	11	23	8.29
Income						
Above 62,400	29	19	30	21	59	20
64,200 to 29,900	74	49	58	41	132	45
Below 13,800	32	21	30	21	62	21
Education						
Primary/Sec.	21	14	22	16	43	15
College/Diploma	42	28	35	25	77	26
Degree	53	35	49	35	102	35
Masters/PhD	34	23	35	25	69	24
Employment						
Unemployed	5	3	8	6	13	4
Not working	22	15	12	9	34	12
Employed	87	58	91	65	178	61
Self-Employed	15	10	17	12	32	11
Studying	21	14	13	9	34	12

Total sample is 291; Dyslexia diagnosis (141), Controls (150)

Materials

GIA was measured by the Internet Addiction Test (IAT; 5045). The IAT is based on the DSM-IV criterion for pathological gambling diagnosis. There are 20 questions (e.g., "How often do you find that you stay on-line longer than you intended?") with six options ranging from Does Not Apply (0) to Always (5). The total score ranges from 0 to 100, interpreted using the following cut-offs: severe (80 and above), moderate (50

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310 to 79), mild (31 to 49) and no addiction or normal usage (0 to 30) (5146). An
311 independent study reported Cronbach's alpha (α) of .90, test-retest reliability of .83
312 and convergent validity range of .62–.84 (5247). In the present study, α = .93 indicating
313 excellent internal consistency.

314

315 SMA was measured by the Bergen Social Media Addiction Scale (BSMAS; 395). The
316 scale is based on the six core components model (salience, mood, modification,
317 tolerance, withdrawal conflict and relapse) proposed by Griffiths to assess social
318 media addiction (5348). The BSMAS is a modified version of the Bergen Facebook
319 Addiction Scale (BFAS; 5449); questions were modified by using the word "social
320 media" instead of "Facebook". There are six questions (e.g., "*How often during the last*
321 *year have you felt an urge to use social media more and more?*"). Participants rate all
322 items on a 5-point Likert scale ranging from Very Rarely (1) to Very Often (5). The total
323 score ranges from 6 to 30. Higher scores indicate higher levels of addiction. Scores
324 above 24 may be indicative of severe addiction and above 18, moderate addiction
325 (550). The internal consistency of the present study compared favourably (α = .91)
326 with the original study (α = .88; 35).

327

328 IGD was measured by the Internet Gaming Disorder Scale, Short-Form 9 (IGDS-SF9;
329 564). The measure includes 9 questions (e.g., "*Have you ever continued your gaming*
330 *activity despite knowing it was causing problems between you and other people?*")
331 rated on a five-point Likert scale, ranging from Never (1) to Very Often (5). The total
332 score ranges from 9 to 45. A higher score indicates a higher likelihood of IGD. A score
333 above 32 is indicative of pathological usage based on Qin (572) who suggested that

334 such a score was adequate to distinguish disordered and non-disordered gamers. A
335 recent study reported $\alpha = .91$ (583). Again, the present study demonstrated strong
336 internal reliability ($\alpha = .95$) in comparison to previous works.

337

338 Procedure

339

340 Participants who signed up for the survey were given a link to Qualtrics where they
341 read the participant information sheet before providing online written informed
342 consent. Participants were guided to click the consent button to proceed to the online
343 survey. They also agreed to the GDPR statement before generating a unique user
344 code. Participants then completed the questions on internet addiction, social media
345 addiction, and internet gaming disorder IGD before providing demographic information
346 (e.g., age, gender, and household income). Lastly, they reaffirmed their consent and
347 viewed the project debrief information. Ethical approval was granted by the University
348 of Derby research ethics committee (ETH2122-1830).

349

350 Analytical Strategy Analyses

351

352 This study used a between-subjects analysis of covariance (ANCOVA) as well as
353 multivariate analysis of covariance (MANCOVA). The continuous independent
354 variable was dyslexia (Level 1: dyslexia diagnosis, Level 2: no dyslexia). For the
355 ANCOVA, the continuous dependent variable was GIA. For MANCOVA, the ~~continuous~~
356 continuous dependent variables were SMA and IGD. The study aimed to ~~explore~~
357 explore if there was a significant difference between the independent variable and the

358 dependent variables, after controlling for the continuous covariate, age and the
 359 nominal covariates, gender, education levels, income levels, and marital status.

360

361

Results

362 Descriptive statistics and data screening

363

364 Table 2 shows descriptive statistics for all scales. As shown in Table 2, the

365 participants with dyslexia had higher scores than controls on all measures.

366 **Table 2. Adjusted Means and Standard Deviations of Scores**

367

Scale	Dyslexia Group	Controls
IAT	40.87 (4.21)	35.78 (4.36)
IGDS-SF9	19.82 (2.21)	16.55 (2.29)
BSMAS	15.41 (1.50)	14.23 (1.55)

368 *Standard deviations are presented in parenthesis. IAT = Internet Addiction Test;*
 369 *IGDS-SF9 = Internet Gaming Disorder Scale, Short Form (9); BSMAS = Bergen*
 370 *Social Media Addiction Scale.*

371

372 A Pearson ~~product-moment~~ correlation was initially run to check for

373 multicollinearity among the dependent variables. While the correlation between GIA

374 and IGD was $r = .61$ and between SMA and IGD was $r = .49$, the correlation between

375 GIA and SMA was $r = .77$. This was deemed to be too high, compared to the acceptable

376 range of around $r = .8$ for multicollinearity (594). This suggested that general and

377 specific internet addictions were not sufficiently independent. Hence it was decided

378 that GIA would be isolated for an ANCOVA, while only SMA and IGD would be

379 included in the MANCOVA.

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ANCOVA for GIA

A one-way between subjects ANCOVA was performed to investigate ~~internet~~ ~~related~~ internet-related addictions among persons with and without dyslexia. The dependent variable was IA. The independent variable of interest was dyslexia diagnosis (no dyslexia vs dyslexia diagnosis). The covariates were age, gender, marital status, education, and income levels.

Initial screening of skewness for GIA (skewness = .54; $z = 3.78$) and GIA residuals (skewness = .62; $z = 4.34$) showed positive skewness a significant ~~K-S ($p = .00$) and Shapiro-Wilk (S-W)~~ test ($p < .001$). Visual inspection of the histograms suggested a moderate positive skew. A square root transformation of IA resulted in an approximately normal distribution of the residuals (skewness = -.02; $z = .15$) to within the +/- 1.96 range and produced a significant ~~Kolmogorov-Smirnov (K-S) ($p = .05$) and Shapiro-Wilk (S-W) ($p = .11$) tests~~ and thus indicated of normality. Visual inspection of the histogram and Q-Q Plot indicated a normal distribution. The linearity assumption was met. Levene's test of equality of error variance was also satisfactory ($p = .69$), indicating homogeneity of variances. The adjusted mean GIA score (untransformed) for the no dyslexia and dyslexia groups was 35.78 and 40.87 respectively. After square root transformation, this difference was statistically significant, after controlling for age, gender, income levels, employment, and education levels $F(1, 271) = 6.01, p = .0245$. The partial ETA squared (η^2p) was .02, thus a small effect. In terms of demographics, only age was negatively and significantly associated with GIA, untransformed $b = -.39, p < .001$ with a ~~partial ETA- η^2p~~ of .10 (small effect). For continuous variables like age,

404 this beta is interpreted for every one year-increase in age, GIA scores decrease by .39
 405 units. The other demographics were not significantly associated with GIA.
 406

407 **MANCOVA for SMA and IGD**

408
 409 A one-way between-subjects MANCOVA was performed to investigate SMA and IGD
 410 addictions among persons with and without dyslexia. The dependent variables were
 411 SMA and IGD. The independent variable of interest was dyslexia diagnosis (no
 412 dyslexia vs dyslexia diagnosis). The covariates were age, gender, marital status,
 413 education, and income levels.
 414

415 The initial screening of SMA's residuals showed moderate positive skewness
 416 (skewness = .31; $z = 2.16216$) and significant ~~K-S ($p = .05$) and S-W test ($p = .001$)~~.
 417 Visual inspection of the SMA residuals histogram suggested a slightly positive skew.
 418 A square root transformation of the SMA reduced the skewness of the residuals
 419 (skewness = .08; $z = .53$) to within the +/- 1.96 range though the ~~K-S ($p = .03$) test and~~
 420 ~~S-W ($p = .01$) test~~ was were still significant. However visual inspection of the histogram
 421 and Q-Q plots suggested a normal distribution. The linearity assumption was met. The
 422 initial screening of IGD residuals showed moderate positive skewness (skewness =
 423 1.01; $z = 7.06$) and a significant ~~K-S ($p < .001$) and S-W test ($p < .001$)~~. Visual
 424 inspection of the histogram suggested a moderately positive skew. An inverse
 425 transformation of the residuals improved the skewness of the residuals (skewness = -
 426 .22; $-z = 1.55$) although ~~the normality tests (K-S and S-W test, both was were~~ still
 427 significant ($p < .001$). The transformed histogram showed a modest negative skew.
 428 The linearity assumption was met.

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429 Multivariate outliers and normality were assessed using Mahalanobis distance (MD).
 430 Using the untransformed SMA and IGD, there was one multivariate outlier exceeding
 431 the critical value of 13.82 for two dependent variables (6055). However, using the
 432 appropriately square root transformed SMA and inverse transformed IGD resulted in
 433 no multivariate outliers. Homogeneity test was satisfactory; the Levene's Test of
 434 Equality of Error Variance was insignificant for the square root SMA (.57) and the
 435 inverse IGD (.08). The Box's Test of Equality of Covariance value was also
 436 insignificant ($F = .98, p = .54$), thus suggesting that the observed covariance matrices
 437 of the dependent variables are equal across groups.

439 After controlling for age, gender, income levels, employment, and education levels,
 440 there was a statistically significant difference between no dyslexia and dyslexia
 441 diagnosis on the combined appropriately transformed dependent variables, $F(2, 270)$
 442 $= 5.62, p < .001$, Wilk's Lambda = .96. The ~~partial eta squared $\eta^2 p$~~ was .04, suggesting
 443 a small effect. The multivariate model also showed that age, $F(2, 270) = 13.58, p <$
 444 $.001$, Wilk's Lambda = .91, ~~partial eta $\eta^2 p$~~ = .09, and gender, $F(6, 540) = 5.76, p <$
 445 $.001$, ~~partial eta $\eta^2 p$~~ = .06, Wilk's Lambda = .88, were statistically significant on the combined
 446 appropriately transformed dependent variables.

447
 448 The adjusted mean SMA (untransformed) for the no dyslexia and dyslexia groups was
 449 14.23 and 15.41 respectively. After square root transformation, this difference was not
 450 statistically significant, $F(1, 271) = 3.48, p = .06$. The ~~partial ETA squared $\eta^2 p$~~ was .01,
 451 thus a small effect. The adjusted mean IGD (untransformed) for the no dyslexia and
 452 dyslexia groups was 16.55 and 19.82 respectively. After inverse transformation, this

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453 difference was statistically significant, $F(1, 271) = 10.9, p < .001$. The ~~partial-ETA~~
 454 ~~squared- η^2p~~ was .04, thus a small effect.

456 The test between subjects effects also showed that gender was significant for SMA
 457 only, $F(3, 271) = 6.03, p < .001, \eta^2p \text{ ETA} = .06$, such that ~~males-men~~ had
 458 significantly lower mean SMA scores than ~~woman females~~ (untransformed adjusted
 459 means 11.75 and 14.33, respectively). The test between subjects effects also
 460 showed that age was negatively and significantly associated with SMA,
 461 untransformed beta = -.15, $p < .001, \eta^2p \text{ partial-eta} = .08$ and IGD, untransformed
 462 beta = -.14, $p < .001, \eta^2p \text{ partial-eta} = .03$. All other demographic variables were not
 463 significant.

465 Interactions

466
 467 A gender ~~x-by~~ dyslexia status interaction was included in the ANCOVA for GIA. This
 468 interaction was not statistically significant $F(1, 270) = .01, p = .94$. An age ~~x-by~~ dyslexia
 469 status interaction was included in the ANCOVA for GIA. Consistent with literature that
 470 older individuals have lower scores of GIA (Lozano-Blasco et al., 2020; MacMullin et
 471 al., 2016) the older controls showed lower score for GIA (29.08) relative to the younger
 472 controls (37.04). In contrast, the score for older participants did not seem to drop as
 473 much (38.95) as compared to younger participants with dyslexia (40.84).
 474 ~~However;However,~~ the statistical trend was not significant for the interaction, $F(1, 270)$
 475 ~~$= 3.41, p = .07, (2, 269) = 1.97, p = .14, Wilks-Lambda = .99$~~ . An age ~~x-by~~ dyslexia status
 476 interaction was included in the MANCOVA for SMA and IGD. This interaction was not
 477 statistically significant

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478 $F(2, 269) = .52, p = .60, \text{Wilk's Lambda} = 1.00$

479

480

Discussion

481 This study aimed to examine if differences exist in General Internet Addiction (GIA),
482 Internet Gaming Disorder (IGD), and Social Media Addiction (SMA) between those
483 with and without dyslexia in a UK population after controlling for age, gender, marital
484 status, employment, and income levels. Findings showed a significant difference for
485 GIA and GD, but no significant difference was found for SMA.

486

487 The finding that adults with dyslexia had significantly higher levels of GIA as compared
488 to controls supports the first hypotheses. This finding is also supportive of studies
489 reporting a significant relationship between GIA and other learning disabilities such as
490 ASD (8, 10) and ADHD (9). The present study ~~is able to can~~ extend this literature by
491 showing that dyslexia in addition to ASD and ADHD is associated with GIA, suggesting
492 that this may be a common factor in learning disabilities.

493

494 The second hypothesis was also supported as results showed that participants with
495 dyslexia had significantly higher levels of IGD than controls. Again, this finding is
496 supportive of studies which have shown a correlation between IGD and other learning
497 disabilities such as ASD (10) and ADHD (14). Hence the results in the present study
498 extend these findings to dyslexia, and again suggest this may be a common factor in
499 learning disabilities.

500

501 However, the third hypothesis was not supported by the results. It was expected that
502 those with dyslexia would score significantly lower on SMA than controls, however,
503 although it did not reach significance, participants with dyslexia ~~actually scored~~ scored
504 slightly higher than controls on SMA. There are ~~a number of~~ several possible
505 explanations for these findings. It may be that those with dyslexia are effectively
506 employing coping strategies ~~(such as using external resources like search engines for~~
507 ~~spell checking)~~ when using social media. ~~_~~ This may have allowed them to mitigate
508 their deficits in writing and reading and still participate in social media activities
509 meaningfully, such that having a dyslexia diagnosis neither increases nor decreases
510 the risk of SMA relative to controls. Hence the results are supportive of studies hinting
511 at such compensating strategies adopted by these users (e.g., ~~6156~~, ~~3530~~, ~~364~~).
512 Another explanation could be that the types of social media used by the participants
513 in this study is not largely written ~~such as based like~~ Twitter ~~or Facebook, but~~ Facebook
514 ~~but~~ could be picture or video based such as Instagram, TikTok or YouTube. ~~Indeed,~~
515 ~~research already shows that those with dyslexia use YouTube as a coping strategy to~~
516 ~~learning~~ learn new information (36). ~~TikTok in particular has seen a large rise in~~
517 ~~usership in recent years, especially amongst adolescents and younger adults (62),~~
518 ~~and research into this area needs to reflect this change in how we use social media.~~
519 ~~Thus~~ Thus, future studies could consider if there are differences in the different types
520 of social media used by those with dyslexia.

521

522 Given that SMA scores were not significantly higher in the dyslexia group, this
523 suggests that not all learning difficulties are associated with social media addiction.
524 Though ADHD may be correlated with SMA (~~6156~~) studies show this is not necessarily
525 the case for ASD (~~163~~), and the results of this study indicate this may not be the case

526 for dyslexia either. This suggests that, unlike IGD and GIA, SMA might not be a
527 common factor across learning disabilities and instead it could depend on the
528 characteristics of the specific condition. For instance, it is perhaps the language
529 defects seen in ASD including challenges with learning to read (6357) and spelling
530 (6458) that may limit these individuals' social media usage in a similar way
531 to those dyslexia-.

532

533 In terms of social demographics, the univariate and multivariate results showed that
534 age was negatively and significantly associated with GIA, SMA, and IGD. This is in
535 line with literature that has suggested that age is significantly correlated with GIA
536 (384), SMA (395), and IGD (395). In this study, only gender and SMA showed
537 statistical significance, such that the female gender was significantly associated with
538 SMA. This is also in line with previous studies (454).

539

540 No interactions were found for gender by dyslexia for GIA, gender by dyslexia for SMA
541 and IGD, age by dyslexia for SMA and IGD. However, age by dyslexia for GIA showed
542 a statistical trend. Consistent with literature that older individuals have lower scores of
543 GIA, the older controls showed lower score for GIA relative to the younger controls. In
544 contrast, the score for older participants did not drop as much as compared to younger
545 participants with dyslexia. This appeared to suggest that age does not moderate GIA
546 levels among those with dyslexia, however the relationship approached but did not
547 reach statistical significance. It is possible that this study was not adequately powered
548 to test for such an interaction effect. Future studies could test this relationship again
549 with larger samples.

550 Taken together the main findings may suggest that internet addiction ~~is~~may more
551 prevalent in those ~~be a "hidden problem" for adults~~ with dyslexia. ~~This said, it must be~~
552 noted that although those with dyslexia were found to have higher levels of GIA and
553 IGD this did not fall within pathological levels, with group means suggesting only a mild
554 addiction. Therefore, although those with dyslexia might be more likely to show
555 addictive behaviour this is not necessarily a cause for concern. Moreover, it should
556 also be noted that in all three scales, standard deviations show that the two groups
557 are highly overlapping, and differences are only statistically significant after square
558 root transformations therefore suggesting that, although significant, these differences
559 are small.

560

561 ~~T~~The current study was preliminary with the aim of exploring if differences exist
562 compared with controls. The findings suggest that this is an area that now warrants
563 further attention. It is possible that the widely reported challenges those with dyslexia
564 face at work, and the accompanying emotional disturbances (5) may be further
565 aggravated by levels levels of internet ~~addictions, or~~addictions or may be pushing
566 them towards higher levels of internet addictions. It is therefore important that future
567 work explores the mechanisms behind these relationships. Additionally, as age is
568 believed to be inversely related to such addictions, it is important for professionals
569 working with younger people who have dyslexia to ~~be~~ consider such matters in their
570 assessments and interventions. Future studies could also focus on younger
571 populations to see if the findings extend to adolescents and children. Also, studies
572 could examine more directly the relationships between such addictions and spelling
573 difficulties and information integration.

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574 A key limitation of this study is the cross-sectional nature which precludes conclusions
575 over causality and direction and does not tell us anything about how these
576 relationships operate. One possible explanation for the link between internet
577 addictions ~~additions~~ and learning disabilities is that learning disabilities may lead to
578 mental health issues, which in turn lead to internet addictions (see 263), or even that
579 mental health mediates the relationship. As this was a preliminary investigation
580 exploring this is beyond the scope of this study and here, to avoid confounding effects,
581 we limited participation only to those who did not have active mental health. This said,
582 it is certainly possible that in our sample, -anxiety and depression presenting presented
583 at sub-clinical levels or was undiagnosed. To explore this further, future research may
584 wish to study self-esteem and anxiety (commonly associated with dyslexia; 244) which
585 may explain a larger amount of variance related to levels of internet addictions or even
586 play a mediating role in the relationship. In doing this the research would be able to
587 understand further how these relationships operate. Additionally, we did not check for
588 the presence of dysgraphia (a writing disability that causes a person's writing to be
589 distorted or incorrect which can be co-morbid with dyslexia; 65) in our sample. A
590 comorbid diagnosis of dysgraphia could further complicate the relationship between
591 dyslexia and internet-based addictions, in particularly SMA, and this should therefore
592 be explored in future work.

593

594 Despite this limitation this study has made a notable contribution to this research area
595 showing that in addition to ASD and ADHD, dyslexia is also related to GIA and IGD.
596 This is important because these findings suggest that internet addictions (at least GIA
597 and IGD) are likely to impact a much larger ambit of people than previously assumed
598 (not just ASD and ADHD). Hence further attention is warranted because if significant

599 relationships between dyslexia and GIA, ~~SMA~~ and IGD are detected early, then
600 interventions can be undertaken to manage such problems for this group.

601

602 In conclusion, this study was a preliminary investigation into possible differences in
603 terms of GIA, IGD and SMA between those with and without dyslexia in a UK
604 population. Controlling for age, gender, marital status, ~~employment~~employment, and
605 income levels, it was found that adults with dyslexia had higher levels of GIA and
606 IGD as compared controls. However, these participants did not show any significant
607 difference in terms of SMA. The results indicate that internet addictions may have a
608 larger ambit for learning disorders beyond just ASD and ADHD and is a hidden
609 problem for users with dyslexia.

610

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613

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Date: 11th Nov 2022
Your reference: PONE-D-22-2124
Title: A preliminary study into internet related addictions among adults with dyslexia
Journal: PLOS ONE

Dear Editor,

RESPONSE TO REVIWERS DATED [12 Oct 2022]

We would like to thank the reviewers for their comments, which have helped improve the manuscript. Please see our categorical responses in red to the comments from both the reviewers. Please note in addition to these changes suggested by the reviewers we have also made some grammar and proof reading amendments.

Response set 1

1.0 Reviewer #1: The manuscript describes a technically sound piece of scientific research with data that supports almost all conclusions.

The data provided supports almost all conclusions, as noted in the review, data considering age is required from Authors. The manuscript is presented in an intelligible fashion and written in standard English.

We thank the reviewer for their kind comments. Age is now included see lines 284-285.

Response set 2

Introduction

2.1 Page 3: "There are several reasons to suspect that dyslexia might be associated with these types of additions." The authors should further explain in the manuscript what they mean by several reasons.

This has been edited in order to make it clear that reason the link is likely is because research shows this relationship in other similar populations, please see lines 76-78.

2.2 Page 4, paragraph 2: The Authors explain how mental health issues as consequences of ASD and ADHD may lead to internet addictions. In order to do so, they line up articles about anxiety, depression and low self-esteem in children with ASD and ADHD, and depression and anxiety as antecedent factors for internet related addictions. Importantly, the Authors base their hypotheses on these associations, as they imply that there is a similar association between dyslexia and internet related addictions. A more thorough explanation of how learning disabilities and internet related addictions might be associated is necessary, especially that the current data focuses on adults and some of the literature is about children.

We thank the reviewer for this comment and believe the changes we have made in order to address this have strengthened this section of the manuscript. See lines 82 to 94 and 96 to 109.

2.3 Page 4, paragraph 3: A thorough and well written explanation about how SMA and dyslexia might be associated is presented. This would be necessary in the previous paragraph as well.

We believe that the changes that we have made to address the previous point have also addressed this. Additionally, we have now made some changes including a re-ordering of paragraphs in order to make our arguments clearer (see lines 183 to 229).

2.4 Page 6, paragraph 1: “Yet coping strategies may help mitigate the challenges and therefore research is needed to identify if those with dyslexia are susceptible to SMA, in the same way that those with ADHD are.” The Authors do not show literature or research on the comparison between ADHD and dyslexia, thus I suggest to take this comparison out.

This comparison has been removed.

2.5 Page 7, present study: Addiction is twice spelled as ‘addition’, please correct.

This has been corrected in lines 65, 67, 77, 85, 94, 242, 252, 253 and 577.

Methods

2.6 Page 8, participants: Authors state that all participants, including participants with dyslexia have no active mental health issues, however the assumption that dyslexia is relatable to internet addiction lies on the fact that people with dyslexia have higher levels of anxiety and depression. Was this controlled in the Prolific survey platform, and if so, how?

We acknowledge this point, which is a good one. Anxiety and depression may present as comorbid conditions with dyslexia but not always, and for this preliminary paper, to avoid confounding effects, we limited participation only to those who do not have active mental health. This said, it is certainly possible that in our sample anxiety and depression could be presenting at sub-clinical levels or be undiagnosed and therefore serve as partial mediators or moderators. However, as this is a preliminary study this goes beyond the scope of but paper. We do however, discuss this as potential areas for future research in the discussion and this section has been expanded for clarity see lines 579 to 583.

2.7 Page 9, sociodemographic characteristics of participants: Please provide age of participants as well.

Age is now included in lines 284- 285.

2.8 Page 9, sociodemographic characteristics of participants: Data is fitted according to marital status, income, education and employment, however gender is not balanced, as male participants are almost double (n=186) compared to female (n=100). If this is a general sociodemographic ratio, it would be important to mention this in the introduction and how it might effect the association between learning disabilities, mental health issues and internet addiction.

We agree with the reviewer. Gender/socio-demographics were already discussed in the introduction. However, this section has been expanded in light of this comment (see lines 239 – 246). Additionally, gender was controlled for in the study to ensure outcomes are not influenced by this

2.9 Page 11: Suggestion to use ‘Analyses’ instead of ‘Analytical strategies’ as subtitle.

Corrected to ‘Analyses’ (see line 350).

Results

2.10 Page12, Descriptive statistics and data screening: Descriptive statistics show that both dyslexia and control group fall into the ‘mild’ IA category, and neither group falls into the pathological category in either IGD or SMA. This is problematic, because in later phases of the manuscript, Authors state that dyslexia is related to IGD and IA, however IA is only mild for both groups, and IGD doesn’t reach pathological levels in neither of the two groups.

Although we agree with the reviewer’s sentiment, here we are consistent with the approach in the literature, in that such addictions are not categorical (addicted vs not addicted) but rather that such addictions lie on a dimension/continuum. Hence it is the levels of addictions that are being compared. Thus, for both scales, the higher the score, the higher the addictive behavior. However, in order to acknowledge the reviewer’s point we have added in a caveat to the discussion and toned our conclusion down somewhat (see lines 551-559).

2.11 The authors imply that the dyslexia group shows higher results in all three scales, however with the standard deviations in mind, the two groups are highly overlapping, differences are only statistically significant after square root transformations, which is explained later. These significant differences don’t imply that participants with dyslexia have IGD. Other than the comment above, results are clearly written and well explained.

We agree with the reviewer’s caution here. In addition to the above caveat, we have added a further caveat which we hope the reviewer feels addresses this point (line 565.)

2.12 Page 13, line 15: please correct ‘sccore’ to score

Amended in line 387.

Discussion

2.13 Page 19 paragraph 2: it is not clear from the manuscript what the Authors mean by 'hidden problem' particularly for people with learning disabilities. Please explain this a bit more in the introduction and the discussion of the manuscript.

We agree with the reviewer that phrasing was confusing, we have therefore changed it for clarity (see line 551).

2.14 Page 20, paragraph 2: IGD scores are higher for participants with dyslexia, however concerning the level of scores on the scales, it seems slightly far-fetched to state that it is related to an actual addiction.

Here we are arguing that there is a statistical difference in terms of levels of IGD between both groups, with the scales suggesting that higher scores are indicative of higher levels of addiction. For clarity on this we have added the word "levels" to line 565.

2.15 Page 20, paragraph 2: "Hence further attention is warranted because if significant relationships between dyslexia and GIA, SMA and IGD are detected early, then interventions can be undertaken to manage such problems for this group.". Importantly, this preliminary study SMA was not higher for participants with dyslexia, therefore it is suggested to exclude it from this assumption.

SMA has now been removed in line 599.

Response set 3

Introduction:

3.1. Introduction should include a clear definition of dyslexia.

We had already included a definition, but we have rewritten the sentence for clarity (see lines 71-74).

3.2 The authors state that there are diverse results on the relationship between SMA and ASD. Could it be due to the different age groups (and probably different severity of the condition) used in the cited studies (children vs adolescents vs adults), and that different age groups use social media for different purposes? Moreover, it seems to be reasonable that for adults with ASD using written online communication to connect others might be more convenient than for example a phone call or a personal contact

The section on ASD and SMA has now been expanded to address these comments (see lines 104-109).

Methods and results:

3.3. Did the authors check the presence of dysgraphia as well? As persons with dysgraphia might have also serious difficulties with typing in addition to the handwriting, one can hypothesize that this condition is also related to problematic internet and social media usage. Moreover, as authors argue that dyslexia affects writing and spelling skills, the simultaneous presence of dysgraphia (which is quite common) could enhance anxiety when using social media based on writing.

This was outside of the scope of the current preliminary study. However, as the reviewer states, this certainly warrants future investigation. We have therefore added a discussion of this see lines 587-592.

3.4. Page 9, Table 1: how can be the percentage of the widowed/divorced participants 829% of the sample? I think that this might be a typo.

This was a typo error it now reads 8 (see Table 1 in line 299).

3.5 Page 12: What was the reason that SMA and IGD ($r=.49$) were submitted into the MANOVA while there was a stronger correlation between GIA and SMA ($r=.77$)? Does IA and GIA refer to the same construct? If yes, these abbreviations should be consistent.

Pallant, (2020)'s recommendation is that "correlations up around .8 and .9" are reason for concern and that when this is the case you need to consider removing one variable. Hence, we felt that .77 was approaching .8 and it would be better to isolate GIA from SMA and IGD. We have made this decision clearer in the manuscript see lines 375-379.

In relation to the abbreviations. Indeed, IA and GIA are the same construct, and this was a consistency error. Changes have now been made to address this in lines 305, 375, 378.

3.6 - Page 13: $p = .05$ and $p = .11$ are not significant results of normality tests, suggesting that the distribution of the data met normality.

Here we meant after transformation. We agree with the reviewer that the previous wording was confusing and have therefore edited for clarity (see the paragraph beginning on line 388).

3.7 Do beta values reflect the differences between groups or do they reflect something else? The authors should clarify.

They reflect between groups; this has now been clarified in lines 403-405.

3.8 There are many inconsistencies in reporting results. When reporting p values, instead of $p = .00$ authors should report either the exact p value or $p < .001$.

This has been correct throughout the manuscript.

Similarly, authors either use partial ETA square or eta or partial eta in the manuscript. I think that the authors should be more consistent (especially if these expressions are the same), and that would be simpler and more parsimonious to use η^2_p .

We agree and have changed to η^2_p throughout.

3.9 - The authors argue that the lack of predicted effects might be due to the low level of statistical power of the study. Indeed, calculating post-hoc sensitivity analysis could better underpin this statement.

While post-hoc power analysis could provide exact power, its computation is complex (not estimable with G-power) and beyond the scope of this paper. We believe the reader would accept our argument that a marginally significant p value could become more significant with more participants, which was what we explicitly stated when we wrote in lines 548-549 "Future studies could test this relationship again with larger samples".

Discussion

3.10 - The authors argue that participants with dyslexia might use compensational strategies when using social media. Although some strategies (e.g., spelling and grammar check) are mentioned in the Introduction, it would be helpful to reflect to these strategies again in a more exact way.

A reference to this has now been added to the discussion (see lines 514-519).

3.11 - The authors also state that the type of social media (visual such as Instagram or TikTok) or verbal (such as Twitter or Facebook) might influence results. As there is mentioned in the Introduction that persons with dyslexia prefer YouTube videos for learning, I think that the potential role of the dominating type of social media platforms in the null effect should be emphasized more in in the manuscript.

A reference to this and short discussion has now been added to the discussion (see lines 514-520).

Minor comments

3.12 - Page 5: "Google" should be written instead of "Goggle"

Corrected in line 206.

3.13 Page 13: authors wrote “sccore” instead of “score”

Corrected in line 297.

3.14 The number of decimals is not consistent across the manuscript.

This has now been correct so that we always round to 2 decimal places.

3.15 Interactions would be easier to read in the format e.g., “age x dyslexia status” instead of “age by dyslexia status”.

This has been corrected in lines 467, 468, 475.

3.16 - I suggest to write “Wilk’s” instead of “Wilk”.

This has been corrected throughout.

3.17 - There should be a space between the two degrees of freedom in ANOVA results.

This has been corrected throughout.

3.18 - Why did the authors apply both Shapiro-Wilk and Kolmogorov-Smirnov tests for normality testing while only one of these should be efficient? Furthermore, the full name of the tests should be marked at the first appearance in the text before using abbreviations.

Shapiro-Wilk test was retained, and the Kolmogorov-Smirnov test was removed. Additionally, the full name of the test was given at the first appearance (see line 389–394).

3.19 - Page 15: there is a missing “b” in “lambda”.

Lambda has been corrected in lines 444-445.

Response set 4 (journal requirements)

4.1. Please ensure that your manuscript meets PLOS ONE's style requirements, including those for file naming. The PLOS ONE style templates can be found at https://journals.plos.org/plosone/s/file?id=wjVg/PLOSONe_formatting_sample_main_body.pdf and

https://journals.plos.org/plosone/s/file?id=ba62/PLOOne_formatting_sample_title_authors_affiliations.pdf

We have made some formatting changes to the manuscript so that formatting is in line with the PLOS ONE style templates. This includes changes to headings and tables.

2. Please change "female" or "male" to "woman" or "man" as appropriate, when used as a noun (see for instance <https://apastyle.apa.org/style-grammar-guidelines/bias-free-language/gender>).

These changes have been made throughout.

3. Thank you for stating the following financial disclosure:

"The cost of recruiting the participants was sponsored by a donor."

At this time, please address the following queries:

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As outlined above we will now upload the data set as a supporting information file and this is outlined in the cover letter.