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A preliminary study into internet related addictions among adults with dyslexia

--Manuscript Draft--

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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.
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	Suresh Kumar, MSc
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Opposed Reviewers:	
Response to Reviewers:	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 η2p.

	We agree and have changed to η2p 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/PLOSOne_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: 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. 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." c) If any authors received a salary from any of your funders, please state which authors and which funders. d) If you did not receive any funding for this study, please state: "The authors received no specific funding for this work." Please include your amended statements within your cover letter; we will change the online submission form on your behalf. These have been addressed in the cover letter. 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. This have been addressed in the cover letter. 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. In your revised cover letter, please address the following prompts: 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. 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. We will update your Data Availability statement on your behalf to reflect the information you provide. There are no restrictions and therefore we will upload the data set as a supporting information file. 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. As outlined above we will now upload the data set as a supporting information file and this is outlined in the cover letter.
Additional Information:	
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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Competing Interests Use the instructions below to enter a competing interest statement for this submission. On behalf of all authors, disclose any competing interests that could be perceived to bias this work—acknowledging all financial support and any other relevant financial or non-financial competing interests. This statement is required for submission and **will appear in the published article** if	The authors have declared that no competing interests exist.

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Ethics Statement Enter an ethics statement for this submission. This statement is required if the study involved: • Human participants • Human specimens or tissue • Vertebrate animals or cephalopods • Vertebrate embryos or tissues • Field research Write "N/A" if the submission does not require an ethics statement. General guidance is provided below. Consult the submission guidelines for detailed instructions. **Make sure that all information entered here is included in the Methods section of the manuscript.**	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.

Format for specific study types **Human Subject Research (involving human participants and/or tissue)** • Give the name of the institutional review board or ethics committee that approved the study • Include the approval number and/or a statement indicating approval of this research • Indicate the form of consent obtained (written/oral) or the reason that consent was not obtained (e.g. the data were analyzed anonymously) **Animal Research (involving vertebrate animals, embryos or tissues)** • Provide the name of the Institutional Animal Care and Use Committee (IACUC) or other relevant ethics board that reviewed the study protocol, and indicate whether they approved this research or granted a formal waiver of ethical approval • Include an approval number if one was obtained • If the study involved *non-human primates*, add *additional details* about animal welfare and steps taken to ameliorate suffering • If anesthesia, euthanasia, or any kind of animal sacrifice is part of the study, include briefly which substances and/or methods were applied **Field Research** Include the following details if this study involves the collection of plant, animal, or other materials from a natural setting: • Field permit number • Name of the institution or relevant body that granted permission	
Data Availability Authors are required to make all data underlying the findings described fully available, without restriction, and from the time of publication. PLOS allows rare exceptions to address legal and ethical concerns. See the PLOS Data Policy and FAQ for detailed information.	Yes - all data are fully available without restriction

A Data Availability Statement describing where the data can be found is required at submission. Your answers to this question constitute the Data Availability Statement and **will be published in the article**, if accepted. **Important:** Stating 'data available on request from the author' is not sufficient. If your data are only available upon request, select 'No' for the first question and explain your exceptional situation in the text box. Do the authors confirm that all data underlying the findings described in their manuscript are fully available without restriction?	
Describe where the data may be found in full sentences. If you are copying our sample text, replace any instances of XXX with the appropriate details. • If the data are **held or will be held in a public repository**, include URLs, accession numbers or DOIs. If this information will only be available after acceptance, indicate this by ticking the box below. For example: *All XXX files are available from the XXX database (accession number(s) XXX, XXX.*). • If the data are all contained **within the manuscript and/or Supporting Information files**, enter the following: *All relevant data are within the manuscript and its Supporting Information files.* • If neither of these applies but you are able to provide **details of access elsewhere**, with or without limitations, please do so. For example: *Data cannot be shared publicly because of [XXX]. Data are available from the XXX Institutional Data Access / Ethics Committee (contact via XXX) for researchers who meet the criteria for access to confidential data.* *The data underlying the results presented in the study are available from (include the name of the third party*	All relevant data are within the manuscript and its Supporting Information files.

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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

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A preliminary study into internet related addictions among adults with dyslexia

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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.

Introduction

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

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

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

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

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

The link between dyslexia and internet gaming seems likely. This is because online games typically do not involve writing and thus have fewer spelling demands.. 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 (27, 28). However, if this leads to high prevalence of IGD in this population is something which has yet to be explored. Hence this was akey aim of the present study.

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

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

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

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

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. 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 to 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. 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 (38) and SMA (39) with younger individuals showing higher levels

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

As for gender, literature suggests that womanare more likely to show SMA as opposed to men (45), while men are more likely to have a GIA (46) and IGD (47). As for ASD populations, these findings are shadowed with research showing that more men with ASD than woman play video-action games (48). Given these links, it is important that work into these internet addictions 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. Despite much evidence showing links to these types of addiction and other forms of learning disability no research has explored these forms of addiction in relation to dyslexia. Such research is warranted because if significant links between dyslexia and problematic internet usage are identified, early detection and targeted interventions can be formulated to mitigate risks for such this group.

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

Method

Design

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

Participants

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

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

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

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; 50). 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 to 79), mild (31 to 49) and no addiction or normal usage (0 to 30) (51). An independent study reported Cronbach's alpha (α) of .90, test-retest reliability of .83 and convergent validity range of .62–.84 (52). In the present study, α = .93 indicating excellent internal consistency.

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

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

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

Procedure

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. Participants then completed the questions on internet addiction, social media addiction, and internet gaming disorder IGD before providing demographic information (e.g., age, gender, and household income). Lastly, they reaffirmed their consent and viewed the project debrief information. Ethical approval was granted by the University of Derby research ethics committee (ETH2122-1830).

Analyses

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

Results

Descriptive statistics and data screening

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

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)

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

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

ANCOVA for GIA

A one-way between subjects ANCOVA was performed to investigate 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 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 S-W (p = .11) tests and thus indicated 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 $F(1, 271) = 6.01$, $p = .02$. 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 η^2p of .10 (small effect). For continuous variables like age, this beta is interpreted for every one year-increase in age, GIA scores decrease by .39 units. The other demographics were not significantly associated with GIA.

MANCOVA for SMA and IGD

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

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

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

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

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

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

Interactions

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

$F(2, 269) = .52$, $p = .60$, Wilk's Lambda= 1.00

Discussion

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

In conclusion, this study was a preliminary investigation into possible differences in terms of GIA, IGD and SMA between those with and without dyslexia in a UK population. Controlling for age, gender, marital status, employment, and income levels, it was found that adults with dyslexia had higher levels of GIA and IGD as compared 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 is a hidden problem for users with dyslexia.

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Anonymised data set

A preliminary study into internet related addictions among adults with dyslexia

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Abstract

In recent decades, studies have investigated associations between learning disorders such as Autism Spectrum Disorders (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, employmentemployment, 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.

Introduction

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

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

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

R~~Moreover, r~~esearch also shows a significant link between Social Media ~~Additi~~Addiction~~on~~ (SMA) and ADHD (15~~2~~), again perhaps because of the instant rewards social media can offer such as 'likes' from peers and other users. Yet the relationships between SMA and ASD is unclear; while one study (16~~3~~) found that children with ASD (n = 202) spent less time on social media than their typically developing siblings (n = 179), another study found no difference in time spent on social media among adolescents with and without ASD (ASD n = 24, control n = 26) (17~~4~~). ~~-~~Meanwhile, another study found that the majority of adults with ASD used social media to connect with others (18~~5~~) perhaps because they find social engagement through the written form more appealing and less challenging than engaging with peers orally such as face-to-face or over the phone, something that may

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

Despite some contradictory findings regarding SMA and ASD, taken together these research studies clearly highlight a link between ASD and ADHD and internet-based addiction ~~ditions~~. In addition to the ones already discussed, another explanation for this link may be due to ASD and ADHD triggering mental health conditions which are in turn a risk factor for internet addictions. For instance, ASD has reportedly induced anxiety (196), which is an antecedent for ~~internet-related~~internet-related addictions (2017, 2118, 2219). Similarly, children with ADHD present with anxiety, depression, and poor self-esteem (230, 241, 252). As dyslexia also triggers similar mental health issues, such as anxiety and low self-esteem (263), a similar relationship may exist between dyslexia GIA, IGD and SMA.

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

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

~~Nonetheless, while spelling deficits and information integration are major issues for those with dyslexia, anecdotal evidence suggests some do employ coping strategies when using the internet. One strategy for searching information is to use search engines (such as Google~~Goggle) ~~because they provide query suggestions and are tolerant of spelling errors (30). This type of strategy was reported in a qualitative study by Barden (2014) (n = 5) where participants with dyslexia talked positively about using Facebook and stated they coped with their spelling deficits by using external resources such as MS word and Google. Similarly, research with students has shown that despite struggling to integrate academic information across multiple sources as compared to their peers (n = 20), some undergraduates with dyslexia (n=13) went 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 to 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,~~ T~~t~~he 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 (27~~32~~, 28~~33~~). ~~Taking all of this evidence together it seems likely that online gaming might be very appealing for someone with~~

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

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

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

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. 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 to 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. 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 addictiontion. However, findings evidence are mixed for IGD (4036, 4137). Age is also shown to be negatively and significantly related to these types of addictiontion in both ASD and ADHD populations (4238, 4339, 440).

As for gender, literature suggests that womanfemales are more likely to show SMA as opposed to men males (451), 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.

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

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

Method

Design

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

Participants

Participants were recruited through Prolific (an online survey platform). In the first step, participants with dyslexia were recruited; the inclusion criteria ~~was~~ were a formal dyslexia diagnosis and no other learning disorders and no active ill mental health. A total of 141 participants with dyslexia completed the survey. In the second step, controls were recruited; the inclusion criteria ~~was~~were no dyslexia diagnosis, no other learning disorders and no active ill mental health. A total of 150 controls completed the survey. All participants were located in the UK and aged 18 and ~~above. The~~above. The mean age ~~age (standard deviation)~~ of controls and participants with dyslexia diagnosis was~~ere~~ 39.4 (*SD* = 14.5) and 43.2 (*SD* = 11.0) years old respectively. Participants were recruited between 22 and 25th February (2022) and were paid 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 ~~829~~
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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to 79), mild (31 to 49) and no addiction or normal usage (0 to 30) (5146). An independent study reported Cronbach's alpha (α) of .90, test-retest reliability of .83 and convergent validity range of .62–.84 (5247). In the present study, α = .93 indicating excellent internal consistency.

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

IGD was measured by the Internet Gaming Disorder Scale, Short-Form 9 (IGDS-SF9; 561). The measure includes 9 questions (e.g., "*Have you ever continued your gaming activity despite knowing it was causing problems between you and other people?)* rated on a five-point Likert scale, ranging from Never (1) to Very Often (5). The total score ranges from 9 to 45. A higher score indicates a higher likelihood of IGD. A score above 32 is indicative of pathological usage based on Qin (572) who suggested that

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

Procedure

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. Participants then completed the questions on internet addiction, social media addiction, and internet gaming disorder IGD before providing demographic information (e.g., age, gender, and household income). Lastly, they reaffirmed their consent and viewed the project debrief information. Ethical approval was granted by the University of Derby research ethics committee (ETH2122-1830).

~~Analytical Strategy~~ Analyses

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

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

Results

Descriptive statistics and data screening

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

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)

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

A Pearson ~~product-moment~~product-moment correlation was initially run to check for multicollinearity among the dependent variables. While the correlation between GIA and IGD was *r* = .61 and between SMA and IGD was *r* = .49, the correlation between GIA and SMA was *r* =.77. This was deemed to be too high, compared to the acceptable range of *around r* = .8~~.70~~ for multicollinearity (594). This suggested that general and specific internet addictions were not sufficiently independent. Hence it was decided that GIA would be isolated for an ANCOVA, while only SMA and IGD would be 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-Willk (~~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 s~~c~~core (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* = .02~~15~~. 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,

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

MANCOVA for SMA and IGD

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

The initial screening of SMA's residuals showed moderate positive skewness (skewness = .31; z = 2.162~~16~~) and significant ~~K-S (p= .05) and~~ S-W test (p = .001). Visual inspection of the SMA residuals histogram suggested a slightly positive skew. A square root transformation of the SMA reduced the skewness of the residuals (skewness = .08; z = .53) to within the +/- 1.96 range though the ~~K-S (p = .03) test and~~ S-W (p = .01) test was ~~were~~ still significant. However visual inspection of the histogram and Q-Q plots suggested a normal distribution. The linearity assumption was met. The initial screening of IGD residuals showed moderate positive skewness (skewness = 1.01; z = 7.06) and a significant ~~K-S (p< .001) and~~ S-W test (p < .001). Visual inspection of the histogram suggested a moderately positive skew. An inverse transformation of the residuals improved the skewness of the residuals (skewness = -.22; -z = 1.55) although the ~~normality tests (K-S and~~ S-W test~~, both~~ was ~~were~~ still significant (p < .001). The transformed histogram showed a modest negative skew. The linearity assumption was met.

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

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

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

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

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

Interactions

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

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F(2, 269) = .52, *p* =.60, Wilk's Lambda= 1.00

Discussion

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

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

The second hypothesis was also supported as results showed that participants with dyslexia had significantly higher levels of IGD than controls. Again, this finding is supportive of studies which have shown a correlation between IGD and other learning disabilities such as ASD (10) and ADHD (1~~4~~1). Hence the results in the present study extend these findings to dyslexia, and again suggest this may be a common factor in learning disabilities.

However, the third hypothesis was not supported by the results. It was expected that those with dyslexia would score significantly lower on SMA than controls, however, although it did not reach significance, participants with dyslexia ~~actually scored~~scored slightly higher than controls on SMA. There are ~~a number of~~several possible explanations for these findings. It may be that those with dyslexia are effectively employing coping strategies (such as using external resources like search engines for spell checking) when using social media. ~~–~~This may have allowed them to mitigate their deficits in writing and reading and still participate in social media activities meaningfully, such that having a dyslexia diagnosis neither increases nor decreases the risk of SMA relative to controls. Hence the results are supportive of studies hinting at such compensating strategies adopted by these users (e.g.,61~~56~~, 35~~30~~, 36~~1~~). Another explanation could be that the types of social media used by the participants in this study is not largely written such as ~~based like~~ Twitter or ~~Facebook, but~~Facebook but could be picture or video based such as Instagram, TikTok or YouTube. Indeed, research already shows that those with dyslexia use YouTube as a coping strategy to ~~learning~~learn new information (36). TikTok in particular has seen a large rise in usership in recent years, especially amongst adolescents and younger adults (62), and research into this area needs to reflect this change in how we use social media. ~~F~~~~Thus~~Thus~~, f~~uture studies could consider if there are differences in the different types of social media used by those with dyslexia.

Given that SMA scores were not significantly higher in the dyslexia group, this suggests that not all learning difficulties are associated with social media addiction. Though ADHD may be correlated with SMA (61~~56~~) studies show this is not necessarily the case for ASD (16~~3~~), and the results of this study indicate this may not be the case

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

In terms of social demographics, the univariate and multivariate results showed that age was negatively and significantly associated with GIA, SMA, and IGD. This is in line with literature that has suggested that age is significantly correlated with GIA (384), SMA (395), and IGD (395). In this study, only gender and SMA showed statistical significance, such that the female gender was significantly associated with SMA. This is also in line with previous studies (451).

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

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

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

A key limitation of this study is the cross-sectional nature which precludes conclusions over causality and direction and does not tell us anything about how these relationships operate. One possible explanation for the link between internet addictions ~~additions~~ and learning disabilities is that learning disabilities may lead to mental health issues, which in turn lead to internet addictions (see 2~~63~~), or even that mental health mediates the relationship. As this was a preliminary investigation exploring this is beyond the scope of this study and here, to avoid confounding effects, we limited participation only to those who did not have active mental health. This said, it is certainly possible that in our sample, ~~-~~anxiety and depression ~~presenting~~ presented at sub-clinical levels or was undiagnosed. To explore this further, future research may wish to study self-esteem and anxiety (commonly associated with dyslexia; 2~~41~~) which may explain a larger amount of variance related to levels of internet addictions or even play a mediating role in the relationship. In doing this the research would be able to understand further how these relationships operate. Additionally, we did not check for the presence of dysgraphia (a writing disability that causes a person's writing to be distorted or incorrect which can be co-morbid with dyslexia; 65) in our sample. A comorbid diagnosis of dysgraphia could further complicate the relationship between dyslexia and internet-based addictions, in particularly SMA, and this should therefore be explored in future work.

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

In conclusion, this study was a preliminary investigation into possible differences in terms of GIA, IGD and SMA between those with and without dyslexia in a UK population. Controlling for age, gender, marital status, ~~employment~~employment, and income levels, it was found that adults with dyslexia had higher levels of GIA and IGD as compared 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 is a hidden problem for users with dyslexia.

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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 η2p.

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/PLOSOne_formatting_sample_main_body.pdf and

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

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.

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."

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Please include your amended statements within your cover letter; we will change the online submission form on your behalf.

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