Revisiting the Relationship Between Cybercrime, Autistic Traits, and Autism

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We thank Kathryn Seigfried-Spellar for providing us with the full version of the CCI-R.

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The data from the study are available at https://osf.io/w8vue/

Author Contributions

AL developed the software, supervised data collection, conducted data analyses, and wrote the original draft. NB developed the study concept and design, provided guidance on data analyses and critical manuscript revisions. RLY provided comments on the manuscript. All authors approved the final version of the paper for submission.

Funding

This research was supported by ARC DP 190100162 and the Hamish Ramsay Fund.

Compliance with Ethical Standards

The authors have no conflicts of interest to disclose.

This study was approved by the Flinders University Social and Behavioral Research Ethics Committee (Project No. 5724). All procedures used in this study adhere to the tenets of the Declaration of Helsinki (1964).

Informed consent was obtained from all individual participants included in the study.

Abstract

Reports of cybercrime being committed by people on the autism spectrum often imply that autism may be more prevalent among cybercriminals than the general population, although this remains unproven. In an online survey of 302 participants, we found that autistic individuals (n = 25) were more likely to report engagement in cybercrime than non-autistic individuals, but this relationship was not mediated by advanced digital skills or deficits in theory of mind. Furthermore, independent of autism diagnosis, autistic traits were not significantly associated with self-reported cyber-criminality. We propose that there may be additional factors moderating the relationship between autism, autistic traits, and cybercrime, such as specific autistic characteristics, understanding of cybercrime, and willingness to disclose criminal activity.

Keywords: autism, autistic traits, cybercrime

Revisiting the Relationship Between Cybercrime, Autistic Traits, and Autism

In 2001, 36-year-old Gary McKinnon, using the handle "Solo," hacked into the computer systems of the U.S. Army, Navy, Air Force, NASA, and Department of Defense from his apartment in London. In 2013, 28-year-old Lauri Love masterminded a break-in of the U.S. Sentencing Commission website to protest the "persecution" of hackers, while Adam Mudd, who was just 16 years old at the time, developed malware that he then sold to international cybercriminals, resulting in 1.7 million cyberattacks. All three hackers received a diagnosis of Asperger's syndrome after their arrest, which subsequently featured in their defense during the trial. These cases are just a few examples of a growing number of reports of autism and cybercrime that have sparked an interest among researchers and law-enforcement agencies alike. Indeed, a report by the UK's National Crime Agency (2017) suggests there may be higher rates of autism among cybercriminals than found in the general population, although this remains unproven.

Defining Cybercrime

Rather than referring to a single act, cybercrime is an umbrella term that refers to any illegal activity involving the use of computers or information technology (Clough, 2012; Donalds & Osei-Bryson, 2019). The wide scope of activities that could fall in this category means that there is currently no single definition of cybercrime that is universally accepted (Donalds & Osei-Bryson, 2019). The first and only international treaty on cybercrime, The Council of Europe Convention on Cybercrime (2001), specifies four broad categories of offences deemed to constitute cybercrime: (1) offences against the confidentiality, integrity and availability of computer data and systems (e.g., dishonest access to a computer system, dishonest transmission of computer data, unauthorized alteration of computer data, unauthorized and intentional damaging of computer systems, unauthorized procurement or distribution of a device or passwords), (2) computer-related offences (e.g., computer-related

forgery, computer-related fraud), (3) content-related offences (e.g., child pornography), and (4) offences related to infringements of copyright and related rights (e.g., digital piracy).

Autism and Cybercrime

Several explanations for a possible link between autism and cybercrime have been suggested. One is that the superior systemizing abilities of people on the autism spectrum mean that they have increased potential to develop advanced computer and technological skills (Baron-Cohen et al., 2003). The notion that people on the autism spectrum are overrepresented in the field of science and technology was first popularized by Baron-Cohen et al. (1997). They surveyed parents of children with developmental disorders and found that fathers of children with autism were significantly more likely to have an occupation in engineering than fathers of children with other developmental disorders such as Tourette's syndrome, Down's syndrome, or language delays, or typically developing children. Baron-Cohen et al. (1997) reasoned that a preference for working with objects and systems rather than people may be part of the broad autistic phenotype. In the two decades that followed, the relationship between autistic traits and STEM occupations was replicated across a number of similar studies (Baron-Cohen et al., 2007; Baron-Cohen, Wheelwright, Skinner, et al., 2001; Billington et al., 2007; Wei et al., 2013), including, most notably, a survey of half a million people in the UK (Ruzich et al., 2015). Though the argument that people on the autism spectrum have an innate predisposition to developing advanced computer skills is intuitively appealing, the research to support Baron-Cohen et al.'s (1997) claims is not without its criticisms. For example, critics have highlighted the lack of replication of Baron-Cohen et al.'s findings, the reliance on subjective self-report measures, and the almost exclusive focus on autistic individuals of high intelligence (Buchen, 2011). Nevertheless, the suggestion that technical skills are associated with traits of autism appears to have gained momentum.

If it is true that autistic people are overrepresented in the statistics surrounding cybercrime, this predisposition to engage in technology is just one possible explanation. Another possible explanation is that people on the autism spectrum may be more vulnerable to naïve involvement in criminal activity due to deficits often associated with autism, such as theory of mind (Brewer & Young, 2015; Howlin, 2004). Theory of mind refers to the ability to infer the mental states, or take the perspective, of others (Premack & Woodruff, 1978). Research has found that at least some adults on the autism spectrum perform more poorly on tasks that require theory of mind compared to neurotypical individuals (Baron-Cohen et al., 1999; Baron-Cohen, Wheelwright, Hill, et al., 2001; Happé, 1994; Zalla et al., 2009). It has been hypothesized that difficulties in taking the perspective of others may cause autistic people to lack awareness of the impact of their behavior on others and thus fail to understand the wrongfulness or severity of cybercrime. Though it might be argued that the anonymity provided by online platforms means that *all* cybercriminals are less likely to consider the impact of their behavior on others, this tendency may be more pronounced for autistic individuals due to their difficulties with perspective taking. In addition, it may also be that such deficits make people on the autism spectrum more susceptible to being exploited or misled by cybercriminals as they may have difficulty detecting the underlying motives of others (Brewer & Young, 2015).

A survey conducted by Ledingham and Mills (2015) of eight international law-enforcement agencies revealed that, although autistic people have been involved in cybercrime, information on current prevalence rates is lacking, and there is no empirical evidence to suggest that people on the autism spectrum are engaged in cybercrime at a higher rate than the general population. To test this hypothesis, Seigfried-Spellar et al. (2015) conducted an online survey of 296 college students and examined the relationship between scores on the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, et al.,

2001)—a measure of autistic traits—and engagement in four types of cybercrime: virus writing, identity theft, hacking, and cyberbullying. Students who had engaged in virus writing, identity theft, or cyberbullying had significantly higher scores on the AQ than those who had not, but there was no difference in level of autistic traits between students who had engaged in hacking and those who had not. While these results lend some empirical support to the hypothesized relationship between autism and certain types of cybercrime, an important caveat is that the AQ is a measure of autistic traits and not a diagnostic tool for autism. This distinction is significant as it has been suggested that there may be qualitative differences between those with a clinical diagnosis of autism and those who have high levels of autistic traits but do not meet the criteria for diagnosis (Ashwood et al., 2016; Frith, 2014; Lundqvist & Lindner, 2017). Mottron and Bzdok (2020) argue that many behaviors that are referred to as "autistic traits" are socialization features that are not autism-specific. They suggest that, for a particular trait to be attributed to autism, it must occur in conjunction with all other diagnostic criteria that make up the autism profile. The term "autistic trait" may thus be a misnomer if the individual's behavior is examined in isolation from the broader context in which it occurs, as "all striped animals are not tigers, and all stripes are not tiger stripes" (Mottron & Bzdok, 2020, p. 3181).

Payne et al. (2019) highlight that another limitation of Seigfried-Spellar et al.'s (2015) study was that it did not distinguish between cyber-dependent crime (crimes that can only be carried out using computer technology, such as hacking) and cyber-enabled crime (online variants of crimes that can also be carried out offline, such as identity theft). Payne et al. (2019) argue that there are differences in the motivation for engaging in each of these types of crime, and that, consequently, the characteristics of individuals who do so may also differ. Unlike cyber-enabled crime, cyber-dependent crime is commonly motivated by a sense of challenge, accomplishment, and pride, rather than financial gain (National Crime Agency,

2017). Further, individuals who engage in cyber-dependent crime do not typically have a history of engaging in traditional crime (National Crime Agency, 2017). Payne et al. (2019) suggest that this distinction is particularly relevant in the examination of autism and cybercrime, given that there is little evidence that people on the autism spectrum are engaged in traditional crime at a higher rate than the general population (Cederlund et al., 2008; Lundstrom et al., 2014; Mouridsen et al., 2008).

To test their hypothesis, Payne et al. (2019) conducted an online study examining the relationship between autism, autistic traits, and cyber-dependent crime. They found that it was autistic traits, but not (self-reported) autism diagnosis, that was associated with an increased risk of cyber-dependent criminal activity. They propose that although autistic people generally also display high levels of autistic traits, involvement in cyber-dependent crime may be an area in which these two groups differ (Payne et al., 2019), consistent with the previously discussed notion that there may be qualitative differences between people who have a diagnosis of autism and people who have high levels of autistic traits but do not meet diagnostic criteria. Consequently, despite suggestions that autism may be more prevalent among cybercriminals than in the general population (National Crime Agency, 2017), autism in itself may not necessarily be a risk factor for cybercrime (Payne et al., 2019). In addition, Payne et al. (2019) found that the relationship between autistic traits and cyber-dependent crime was mediated by advanced digital skills, but not theory of mind. Therefore, our study aimed to better understand if there is a relationship between autism, autistic traits, and cybercrime, and if so, what the possible mechanisms for these relationships may be. Similar to Payne et al. (2019) and Seigfried-Spellar et al. (2015), we used an online survey to present participants with measures of autistic traits, theory of mind, verbal comprehension, digital skills, and cybercriminal activity (both cyber-dependent crime and cyber-enabled crime). We then examined whether having a diagnosis of autism or high levels of autistic traits would

predict self-reported engagement in both cyber-dependent crime and cybercrime more generally, and if these relationships would be mediated by theory of mind or advanced digital skills.

Method

Participants

Participants were recruited online through the crowdsourcing platform TurkPrime and through a mail-out to a university autism database, which comprises autistic individuals who have indicated interest in participating in research projects. No specific inclusion criteria were specified, and all adults aged 18 years and older who were fluent in English were invited to participate in the study. We received a total of 742 responses. Of these, 440 responses were excluded from the analysis based on a priori exclusion criteria: 108 participants were suspected of using robots or other automated methods to complete the study (as indicated by nonsensical responses such as, “i know because women said thats all i need never you minnd incapbale of lying metzger wrote in a now deleted facebook post”), 77 participants failed to watch one or more of the A-ToM-Q videos in their entirety (as indicated by the duration of time spent on the page of the online survey), and 255 participants endorsed knowledge of a non-existent piece of computer software. The final sample consisted of 302 participants (175 male, 123 female, four preferred not to say) ranging in age from 18 to 73 years (M = 37.76, SD = 10.96). Seventeen participants were on a university autism database and known to have a formal diagnosis of autism that was provided by at least one qualified diagnostician according to DSM-IV-TR (American Psychiatric Association, 2000) or DSM-5 (American Psychiatric Association, 2013) criteria, while a further eight participants from TurkPrime self-reported having a diagnosis of autism. The study was approved by the appropriate institutional ethics committee.

Materials

Autism Diagnosis

All participants were asked, “Have you received a formal diagnosis of Autism Spectrum Disorder (i.e., from a clinician)?” (yes/no).

Autistic Traits

Autistic traits were measured using the 12-item version of the Autism Spectrum Quotient (AQ-12; Lundqvist & Lindner, 2017). Based on the original Autism Spectrum Quotient (Baron-Cohen, Wheelwright, Skinner, et al., 2001), the AQ-12 is a self-report measure that asks participants to indicate the degree to which each of 12 statements describe them (e.g., “I find social situations easy”). The AQ-12 was used in this study because it appears to better meet the requirements of a unidimensional measure of autistic traits than the AQ-50 (Lundqvist & Lindner, 2017). Scores on this measure range from 0 to 12, with higher scores indicating higher levels of autistic traits.

Digital Skills

Participants’ digital skills were measured using the 10-item basic digital skills questionnaire and the 10-item advanced digital skills questionnaire developed by Payne et al. (2019). Items on the basic digital skills questionnaire include, “I know how to open downloaded files,” and “I know how to connect to a WIFI network,” while items on the advanced digital skills questionnaire include, “I know how to use Linux,” and “I understand details of TCP/IP protocol stack and fields.” Each item is rated on a 5-point Likert scale from 1 (*Not at all true of me*) to 5 (*Very true of me*) for a total score of 50 for each scale, with higher scores indicating higher levels of digital skills.

Bogus Question

To detect potentially unreliable respondents, a bogus question was embedded in the advanced digital skills questionnaire. Participants were asked to indicate the extent to which

the statement, “I know how to use GFTI snooping video software,” was true of them on a 5-point Likert scale from 1 (*Not at all true of me*) to 5 (*Very true of me*). Only the responses from participants who indicated that this statement was not at all true of them were retained in the main data analysis, though the excluded participants were considered in supplementary analyses (see Supplemental Materials, p. 4).

Theory of Mind

Theory of mind was measured using the social subscale of the Adult Theory of Mind–Quick (A-ToM-Q) test (Brewer et al., 2021). The social subscale is the specific component of the A-ToM-Q that measures perspective taking or theory of mind. It requires respondents to view six short videos of interpersonal interactions and to answer a multiple-choice question (with four alternatives) about each scenario that requires the understanding and interpretation of subtle social nuances (e.g., *faux pas*, sarcasm, white lie). With the exception of the response format, which permits computer scoring and obviates inter-rater reliability assessment, the A-ToM-Q was identical to the original Adult Theory of Mind measure (A-ToM; Brewer et al., 2017), which requires participants to provide an open-ended response for each item and demonstrated impressive test-retest reliability (r = .82, at an average interval of 23.7 weeks). In the psychometric evaluation of the A-ToM-Q (Brewer et al., 2021), multiple-choice responses were scored as 1 (correct) or 0 (incorrect). However, partially correct responses were also indicated, allowing for an alternative scoring as 2 (correct), 1 (partially correct) or 0 (incorrect). Using the latter scoring, scores on the social subscale can range from 0 to 12, with lower scores indicating poorer performance.

The social subscale of the A-ToM-Q demonstrates good concurrent validity with existing indices of theory of mind, such as the Strange Stories task and Frith-Happé animations (with values of r ranging from .17 to .45 in the A-ToM-Q validation study; see Brewer et al., 2021). The A-ToM-Q social subscale also correlates significantly with

criterion-related measures such as self-reported social-behavioral skills and interpersonal relationships, and the IRI's perspective-taking and empathic concern subscales. The A-ToM-Q's divergent validity is indicated by the absence of correlations with other measures that clearly differentiate autistic and neurotypical samples but do not demand the social-cognitive inferences involved with taking the perspective of others, such as the IRI personal distress subscale and Mini-SPIN social anxiety scale. Finally, the discriminant validity of the A-ToM-Q is evidenced by autistic adults being more strongly differentiated on the social subscale than the physical (i.e., the control) subscale.

Verbal Comprehension

As it was not possible to administer a carefully standardized test of intelligence online, participants' level of verbal comprehension was measured using Part 1 of the Advanced Vocabulary Test I–V-4 (AVT) from the Educational Testing Service's Kit of Factor-Referenced Cognitive Tests (Ekstrom et al., 1976). This measure comprises 18 items that assess knowledge of word meanings within a 4-minute time limit. On each item, participants are presented with a word and asked to select its synonym from a list of five options. Participants' scores on the test are the number of items answered correctly minus a fraction of the number of items answered incorrectly (participants may opt not to answer particular items if they are uncertain). Scores on this measure can therefore range from -4.5 to 18, with higher scores indicating higher levels of verbal comprehension.

Cybercrime

Engagement in cybercrime was measured using two measures: the Computer Crime Index–Revised (CCI-R) and the Cyber-Dependent Crime Questionnaire (CDCQ). While the CDCQ examines only cyber-dependent crime, the CCI-R examines both cyber-dependent and cyber-enabled crime. As Payne et al. (2019) suggested that the characteristics of individuals who engage exclusively in cyber-dependent crime may differ from those who engage in

cybercrime more broadly, measures of both types of cybercrime were included in the present study.

The CCI-R (Rogers et al., 2006) is a 22-item self-report questionnaire that measures the prevalence, frequency, and age of first engagement in various types of cybercrime, including digital piracy, hacking, identity theft, cyberbullying, and virus writing. For this study, only Section II of the CCI-R was used, in which participants were asked to indicate their engagement in cybercrime over the past three years. Participants were classified as having engaged in cybercrime if they endorsed one or more items on this measure. As recommended by the authors of the scale (see Seigfried-Spellar et al., 2015), two items on the CCI-R that pertain to engagement in digital piracy (e.g., "Knowingly downloaded music, movies or other multimedia files that you did not legitimately purchase") were not included in the scoring of the CCI-R given the widespread acceptance of digital piracy in today's society and the grey area of what constitutes copyright infringement (Bernat & Makin, 2014).

The CDCQ is an 8-item self-report measure of cyber-dependent criminal behavior developed by Payne et al. (2019) and based on the eight activities identified by the UK's National Crime Agency (NCA) as constituting cybercrime. Each item specifies an area of cyber-dependent crime (e.g., phishing, file hijacking, DDoS attacks) and participants are required to indicate if they have ever participated in that activity. Similar to the scoring of the CCI-R, participants were considered to have engaged in cyber-dependent crime if they endorsed one or more items on the CDCQ.

Procedure

The study was presented through an online survey platform (Qualtrics, Provo, UT). Participants completed the study in their own time and were free to decline to answer particular questions. Participants were also informed that all information collected would be stored in a de-identified format. Participants were presented with the measures in the

following order: basic digital skills questionnaire, advanced digital skills questionnaire, Cyber-Dependent Crime Questionnaire (CDCQ), Autism Spectrum Quotient (AQ-12), Advanced Vocabulary Test I (AVT), A-ToM-Q social subscale, Computer Crime Index–Revised (CCI-R), and a demographic questionnaire. To ensure that all responses remained anonymous, at the end of the survey, participants were redirected to a separate online form where they were given the opportunity to enter their email address to receive an honorarium for participation in the study.

Results

Descriptive Statistics

Of the 302 participants included in the final sample, 25 (8.3%) reported having a formal diagnosis of autism, similar to the numbers (23 of 290, i.e., 7.9%) self-reporting an autism diagnosis in Payne et al. (2019). Of the 25 reporting a formal diagnosis of autism, seventeen participants were known to have a formal diagnosis of autism from a qualified diagnostician (as previously confirmed during their registration with a university research database) and eight participants self-reported having a formal diagnosis. Both subgroups of autistic individuals scored relatively high on the AQ-12 and relatively low on the A-ToM-Q social subscale (see Supplemental Materials, p. 1, Table 1). *T*-test contrasts indicated that the two groups did not differ significantly on any of the measures, although a weak effect size (with the self-reported diagnosis individuals performing worse) was observed for the A-ToM-Q ($d = 0.47$) and a large effect size for advanced digital skills ($d = 0.87$). Although these patterns do not prove the validity of the eight self-reported autism diagnoses, they do not undermine that conclusion.

Differences in age, basic and advanced digital skills, autistic traits (AQ-12), verbal comprehension (AVT), and theory of mind (A-ToM-Q) between autistic and non-autistic participants were examined using six separate *t*-tests with Bonferroni correction, while

differences in engagement in cybercriminal activity (as measured by the CCI-R and CDCQ) between the two groups were examined using two separate chi-square analyses. As expected, autistic participants had significantly higher scores on the AQ-12 (M = 9.32, SD = 3.09) than non-autistic participants (M = 5.86, SD = 4.03). Autistic participants also scored lower on the A-ToM-Q (M = 9.48, SD = 2.28) than non-autistic participants (M = 10.75, SD = 1.57), though this difference was not statistically significant (d = 0.78, p = .07). No significant difference in level of basic or advanced digital skills was found between the two groups, though a moderate effect size was observed for basic digital skills. However, this effect was not in the expected direction based on the previous research on computing and technological skills, as autistic participants reported having weaker basic digital skills than non-autistic participants (see Table 1).

[Insert Table 1 about here]

Thirty-six participants (11.92%) endorsed engagement in one or more cyber-dependent crimes as measured by the CDCQ, while 98 participants (32.45%) endorsed engagement in one or more cybercrimes as measured by the CCI-R. A breakdown of the specific cybercrimes endorsed on each measure are presented in Tables 2 and 3.

[Insert Tables 2 and 3 about here]

Predictors of Cybercriminal Activity

Logistic regression analyses were carried out to examine the degree to which age, sex, verbal comprehension, autism diagnosis, autistic traits, theory of mind, and digital skills predicted engagement in cybercrime as measured by the CDCQ and CCI-R, respectively. For each analysis, all predictors were entered into a single model. As shown in Table 4, the results suggested that when engagement in cybercrime was measured using the CCI-R, individuals with a diagnosis of autism were 2.93 times more likely to report engagement in

criminal activity than individuals without a diagnosis, 95% CI [1.12, 7.60], $p = .03$. Younger age was also found to be predictive of cybercriminal activity on the CCI-R, OR 0.96, 95% CI [0.93, 0.98], $p = .002$; however, there was no significant relationship between verbal comprehension (AVT), autistic traits (AQ-12), theory of mind (A-ToM-Q), or digital skills and endorsement of cybercrime on the CCI-R. In contrast, when cybercriminal activity was measured using the CDCQ, age, sex, autistic traits (AQ-12), theory of mind (A-ToM-Q), and autism diagnosis did not significantly predict engagement in cybercrime. Instead, it was advanced digital skills, OR 1.06, 95% CI [1.02, 1.10], $p = .002$, and verbal comprehension (AVT), OR 0.82, 95% CI [0.73, 0.93], $p = .001$, that were associated with reports of cyber-dependent crime on the CDCQ.

[Insert Table 4 about here]

Seigfried-Spellar et al. (2015) suggested that certain types of cybercrime are more likely to be predicted by autistic traits than others and, therefore, we conducted an item-by-item analysis of scores on the CDCQ and CCI-R to examine this possibility (see Supplemental Materials, pp. 2-3). However, we failed to replicate the findings of Seigfried-Spellar et al. (2015): only one item on the CCI-R ("Monitored network/ internet traffic without authorization or permission") was significantly predicted by autistic traits and this was not in the expected direction, as individuals with higher autistic traits were found to be less likely to report engagement in unauthorized network monitoring, OR 0.83, 95% CI [0.70, 1.00], $p = .05$.

Given that autistic traits did not significantly predict scores on the CDCQ or CCI-R, a mediation analysis of the relationship between autistic traits and cybercriminal activity was not conducted. However, autism diagnosis did significantly predict engagement in cybercrime as measured by the CCI-R and, thus, to examine the possible pathways through which this relationship may occur, a mediation analysis using the PROCESS macro version

3.3 for SPSS (Hayes, 2017) was carried out to test the model shown in Figure 1. A total of 5000 bootstrap samples were employed. The results indicated that autism diagnosis was a significant predictor of engagement in cybercrime (as measured by the CCI-R) after controlling for age, verbal comprehension, and basic digital skills, b = 1.12, BCa CI [0.13, 2.23]; however, there was no evidence that this relationship was mediated by advanced digital skills, b = -0.03, BCa CI [-0.17, 0.11] or theory of mind, b = -0.11, BCa CI [-0.43, 0.04].

[Insert Figure 1 about here]

Supplemental Analyses

To explore the reliability of the data, the responses of participants who did (n = 255) and did not (n = 302) endorse the bogus question were compared. Logistic regression analyses revealed that participants who answered affirmatively to the bogus question were eight times more likely to report engagement in cybercrime on the CDCQ, OR 8.31, 95% CI [5.43, 12.73], $p < .001$, and four times more likely to report engagement in cybercrime on the CCI-R, OR 4.29, 95% CI [3.01, 6.13], $p < .001$, than those who did not. Among participants who endorsed this bogus question, poorer theory of mind (A-ToM-Q), poorer verbal comprehension (AVT), and advanced digital skills significantly predicted reported engagement in cybercrime as measured by the CCI-R. In addition, when responses from both participants who did and did not endorse the bogus question were examined together, autism diagnosis was a significant predictor of reported engagement in cyber-dependent crime as measured by the CDCQ. Further details on these analyses can be found in Supplemental Materials (p. 4).

Discussion

In this study, we examined the relationship between autism, autistic traits, and cybercrime, and the possible mechanisms through which these relationships may occur, such

as advanced digital skills and deficits in theory of mind. Overall, the results indicated that individuals with a diagnosis of autism were more likely to endorse engagement in cybercrime on the Computer Crime Index–Revised (CCI-R) than individuals without a diagnosis. If these findings prove to be reliable, they are at odds with the findings of many crime prevalence studies that suggest similar crime prevalence rates for autistic and non-autistic individuals (Cederlund et al., 2008; Lundstrom et al., 2014; Mouridsen et al., 2008). In turn, such a pattern would suggest that autistic individuals may be particularly vulnerable to cybercriminal activity. However, there was no evidence that this relationship was mediated by advanced digital skills or deficits in theory of mind. Furthermore, independent of autism diagnosis, autistic traits were not significantly associated with endorsement of cyber-criminality on the CCI-R. Thus, although it appears that people on the autism spectrum may be more likely to report engagement in cybercrime than neurotypical comparisons, it remains uncertain why this is the case. Below we consider several possible explanations.

In contrast to the results obtained on the CCI-R, neither autism diagnosis nor autistic traits were predictive of cyber-criminality when participation in cybercrime was examined using the Cyber-Dependent Crime Questionnaire (CDCQ). Payne et al. (2019) propose that these two measures tap into slightly different constructs, with the CDCQ measuring cyber-dependent crime (crimes that can only be carried out using computer technology, such as hacking) and the CCI-R measuring both cyber-dependent crime *and* cyber-enabled crime (online variants of crimes that can also be carried out offline, such as identity theft). They argue that there are differences in the motivation for engaging in each of these types of crime, and that, consequently, the characteristics of individuals who do so may also differ (Payne et al., 2019).

Another possible explanation for the difference in findings between the CDCQ and CCI-R is that self-reports of engagement in cybercrime may be dependent on participants'

understanding and interpretation of what constitutes cybercrime. For example, while 31 participants reported that they had accessed or used another person's email account without their permission (on the CCI-R), only 12 participants reported having engaged in hacking (on the CDCQ), even though the former arguably constitutes the latter. The lower incidence of cybercrime captured by the CDCQ compared to the CCI-R may therefore reflect the fact that items on the CDCQ were not as clearly defined and may have been subject to varying interpretations by participants. This highlights the importance of ensuring that all behaviors of interest are clearly and consistently operationalized in self-report studies of cybercrime.

Nonetheless, regardless of the measure used, our findings stand in contrast to those of past studies that found that autistic traits were associated with increased engagement in both cyber-dependent crime (as assessed by the CDCQ; Payne et al., 2019) and cybercrime more generally (as assessed CCI-R; Seigfried-Spellar et al., 2015). It is possible that these inconsistencies may be partially attributable to the different forms of the Autism Spectrum Quotient (AQ) used to measure autistic traits across studies. The AQ-12 (Lundqvist & Lindner, 2017) was used in this study because it appears to better meet the requirements of a unidimensional measure of autistic traits than the AQ-50. It is possible that it resulted in a loss of explanatory power when compared to the original 50-item AQ (Baron-Cohen, Wheelwright, Skinner, et al., 2001) used by Payne et al. (2019) and Seigfried-Spellar et al. (2015). However, the odds ratio values of 0.97 (for the CDCQ) and 1.00 (for the CCI-R) suggest that it is unlikely that the use of the AQ-12 alone is sufficient to explain the lack of replicability of these findings. Rather, there are likely additional factors that moderate the relationship between autistic traits and engagement in cybercrime. Considering that autistic traits constitute a wide variety of different behaviors and characteristics, it may be that only a specific subset of autistic traits predict cyber-criminality. This hypothesis is consistent with the findings of Seigfried-Spellar et al. (2015) that different subscales of the AQ (i.e., social

skills, attention switching, attention to detail, communication, and imagination) were correlated with engagement in different types of cybercrime. Therefore, instead of interpreting autistic traits as a unitary construct (see Lundqvist & Lindner, 2017), a more nuanced examination may be necessary in order to identify the specific characteristics that are predictive of cyber-criminality.

Furthermore, in contrast to the findings of Payne et al. (2019) that the relationship between autistic traits and cyber-dependent criminal activity was mediated by advanced digital skills, we did not find any evidence that participants on the autism spectrum had higher levels of digital skills than non-autistic participants. In fact, the autistic group had lower mean scores on measures of both basic and advanced digital skills than the non-autistic group, though these differences were not statistically significant. This may be due to the different sampling methods employed. While Payne et al. (2019) aimed to target individuals with education in computer science, our study was open to individuals from the general public and a university autism database. It is thus possible that differences in digital skills between autistic and non-autistic individuals are only observed at the higher skill level. These findings may also reflect the heterogeneity of people on the autism spectrum and suggest that, while a general predisposition to developing technical skills might be a characteristic of the broad autistic phenotype (Baron-Cohen et al., 2007), there remains great variability in the abilities and interests of people on the autism spectrum.

A significant limitation of studies to date, including Payne et al. (2019) and Seigfried-Spellar et al. (2015), is that they relied on self-reports of engagement in cybercrime. Given the nature of the subject matter, it is impossible to exclude the possibility that the difference in reported rates of cybercrime between the autistic and non-autistic groups was really a difference in *disclosure* of participation in cybercrime. In the present study, a large number of respondents (n = 255) endorsed knowing how to use a non-existent piece of computer

software ("GFTI snooping video software") and were subsequently excluded from the main data analysis. To examine the possibility that the results may have been affected by participants' willingness or ability to accurately report their engagement in cybercrime, the responses of participants who did (n = 255) and did not (n = 302) endorse knowing how to use this bogus software were compared. Logistic regression analyses revealed that participants who answered affirmatively to the bogus question were eight times more likely to report engagement in cybercrime on the CDCQ and four times more likely to report engagement in cybercrime on the CCI-R than those who did not. Among participants who endorsed the bogus question, poorer theory of mind, poorer verbal comprehension, and advanced digital skills significantly predicted engagement in cybercrime as measured by the CCI-R (see Supplemental Materials, p. 4, Table S6). In addition, when responses from participants who did and did not endorse the bogus question were examined together, autism diagnosis was a significant predictor of engagement in cybercrime as measured by the CDCQ (see Supplemental Materials, p. 4, Table S5). One could only speculate about how these variables might alone, or in conjunction, be associated with increased reports of cybercrime. However, what is clear is that there are likely additional factors influencing the disclosure of engagement in cybercrime and further examination into potential variables is necessary. Further, the inclusion of items such as the bogus question we used appears to be worthwhile when using self-report measures.

One possible explanation that could account for differences in rates of disclosure of cybercrime between autistic and non-autistic participants is that people on the autism spectrum are reported to be more compliant with requests than neurotypical individuals (Chandler et al., 2019; North et al., 2008) and, when asked, may have disclosed their participation in cybercrime with little hesitation. This tendency may arise from rigidity in thinking around following rules and instructions, which reflects diagnostic criterion B2 in the

DSM-5 (American Psychiatric Association, 2013). In contrast, neurotypical participants may have been more cautious about disclosing their involvement in cybercrime, potentially resulting in under-reporting of criminal activity in this study. Another source of variance in levels of self-reported criminal activity may have been literal interpretation of the survey questions. In the present dataset, a small number of non-autistic participants provided open-ended comments highlighting that, although they had engaged in some of the aforementioned activities, they did not believe their behaviors constituted cybercrime (e.g., accessing a deceased relative's account or carrying out the activities as part of their studies in IT). These anecdotal observations raise the question of whether autistic participants, who are commonly thought to have difficulties with overly literal interpretations, would have also made the same delineations in their responses. Further research would benefit from examining autism diagnosis and autistic traits specifically among individuals convicted of cybercrime, to better understand whether the reported relationships between autism, autistic traits, and cyber-criminality is in fact attributable to differences in self-disclosure.

Limitations

While the results of this study suggest that autistic individuals are more likely to engage in cybercrime than non-autistic individuals, these findings were based on only a small sample of autistic participants (n = 25) and replication of these findings is necessary. The sampling method used in this study may have also contributed to a self-selection bias, in which individuals who have an interest in cybersecurity may have been more likely to participate in the study. Hence caution must be exercised when attempting to interpret these findings in the context of the wider autistic population.

Conclusion

Overall, we failed to replicate the findings of Payne et al. (2019) and Seigfried-Spellar et al. (2015) that high levels of autistic traits are predictive of engagement in both cyber-

dependent crime and cybercrime more generally. This suggests that there may be additional factors moderating the purported relationships between autism, autistic traits, and cyber-criminality, such as specific autistic characteristics, participants' understanding of what constitutes cybercrime, and willingness to disclose criminal activity. As other researchers have pointed out (e.g., Brewer & Young, 2018), to the extent that the particular interests or lifestyles of autistic individuals are associated with a relatively high level of engagement with the internet, people on the autism spectrum may be (a) particularly vulnerable to grooming activities of other internet users and (b) at an enhanced risk of becoming involved in some kind of illegal cyber activity. Thus, if these vulnerabilities are to be minimized, it is important that researchers find ways of reliably identifying both the extent and the antecedents of autistic individuals' involvement in cybercriminal activity. One potentially informative research direction would be to conduct a fine-grained analysis of autistic traits among individuals formally convicted of cybercrime.

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Figure 1

Mediation Analysis of the Relationship Between Autism Diagnosis and Engagement in Cybercrime Through Advanced Digital Skills and Theory of Mind While Controlling for Age, Verbal Comprehension, and Basic Digital Skills

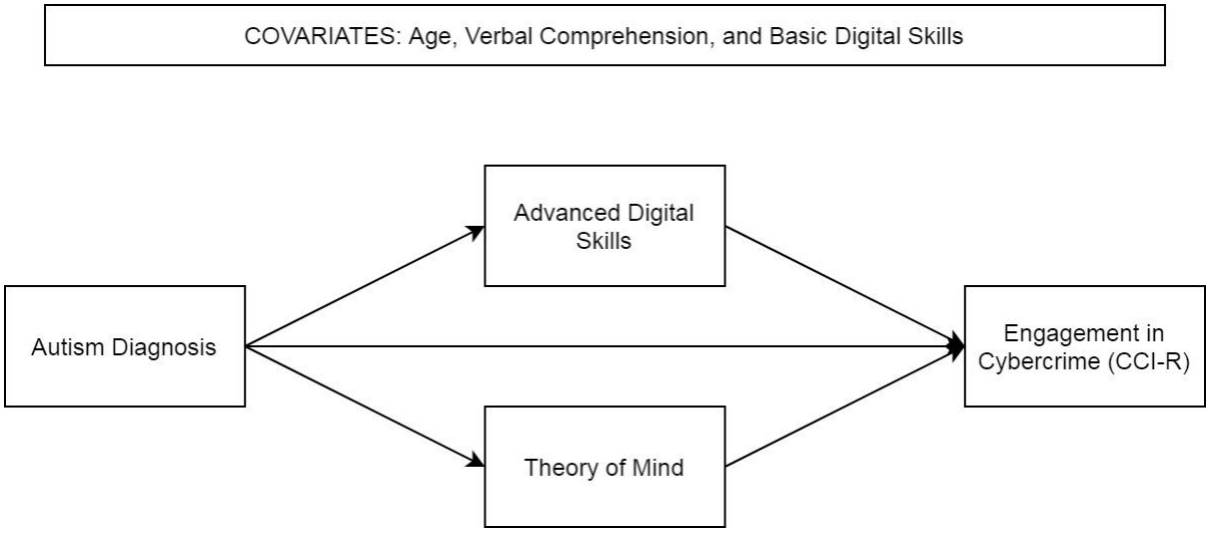

Table 1

Descriptive Statistics for All Measures by Self-Reported Autism Diagnosis

	Autistic (n = 25, 8.28%)	Non-Autistic (n = 277, 91.72%)	p	Effect Size
Age (*M*, S*D*)	35.52 (11.33)	37.97 (10.93)	1.0	d = 0.22
Basic Digital Skills (*M*, *SD*)	45.32 (9.41)	48.34 (3.16)	.74	d = 0.75
Advanced Digital Skills (*M*, *SD*)	18.72 (9.75)	20.70 (9.28)	1.0	d = 0.21
AQ-12 (*M*, *SD*)	9.32 (3.09)	5.86 (4.03)	< .001	d = 0.87
AVT (*M*, *SD*)	8.76 (4.19)	9.20 (3.62)	1.0	d = 0.12
A-ToM-Q (*M*, *SD*)	9.48 (2.28)	10.75 (1.57)	.07	d = 0.78
Crime endorsed on CDCQ (*n*, %)	5 (20.00%)	31 (11.19%)	.19	V = .08
Crime endorsed on CCI-R (*n*, %)	13 (52.00%)	85 (30.69%)	.02	V = .14

Note. *p*-values were derived from *t*-tests and chi-square tests. The effect sizes presented are Cohen's *d* and Cramer's *V*. The range for each measure was: Basic Digital Skills (10 – 50), Advanced Digital Skills (10 – 50), AQ-12 (0 – 12), AVT (-4.5 – 18), and A-ToM-Q (0 – 12).

Table 2

Number and Percentage of Participants Who Reported Cybercrimes on the CDCQ

CDCQ Item	Autistic (*n* = 25)		Non-Autistic (*n* = 277)		Total (*n* = 302)	
	n	%	*n*	%	*n*	%
Phishing	0	0.00	9	3.25	9	2.98
Web Cam Manager	0	0.00	8	2.89	8	2.65
File Hijacking	1	4.00	9	3.25	10	3.31
Key Logging	0	0.00	16	5.78	16	5.30
Screen Shot Manager	5	20.00	18	6.50	23	7.62
Ad-Clicker	0	0.00	6	2.17	6	1.99
Hacking	0	0.00	12	4.33	12	3.97
DDoS	0	0.00	8	2.89	8	2.65

Note. Phishing (sending bogus emails asking for security information and personal details), Webcam managing (taking over someone's webcam), File hijacking (hijacking someone's files without their permission), Keylogging (recording what someone types on their keyboard), Screenshot managing (taking screenshots of someone's computer screen), Employing ad clicking (directing someone's computer to click on a specific link), Hacking (accessing computer systems), Launching distributed denial of service (DDoS) attacks (targeting a computer system to prevent it working).

Table 3

Number and Percentage of Participants Who Reported Cybercrimes on the CCI-R

CCI-R Item	Autistic (*n* = 25)		Non-Autistic (*n* = 275)		Total (*n* = 302)	
	n	%	*n*	%	*n*	%
Tried to guess another's password to get into his/her computer account or files	7	28.00	32	11.55	39	13.00
Accessed another person's computer account or files without his/her knowledge or permission just to look at the information or files	5	20.00	24	8.66	29	9.63
Accessed or used another person's email account without their permission	5	20.00	26	9.39	31	10.30
Added, deleted, changed or printed any information in another's computer account without their knowledge or permission	1	4.00	10	3.61	11	3.67
Written or used a program that would destroy someone's data, infect a system or network or potentially cause problems (e.g., a virus, logic bomb or Trojan horse)	1	4.00	6	2.17	7	2.33
Knowingly used or gave to another person someone else's account password without their permission (e.g., Facebook, Myspace)	2	8.00	8	2.89	10	3.32
Electronically obtained or possessed another person's credit card number without his/her knowledge or permission	0	0.00	5	1.81	5	1.67
Used another person's cell phone number or cell phone without their permission	3	12.00	27	9.75	30	10.00
Used someone else's identity online (without their permission) to conduct a commercial transaction, apply for credit, or conduct any other financial transaction	0	0.00	6	2.17	6	1.99
Used a wireless access point that you did not have permission or authorization to use	5	20.00	26	9.39	31	10.30
Monitored network/ internet traffic without authorization or permission	0	0.00	10	3.61	10	3.33
Accessed a computer system, network, or website without permission or authorization	1	4.00	17	6.14	18	6.00
Defaced/altered a website without authorization or permission	1	4.00	4	1.44	5	1.67
Disclosed passwords, used IDs, or other account information without authorization or permission	1	4.00	7	2.53	8	2.66

Viewed information on a business system or network that you did not have authorization or permission to see	2	8.00	12	4.33	14	4.65
Harassed, annoyed or stalked someone through emails, IM, Facebook or other web-based technology	8	32.00	12	4.33	20	6.64
Engaged in internet activities (e.g., emails, web pages) designed to fraudulently obtain personal information	0	0.00	4	1.44	4	1.33
Sent unsolicited bulk emails	1	4.00	7	2.53	8	2.68
Without authorization or permission, installed or used a device or software in order to obtain/sniff user IDs and/or passwords	0	0.00	6	2.17	6	1.99
Without authorization or permission, installed software or device on a network or system, that was designed to circumvent a security control	1	4.00	6	2.17	7	2.33

Table 4

Logistic Regression Analyses to Assess the Association Between Age, Sex, Autism Diagnosis, Autistic Traits (AQ-12), Theory of Mind (A-ToM-Q), Basic Digital Skills, Advanced Digital Skills, Verbal Comprehension (AVT), and Engagement in One or More Cybercrimes

	CDCQ		CCI-R	
	Odds Ratio [95% CI]	*p*	Odds Ratio [95% CI]	*p*
Age	1.00 [0.96, 1.03]	.85	0.96 [0.93, 0.98]	.002**
Male Sex	0.57 [0.04, 7.89]	.68	0.44 [0.03, 6.05]	.54
Autism Diagnosis	2.19 [0.64, 7.50]	.21	2.93 [1.12, 7.60]	.03*
AQ-12	0.97 [0.88, 1.07]	.53	1.00 [.093, 1.06]	.90
A-ToM-Q	1.06 [0.85, 1.32]	.59	1.15 [0.96, 1.37]	.13
Basic Digital Skills	0.98 [0.89, 1.07]	.60	.98 [.92, 1.05]	.57
Advanced Digital Skills	1.06 [1.02, 1.10]	.002**	1.02 [.99, 1.05]	.13
AVT	0.82 [0.73, 0.93]	.001***	1.00 [.92, 1.08]	.94

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$