RESEARCH ARTICLE

Domains of the autism phenotype, cognitive control, and rumination as transdiagnostic predictors of DSM-5 suicide risk

Darren Hedley1*, Mirko Uljarević2,3, Ru Ying Cai4, Simon M. Bury1, Mark A. Stokes1, David W. Evans6

1 Olga Tennison Autism Research Centre, La Trobe University, Melbourne, Victoria, Australia, 2 University of Melbourne, Melbourne, Victoria, Australia, 3 Stanford Autism Center, Department of Psychiatry and Behavioral Sciences, School of Medicine, Stanford University, Stanford, California, United States of America, 4 Aspect Research Centre for Autism Practice, Melbourne, Victoria, Australia, 5 School of Psychology, Deakin University, Melbourne, Victoria, Australia, 6 Bucknell University, Lewisburg, Pennsylvania, United States of America

* D.Hedley@latrobe.edu.au

Abstract

Suicide is a global health problem affecting both normative and clinical populations. Theoretical models that examine mechanisms underlying suicide risk across heterogeneous samples are needed. The present study explored core characteristics associated with autism spectrum disorder (ASD), a sub-population at high risk of suicide, as well as two dimensional cognitive constructs, as potential transdiagnostic predictors of suicidal ideation in a clinically diverse sample. Participants (n = 1851, 62% female) aged 18 to 89 years completed online questionnaires assessing: social communication difficulties; insistence on sameness; cognitive control; and rumination. Forty-three percent of participants reported the presence of at least one neurodevelopmental or neuropsychiatric disorder. One third of the sample reported some suicidal ideation (SI), and 40 percent met the threshold for concern for depression. All hypothesized constructs were associated with SI and depression and, with the exception of rumination, contributed significantly to SI. Participants reporting SI returned significantly higher social communication difficulties and insistence on sameness, and lower levels of cognitive control than those reporting no-SI. The study was limited by the use of a cross-sectional sample assessed with self-report measures. All diagnoses were self-reported and the study was additionally limited by the use of a single item indicator of suicidal ideation. These findings support a role for constructs associated with the ASD phenotype and associated broad cognitive domains as potential risk factors underlying suicidal ideation in a large clinically diverse sample. Our findings suggest directions for future longitudinal research studies, along with specific targets for suicide prevention and clinical practice.
Introduction

Suicide and attempted suicide are major public health concerns, with suicide being a leading cause of death globally [1]. The World Health Organization estimates over 800,000 people die annually as a result of suicide, and it is the leading cause of death in youth aged 15 to 19 years [1]. Suicide is defined as the act of deliberately killing oneself, whereas suicide behavior refers to a range of behaviors including thinking about suicide (ideation), planning for suicide, non-fatal suicide attempt, as well as suicide [1]. To advance research in suicide prevention, O’Connor and Portzky, along with multiple international experts, identified key future developments and challenges in the field [2]. These included the need for more research into the testing and application of theoretical models of suicidal behavior, refining the understanding of sub-groups of people at risk in order to develop tailored interventions, and consideration of trans-diagnostic theoretical frameworks and models that better address the heterogeneity between people who experience suicidal behavior.

In the present study we adopt a dimensional approach, based on principles derived from the National Institute of Mental Health Research Domain Criteria (RDoC) [3, 4], as well as the support for a continuum between autistic traits in clinical cases and the general population [5, 6], to explore the contribution of autistic traits to heightened suicidal ideation in a large, clinically diverse sample. Autistic traits were selected due to the heightened risk of suicide amongst clinical cases (i.e., a sub-group at risk) [2], as well as recent evidence of an association between elevated autistic-related traits and global suicide risk [7].

Suicide risk has traditionally been studied within the context of single disorders (e.g., most notably, depression) [8]. However, suicide rates are elevated across a wide range of psychiatric disorders, and are compounded by the presence of comorbidities [9–11]. In addition, suicide risk is elevated in those with subclinical traits who may not meet criteria for a formal diagnosis of a psychiatric disorder [8, 11, 12]. Better understanding of sub-groups at risk, embedded within a transdiagnostic framework, is suggested to be a useful approach to improving understanding of mechanisms that underpin elevated suicide risk [2]. Notably, recent research has highlighted particularly high risk for suicidal behavior—including death by suicide—among individuals with autism spectrum disorder (ASD) who also exhibit increased levels of other neuropsychiatric symptoms [13–17]. Furthermore, autistic traits are present in other (i.e., non-ASD) clinical groups [18] and in the general population [5, 6, 19, 20]. Thus, traits present in clinical cases of ASD (e.g., social communication difficulties, cognitive rigidity and insistence on sameness) might also underlie psychiatric difficulties across normative and clinical samples [5, 6]; for example, ASD traits are found to be associated with a range of negative outcomes (e.g., anxiety; depression) [21, 22], including suicide [23]. Based on these observations, a prudent approach towards better understanding of the suicide risk and personalization of treatment is to adopt a dimensional and individual differences approach [24, 25].

Indeed, it is now widely understood that a range of domains transect categorical diagnostic boundaries, and these domains might provide predictive value in explaining phenomena over and beyond, and independent from, specific diagnoses [4, 24–26]. A dimensional approach— which focuses on identifying specific risk and protective factors and attempts to understand underlying mechanisms—is therefore likely to provide a useful framework for understanding suicide risk and behavior across clinically diverse samples [24, 25, 27]. Recently, estimates of dimensional psychopathology derived from RDoC [3, 4] and applied to hospital discharge documentation were found to be associated with patient suicide and accidental death [27]; thereby demonstrating a potential application of dimensional frameworks to suicide prevention. However, to our knowledge, studies have yet to explore the nature of the interaction between constructs or traits associated with ASD, and transdiagnostic risk and resilience.
factors such as cognitive control and positive and negative valence, in predicting suicidality in a large community sample spanning normative and atypical development. Furthermore, we currently lack insight into how elevated traits associated with ASD alone, and in combination with other neuropsychiatric symptoms, relate to suicidality in community samples.

**Autism phenotype as a risk factor for suicide**

There is considerable evidence of heightened risk of suicidal behavior in people with ASD [13, 28–31], with suicide being the most significant predictor of premature mortality in individuals with ASD who do not have co-occurring intellectual disability (ID), as well as a significant risk factor in those with ID [14, 32]. Additionally, ASD trait severity is increased in adults with ASD who have planned or attempted suicide compared to those who do not have a lifetime history of planned or attempted suicide [13]. This suggests ASD trait severity may be a risk marker for suicide behavior in people with clinical ASD diagnoses. In terms of mechanisms, research with ASD clinical samples suggests ASD trait severity indirectly increases suicide risk through depression [30].

There is additional reason to believe that ASD traits may be an important risk factor for suicide behavior in broader clinical and non-clinical populations. From the standpoint of categorical diagnostic classifications, ASD commonly co-occurs with other neurodevelopmental and neuropsychiatric disorders [17], thereby compounding risk through the presence of multiple (vs. single) disorders. Traits or characteristics associated with ASD are normally distributed throughout the general population [33, 34] and, if viewed dimensionally, tend to be associated with elevated traits and symptoms of other disorders [35, 36]. There is emerging evidence that ASD traits are risk markers for suicide in people who do not have a diagnosis of ASD, including both non-clinical [7, 23, 28, 37, 38] and clinical (e.g., first episode psychosis) [17] populations.

Research with non-ASD populations suggests a direct relationship between ASD traits and suicidal behavior. In a non-clinical sample of young adults, Pelton and Cassidy [38] examined the relationship between ASD traits (broadly assessed with the Autism Spectrum Quotient, AQ) [33] and suicidal behavior within the context of the Interpersonal-Psychological Theory of Suicide (ITPS) [39]. ASD traits were found to significantly correlate with suicidal behavior, and this relationship was mediated by burdensomeness and thwarted belonging, suggesting a possible mechanism whereby social difficulties, which characterize ASD, may increase vulnerability to social risk factors for suicidal behavior. ASD traits also independently predicted variance in suicidal behavior in adults from the general population [28] and active military service members [23], supporting the hypothesis that heightened ASD traits increase risk for suicidal behavior in non-clinical populations. A study by Upthegrove et al. [17] examined the contribution of ASD traits to depression and suicide in a healthy, non-help seeking population, and in individuals experiencing first episode psychosis. Traits of ASD and psychosis were associated with increased levels of depressive symptoms in the non-help seeking population, and ASD traits and positive symptoms were associated with increased depressive symptoms, hopelessness, and suicidal ideation in the clinical sample. However, further research is required to assess the contribution of distinct constructs or characteristics directly associated with ASD, as well as broader but associated cognitive difficulties, to suicide risk.

Together, these studies suggest that traits associated with the ASD phenotype contribute to psychopathology. Moreover, it is plausible that ASD traits increase suicide risk either directly, or indirectly through depression and mediators such as hopelessness [17], loneliness, and low perceived social support [30], or burdensomeness and belonging [23, 38]. Furthermore, as has been demonstrated above, ASD traits may be present at the clinical or sub-clinical level thereby
affecting a larger sector of the population. To gain better understanding of the association between ASD traits and suicidal behavior, two important gaps in the research must be addressed. First, research is needed to tease apart those aspects of the ASD phenotype that confer risk for suicidality; for example, social communication difficulties and insistence on sameness or perseveration are factors that have been linked to suicidal behavior [24], and are also defining characteristics of ASD [40]. Second, it is important to understand how different aspects of the ASD phenotype interact with other transdiagnostic domains (e.g., cognitive control, negative valence) to predict suicidal behavior. This is clinically important as some of these factors might be modifiable through targeted treatment.

**Mechanisms underpinning suicide risk and the autistic phenotype**

Diagnostically, ASD is characterized by persistent impairments in social communication and interaction, and the presence of restricted and repetitive patterns of behavior, interests and activities, inclusive of hyper- or hypo-reactivity to sensory stimuli [40]. Of these core symptoms, social communication difficulties and cognitive rigidity or insistence on sameness, that are also distributed across normative and clinical samples, may be particularly important risk factors for depression and suicidality [24, 25]. It is therefore important to understand how these factors individually, and collectively, interact to predict suicidal behavior within a clinically diverse, transdiagnostic sample.

Rumination and cognitive rigidity, which are associated with the restricted and repetitive domains of ASD [41], are not specific to ASD and are distributed across the general population, forming part of the RDoC Negative Valence system [3, 4]. Several studies have demonstrated a link between cognitive rigidity, which is associated with externalizing disorders [42], and suicide risk and behavior [42–44]. Rumination, on the other hand, is associated with internalizing symptoms [45] and depressive symptoms both in ASD [41, 45] and non-ASD populations [46]. Specifically, rumination has been found to predict the onset and duration of depression, and is associated with self-harm and suicidal ideation [47, 48].

In addition to the core symptoms, people with ASD often present with difficulties in broad cognitive domains including executive function and cognitive control [49–52], with these difficulties likely underpinning cognitive and behavioral rigidity, as well as social communication difficulties [53]. However, these deficits are not specific to ASD, but also feature across neuro-developmental and neuropsychiatric disorders, as well as the general population, potentially leading to poor outcomes, which include suicide risk and behavior [54, 55].

The aims of the present study were to examine (1) the contribution of the two core clinical domains of ASD—social communication difficulties, insistence on sameness—on suicide risk (assessed using DSM-5 suicidal ideation; SI) and (2) the additional contribution and interaction of two key dimensional constructs—cognitive control and rumination. We predict that each of the identified constructs will independently contribute to SI, controlling for depression.

**Materials and methods**

**Participants**

Participants were 1851 (62.3% female) individuals aged 18–89 years ($M = 37.09, SD = 12.28$). The recruitment strategy followed that of previously published research and conducted recruitment online using Survey Sampling International (SSI; Shelton, CT) [56, 57], an online recruitment platform that specializes in recruiting demographically representative samples for scientific research in the United States and that is similar to other established and reliable commercial data recruitment platform (e.g., Prolific Academic, Amazon’s Mechanical Turk).
Eligible participants were provided with a Qualtrics link to the survey questionnaires. Participant demographics are provided in Table 1. The resultant sample was generally representative of the US population for race (although there were fewer Hispanics/Latinos in the study sample), income, education, and rural and urban populations, representing all 50 States as well as the District of Columbia (S1 Table). Given the sample consisted of a higher proportion of females than males, demographic variables were explored between genders using Pearson’s chi-squared test (Table 1). Race was proportionately distributed across gender, except for a slightly higher proportion of Hispanic males relative to females. Females were also more likely to report having more than one racial identity than males. Male and female participants differed significantly on highest education level achieved, household income, and marital status. Because the sample was otherwise representative of the general population, lifetime presence of neurodevelopmental and neuropsychiatric disorders (43.5%) was consistent with that reported for the United States (46.4%) [63]. Females reported a relatively higher number of psychiatric diagnoses than males overall, including significantly more diagnoses of anxiety, depression, and approaching significance for post-traumatic stress disorder; however, relatively more males than females reported a diagnosis of schizophrenia. Approximately one quarter of the sample reported taking medications for their condition, the difference in medication use between males and females was not statistically significant.

Procedures

The research was approved by Bucknell University, Institutional Review Board (DWE’s home institution). All participants reviewed an information document and were informed that participation was voluntary prior to agreeing to participate in the study. Online consent was received from all study participants.

Construct items. To measure the constructs, specific items or subscales were selected from a series of measures after careful review by the first and second authors. The second and last author are additionally authors of one of the measures, the Adult Routines Inventory (ARI) [57]. All individual scale items were further reviewed to minimize the risk of introduced covariance between constructs. Items for each construct along with scoring information are provided in S1 Appendix.

Social Communication Difficulties were assessed using items specifically designed to evaluate these difficulties in those with ASD. These were drawn from the Autism Spectrum Quotient, an instrument designed to detect ASD traits in people with average or above intelligence quotient (IQ) [64]. Higher scores reflect greater social communication difficulties. These items were not used for the presence of ASD, but simply only social communication difficulties. Similarly, Insistence on Sameness was assessed with items drawn from a measure that evaluates this in part, the ARI [57]. The selected items assess routines, habits, and “compulsive-like” restricted and repetitive behaviors often seen in disorders such as OCD and ASD. Higher scores reflect greater rigidity. Cognitive Control was assessed with the Attentional and Inhibitory Control scales of the Adult Temperament Questionnaire [65]. Higher scores indicate greater control. Rumination was assessed with all 3-items from the Penn State Worry Questionnaire, ultra-brief version (PSWQ-3), which assesses pathological worry [66]. Higher scores indicate increased worry. Depression and Suicidal Ideation were assessed with three items from the adult version of the DSM-5 Level 1 Cross-Cutting (CC) Symptom Measure [67, 68], a self-rated measure of mental health domains that was developed by the DSM-5 Task Force and Work Groups [69]. Depressive symptoms are indicated by two items and suicide risk is assessed with a single item which assesses SI. Respondents are asked to consider how much or how often they have been bothered by a specific symptom during the last two weeks. A score
Table 1. Demographics including neurodevelopmental and neuropsychiatric disorders, and gender comparisons.

| Variable | Label | Male | Female | Total | General population data | Variable × Gender [95% BCa CI] |
|----------|-------|------|--------|-------|--------------------------|--------------------------------|
| n        |       | 698 (37.7%) | 1153 (62.3%) | 1851 (100%) | - | - |
| Race     | White | 510 (73.1%) | 821 (71.2%) | 1331 (71.9%) | 72.4% | $\chi^2(1) = 0.745, p = .388$ |
|          | Black/African American | 73 (10.5%) | 129 (11.2%) | 202 (10.9%) | 12.6% | $\chi^2(1) = 0.238, p = .626$ |
|          | Hispanic | 54 (7.7%) | 62 (5.4%) | 116 (6.3%) | 16.4% | $\chi^2(1) = 4.12, p = .042$ |
|          | Asian | 34 (4.9%) | 44 (3.8%) | 78 (4.2%) | 4.8% | $\chi^2(1) = 1.20, p = .274$ |
|          | Native Hawaiian/Pacific Islander | 2 (0.3%) | 4 (0.3%) | 6 (0.3%) | 0.2% | $\chi^2(1) = 0.049, p = .826$ |
|          | More than one | 21 (3%) | 72 (6.2%) | 93 (5%) | - | $\chi^2(1) = 9.54, p = .002$ |
|          | Other | 1 (0.1%) | 6 (0.5%) | 7 (0.4%) | - | $\chi^2(1) = 1.64, p = .200$ |
| Education | Less than high school | 16 (2.3%) | 31 (2.7%) | 47 (2.5%) | - | - |
|          | High school or GED | 169 (24.2%) | 316 (27.4%) | 485 (26.2%) | - | - |
|          | Some college | 117 (16.8%) | 320 (27.8%) | 437 (23.6%) | - | - |
|          | 2-year college degree | 67 (9.6%) | 182 (15.8%) | 249 (13.5%) | - | - |
|          | 4-year college degree (BA, BS) | 207 (29.7%) | 250 (21.7%) | 457 (24.7%) | - | - |
|          | Master’s degree (MA, MS) | 72 (10.3%) | 40 (3.5%) | 112 (6.1%) | - | - |
|          | Doctoral degree (PhD) | 23 (3.3%) | 4 (0.3%) | 27 (1.5%) | - | - |
|          | Professional degree (MD, JD) | 23 (3.3%) | 8 (0.7%) | 31 (1.7%) | - | - |
|          | Not reported | 4 (0.6%) | 2 (0.2%) | 6 (0.3%) | - | - |
| Income   | < $10,000 | 29 (4.2%) | 87 (7.5%) | 116 (6.3%) | 7.3% | $\chi^2(11) = 293.37, p < .001^d$ |
|          | $10,000–$19,999 | 35 (5%) | 77 (6.7%) | 112 (6.1%) | 11.5% | - |
|          | $20,000–$29,999 | 55 (7.9%) | 131 (11.4%) | 186 (10%) | 10.9% | - |
|          | $30,000–$39,999 | 52 (7.4%) | 150 (13%) | 202 (10.9%) | 10% | - |
|          | $40,000–$49,999 | 60 (8.6%) | 126 (10.9%) | 186 (10%) | 8.9% | - |
|          | $50,000–$59,999 | 55 (7.9%) | 123 (10.7%) | 178 (9.6%) | 7.6% | - |
|          | $60,000–$69,999 | 45 (6.4%) | 87 (7.5%) | 132 (7.1%) | 6.8% | - |
|          | $70,000–$79,999 | 73 (10.5%) | 94 (8.2%) | 167 (9%) | 5.9% | - |
|          | $80,000–$89,999 | 47 (6.7%) | 38 (3.3%) | 85 (4.6%) | 4.9% | - |
|          | $90,000–$99,999 | 57 (8.2%) | 66 (5.7%) | 123 (6.6%) | 4% | - |
|          | $100,000–$149,999 | 105 (15%) | 119 (10.3%) | 224 (12.1%) | 12.4% | - |
|          | ≥ $150,000 | 76 (10.9%) | 44 (3.8%) | 120 (6.5%) | 9.5% | - |
|          | Not reported | 9 (1.3%) | 11 (1%) | 20 (1.1%) | - | - |
| Marital status | Single, never married | 142 (20.3%) | 250 (21.7%) | 392 (21.2%) | - | $\chi^2(4) = 40.85, p < .001^d$ |
|          | Married | 522 (74.8%) | 752 (65.2%) | 1274 (68.8%) | - | - |
|          | Separated | 7 (1%) | 30 (2.6%) | 37 (2%) | - | - |
|          | Divorced | 24 (3.4%) | 87 (7.5%) | 111 (6%) | - | - |
|          | Widowed | 1 (0.1%) | 32 (2.8%) | 33 (1.8%) | - | - |
|          | Not reported | 2 (0.3%) | 2 (0.2%) | 4 (0.2%) | - | - |
| Diagnosisb | None | 435 (62.3%) | 610 (52.9%) | 1045 (56.5%) | - | $\chi^2(1) = 15.68, p < .001$ |
|          | Anxiety | 117 (16.8%) | 355 (30.8%) | 472 (25.5%) | - | $\chi^2(1) = 45.03, p < .001$ |
|          | Depression | 107 (15.3%) | 351 (30.4%) | 458 (24.7%) | - | $\chi^2(1) = 53.33, p < .001$ |
|          | ADD/ADHD | 44 (6.3%) | 82 (7.1%) | 126 (6.8%) | - | $\chi^2(1) = 0.448, p = .503$ |
|          | Bipolar Disorder | 32 (4.6%) | 73 (6.3%) | 105 (5.7%) | - | $\chi^2(1) = 2.48, p = .115$ |
|          | Obsessive Compulsive Disorder | 25 (3.6%) | 42 (3.6%) | 67 (3.6%) | - | $\chi^2(1) = 0.003, p = .960$ |
|          | Autism Spectrum Disorder | 8 (1.1%) | 7 (0.6%) | 15 (0.8%) | - | $\chi^2(1) = 1.57, p = .210$ |

(Continued)
Data cleaning and analysis. No more than 1% (M = 0.303, SD = .19, Range = 0–1%) of data were missing for any questionnaire item overall, and Little’s MCAR test was not significant, p = .895 [70]. Thus, following Tabachnick and Fidell [71], cases with missing data on any of the questionnaires were deleted (n = 77, 3.8%). Where appropriate to do so, analyses were conducted using bootstrapping with 5000 resamples to provide more robust statistics, and 95% confidence intervals (BCa 95% CI) were used to interpret significance [71, 72]. Correlational analysis was used first to explore relationships between study variables. Bonferroni adjustment was used to account for multiple comparisons. Multiple linear regression was then run to identify factors contributing to suicidal ideation. Prior to performing the regression analysis the distribution of the residuals of the regression was reviewed for normality [73]. A Predicted Probability (P-P) plot was examined for normality with all constructs entered with suicidal ideation entered as the dependent variable. Examination of the P-P plot revealed that the residuals were normally distributed. All VIF values were below 10 (range 1.06–1.99).

Bootstrapped analysis of covariance (ANCOVA) controlling for age and depression were used to compare participants reporting no suicidal ideation (SI = 0) and those reporting presence of suicidal ideation (SI ≥ 1) on key study variables.

Results

The data that support the findings of the study are openly available at "OSF" at https://doi.org/10.1371/journal.pone.0245562.t001

| Variable | Label | Male | Female | Total | General population data | Variable × Gender [95% BCa CI] |
|----------|-------|------|--------|-------|--------------------------|--------------------------------|
| Tic Disorder | 6 (0.9%) | 4 (0.3%) | 10 (0.5%) | – | $\chi^2(1) = 2.13, p = .145$ |
| Post-Traumatic Stress Disorder | 1 (0.1%) | 9 (0.8%) | 10 (0.5%) | – | $\chi^2(1) = 3.29, p = .070$ |
| Schizophrenia | 6 (0.9%) | 2 (0.2%) | 8 (0.4%) | – | $\chi^2(1) = 4.76, p = .029$ |
| Personality Disorder | 1 (0.1%) | 2 (0.2%) | 3 (0.2%) | – | $\chi^2(1) = 0.024, p = .876$ |
| Other$^c$ | 35 (5%) | 20 (1.7%) | 55 (3%) | – | $\chi^2(1) = 1.61, p = .205$ |
| Medication | 158 (22.6%) | 299 (25.9%) | 457 (24.7%) | – | $\chi^2(1) = 2.57, p = .109$ |

$^a$Hebrew Israelite, Indigenous, German (all n = 1), mixed (n = 2), not reported (n = 2).

$^b$Sum of diagnoses is more than total number of individuals due to selecting multiple options.

$^c$Other reported diagnoses were mostly non-psychiatric diagnoses and included anger/rage, arthritis, back/shoulder pain (n = 2), bronchitis, cancer (unspecified = 1, thyroid = 1), celiac disease, eczema, epilepsy (n = 2), diabetes (n = 3), gastroesophageal reflux disease (GERD), high blood pressure/cholesterol, human papillomavirus (HPV), insomnia, migraines (n = 3), Meniere’s disease, menopause, multiple sclerosis, obesity, trichotillomania, panic disorder, not reported (n = 28).

$^d$Group comparison statistics are reported for the overall category only.

https://doi.org/10.1371/journal.pone.0245562.t001

≥2 on any item for depression and ≥1 for SI serve as a clinical guide for additional inquiry and follow up.

≥2 on any item for depression and ≥1 for SI serve as a clinical guide for additional inquiry and follow up.
small to large range ($r_p = -.117–.590$). Effect sizes for Social Communication Difficulties were in the medium range for Depression and SI and, as expected, SI was strongly correlated with Depression. In terms of the other variables, Insistence on Sameness, Rumination (both positively) and Attentional Control (negatively) were most strongly associated with Depression, and Attentional Control (negatively) was most strongly associated with SI. Thus, all of the hypothesized constructs were found to be significantly associated with SI thereby warranting their inclusion in the linear regression analysis.

### Regression analysis

Table 4 presents the results of the linear regression model predicting SI. All hypothesized constructs were included in the model. Age was controlled for by including it in the model. The full model accounted for 43.3% of variance in SI scores, $F(7, 1843) = 201.19, p < .001$. Social Communication Difficulties significantly predicted SI, with the b-weight revealing that for each unit increase in Social Communication Difficulties, SI increased by 0.085 units. Similarly,

---

**Table 2. Distribution of scores on DSM-5 CC Symptom Measure, depression and suicidal ideation ($N = 1851$).**

| Score    | Depression item 1a | Depression item 2b | Suicidal ideation |
|----------|--------------------|--------------------|-------------------|
| None (0) | 574 (31%)          | 594 (32.1%)        | 1241 (67%)        |
| Slight (1) | 463 (25%)       | 478 (25.8%)        | 207 (11.2%)        |
| Mild (2) | 404 (21.8%)       | 384 (20.7%)        | 187 (10.1%)        |
| Moderate (3) | 258 (13.9%)     | 260 (14.0%)        | 143 (7.7%)         |
| Severe (4) | 152 (8.2%)       | 135 (7.3%)         | 73 (3.9%)          |
| Threshold for further inquiryc | 814 (44%)       | 779 (42.1%)        | 610 (33%)          |

---

*a* “Little interest or pleasure in doing things”.

*b* “Feeling down, depressed, or hopeless”.

*c* Depression score ≥ 2, Suicidal ideation ≥ 1.

---

**Table 3. Study variables ($M$, SD, range, normality) with Pearson’s bootstrapped correlations (upper panel, shaded), and partial correlations (lower panel) controlling for age ($n = 1851$).**

| Variable               | $M$  | SD  | Range   | Shapiro-Wilk | 2.   | 3.   | 4.   | 5.   | 6.   | 7.   | 8.   |
|------------------------|------|-----|---------|---------------|------|------|------|------|------|------|------|------|
| 1. Age (years)         | 37.09| 12.28| 18–89   | .912*         | -.094* [-.14, -.05] | -.132* [-.18, -.09] | .173* [.13, .22] | .169* [.12, .22] | -.139* [-.18, -.09] | -.181* [-.22, -.14] | -.199* [-.24, -.15] |
| 2. Social Communication Difficulties | 9.96 | 2.61 | 5–20    | .975*         | -.257* [-.21, .30] | -.432* [-.47, -.39] | -.178* [-.22, -.13] | -.487* [.45, .53] | .428* [.39, .47] | -.386* [.35, .43] |
| 3. Insistence on Sameness | 44.30| 14.08| 15–75   | .989*         | -.292* [-.34, -.25] | -.159* [-.20, -.11] | .365* [.32, .41] | -.270* [-.31, -.23] | -.342* [-.37, .09] | -.436* [-.47, -.40] |
| 4. Attentional Control | 22.62| 6.60 | 5–35    | .983*         | .364* [-.40, -.32] | .419* [-.46, -.38] | –     | .384* [.34, .42] | -.587* [-.62, -.55] | -.537* [-.57, -.50] | -.436* [-.47, -.40] |
| 5. Inhibitory Control  | 30.40| 6.17 | 11–49   | .974*         | -.292* [-.34, -.25] | -.159* [-.20, -.11] | .365* [.32, .41] | –     | -.270* [-.31, -.23] | -.436* [-.47, -.40] | -.146* [-.18, -.11] |
| 6. Ruminination        | 9.28 | 4.79 | 3–18    | .929*         | .216* [.17, .26] | .478* [.44, .52] | -.578* [.61, .54] | -.254* [.30, .21] | –     | .600* [.57, .63] | .388* [.35, .43] |
| 7. Depression          | 2.82 | 2.36 | 0–8     | .914*         | .276* [.23, .32] | .414* [.37, .46] | -.523* [.56, .49] | -.202* [.25, -.16] | .590* [.56, .62] | –     | .602* [.57, .64] |
| 8. Suicidal ideation   | .703 | 1.16 | 0–4     | .652*         | .365* [.33, .40] | .371* [.33, .41] | -.416* [.45, -.38] | -.117* [.15, -.08] | .371* [.33, .41] | .588* [.55, .62] | –     |

---

*p < .001.

https://doi.org/10.1371/journal.pone.0245562.t002

---

https://doi.org/10.1371/journal.pone.0245562.t003
Insistence on Sameness was also identified as a significant predictor of SI, with the b-weight revealing that for each unit increase in Insistence on Sameness, SI increased by 0.012 units. Attentional and Inhibitory Control both significantly predicted SI, with the b-weights revealing that for each unit increase in Attentional Control, SI decreased by 0.015 units, and for each unit increase in Inhibitory Control, SI increased by 0.015 units. Rumination was not a significant predictor of SI when entered in the model with the other variables, with each unit increase in Rumination associated with a decrease in SI of -0.010 units. Overall, Depression made the largest contribution to SI ($\beta = 0.484$). Comparing Social Communication to Insistence on Sameness; Social Communication Difficulties ($\beta = 0.192$) was relatively more important than Insistence on Sameness ($\beta = 0.144$). These two core variables shared some variance, but correlations in Table 3 reveal that these were largely independent contributions. Attentional Control ($\beta = -0.085$) and Inhibitory Control ($\beta = 0.077$) made similar, yet relatively smaller contributions to the model.

Suicidal ideation present versus not present comparisons

The sample was split into those reporting no suicidal ideation (SI = 0, $n = 1241$) and those reporting at least some ideation (SI $\geq 1$, $n = 610$). Groups were compared on age, depression, and social communication difficulties.

Table 4. Linear regression model of predictors of suicidal ideation.

| Variable                  | $b$   | SEB*  | $\beta$  | p-value  | BCa 95% CI  |
|---------------------------|-------|-------|----------|----------|-------------|
| Constant                  | -1.076| 0.224 | -        | < .001   | -1.508, -0.617 |
| Age                       | -0.007| 0.002 | -0.079   | .001     | -0.011, -0.004 |
| Social Communication Difficulties | 0.085  | 0.009 | 0.192    | < .001   | 0.067, 0.104 |
| Insistence on Sameness    | 0.012  | 0.002 | 0.144    | < .001   | 0.009, 0.015 |
| Attentional Control       | -0.015 | 0.004 | -0.085   | .001     | -0.023, -0.006 |
| Inhibitory Control        | 0.015  | 0.004 | 0.077    | < .001   | 0.008, 0.021 |
| Rumination                | -0.010 | 0.006 | -0.042   | .086     | -0.022, 0.001 |
| Depression                | 0.238  | 0.011 | 0.484    | < .001   | 0.213, 0.264 |

$R^2 = .433$, $F(7, 1843) = 201.19, p < .001$. BCa 95% confidence intervals that do not cross zero are bolded.

*SEB: the standard error for the unstandardized beta.

95% bias corrected and accelerated confidence intervals and standard errors based on 5000 bootstrap samples.

https://doi.org/10.1371/journal.pone.0245562.t004

Table 5. Means (SD) and bootstrapped ANCOVA comparisons between no-SI and SI groups on key variables controlling for age and depression.

| Variable                  | No-SI ($n = 1241$) | SI ($n = 610$) | F-statistic | $p$-value* | BCa 95% CI* | Cohen’s $d$ [95% CI] |
|---------------------------|--------------------|----------------|-------------|-----------|-------------|----------------------|
| Social communication difficulties | 9.36               | 2.60           | 11.17       | 2.20      | 128.82      | < .001               | -1.99, -1.39          | -0.73 [-0.88, -0.56] |
| Insistence on sameness    | 41.16              | 13.61          | 50.70       | 12.80     | 17.51       | < .001               | -4.66, -1.68          | -0.72 [-1.47, 0.30]  |
| Attentional control       | 24.51              | 6.30           | 18.79       | 5.45      | 36.53       | < .001               | 1.34, 2.67            | 0.95 [0.60, 1.38]   |
| Inhibitory control        | 31.23              | 6.76           | 28.71       | 4.29      | 7.62        | .003                 | 0.354, 1.67           | 0.42 [0.04, 0.76]   |
| Rumination                | 8.07               | 4.55           | 11.72       | 4.30      | 1.07        | .316                 | -0.714, 0.236         | -0.82 [-1.07, -0.48] |

*Age and depression entered as covariates in the model.

*5000 samples bootstrapped p-value.

*BCa 95% confidence intervals that do not cross zero are bolded.

https://doi.org/10.1371/journal.pone.0245562.t005
and the main study variables. Results of these analyses are presented in Table 5. Groups differed significantly on age, with those reporting no SI being overall older than those reporting presence of SI. Cohen’s $d$ effect size for the difference was in the small to moderate range. As would be expected, depression scores were also significantly higher in those reporting SI than the no SI group, with the difference returning a large effect size. Subsequently, bootstrapped ANCOVAs were used to compare the two groups on each of the main study variables, controlling for age and depression. Group membership did not have a significant effect on Rumination after controlling for age and depression in the model. There was a significant effect of group membership on core ASD related traits (i.e., Social Communication Difficulties, Insistence on Sameness) and cognitive variables (i.e., Attentional and Inhibitory Control). Thus, participants who reported some SI reported significantly greater Social Communication Difficulties, higher levels of Insistence on Sameness, and lower levels of Attentional and Inhibitory Control, than participants who did not report any SI.

**Discussion**

The present study aimed to examine the contribution of social communication difficulties and insistence on sameness, representative of core features of ASD, as well as cognitive control and ruminative thinking, to DSM-5 suicidal ideation [67, 68] in a large online recruited sample comprising normative and clinically diverse individuals. Cognitive control is a potential trans-diagnostic risk factor for suicidal behavior that remains underexplored [24, 25], and is affected in ASD [49–51, 53, 75]. Similarly, rumination and cognitive rigidity/insistence on sameness have been shown to be associated with depression [46, 76] and suicidal ideation [47, 48], as well as ASD traits [45]. Social communication difficulties, which are associated with depression in non-ASD samples [77, 78], are relatively unexplored in terms of their contribution to suicide risk, but are core characteristics of the ASD phenotype. We were specifically interested to know whether each of these constructs provided a unique contribution to suicidal ideation after controlling for depressive symptoms.

One third of the sample met the DSM-5 CC threshold for further inquiry for suicide risk due to presence of suicidal ideation, with around 40 percent meeting the threshold for concern for depression. Correlational analyses revealed that higher scores on social communication difficulties, insistence on sameness and rumination, and lower scores on attentional and inhibitory control were all significantly associated with DSM-5 CC depression and suicidal ideation. Regression analysis controlling for depression revealed that all factors excepting rumination contributed significantly to DSM-5 CC suicidal ideation, with the full model accounting for 43 percent of variance in suicidal ideation scores. Comparison of participants reporting at least some versus no suicidal ideation, controlling for age and depression, revealed significantly higher levels of social communication difficulties and insistence of sameness, and lower levels of attentional and inhibitory control in the group reporting some suicidal ideation.

Our findings suggest a role for core ASD related traits in suicidal ideation, consistent with studies reporting a high level of risk in ASD clinical [13, 14, 28, 30] and non-ASD [15, 17, 23, 38] samples. Indeed, our findings indicate that social communication difficulties and insistence on sameness independently predicted suicidal ideation when controlling for cognitive risk factors and depression. Moreover, results of this study contribute to an emerging evidence base positing ASD traits as an important dimensional construct underlying suicide risk that cuts across diagnostic boundaries. Our study extends previous research [13, 17, 28, 30, 38] by deconstructing specific components (i.e., social communication difficulties, insistence on sameness) of the ASD phenotype that represent the two primary clinical domains of the disorder. Importantly, the identification of the role of domains associated with the ASD phenotype,
representative of a clinical group at high risk of suicide, contributes to understanding and development of a transdiagnostic and dimensional framework for understanding suicide risk [8, 24, 25, 27]. The development of such a model pinpoints specific targets for intervention, and strengthens the call for assessing both individuals with clinical diagnoses of ASD, and those with high levels of ASD traits, for suicide risk [17].

Additional work is needed, however, to further clarify the processes (e.g., social, cognitive) whereby ASD traits contribute to suicide risk. Previous research has identified social relationships and loneliness as potentially important to depression and suicide in individuals with ASD [30, 79, 80], the present study extends this model by also examining cognitive control and negative valence domains.

Our findings provide support for the contribution of poor cognitive control, cognitive rigidity, and ruminative thinking style to suicidal ideation. However, it is interesting to note that the association between rumination and suicidal ideation was no longer significant when controlling for depression, suggesting overlap between these two factors. While depression is highly prevalent in people with ASD [81, 82], the mechanisms underlying increased suicide risk in this population may represent an interaction between traits associated with the core characteristics of the diagnosis, associated cognitive dysfunction, and co-occurring psychiatric conditions. Moreover, our findings suggest these mechanisms are not limited to clinical cases, but may constitute transdiagnostic risk factors. Together, our findings are significant in that they a) represent an attempt at unpacking the mechanisms associated with the ASD phenotype that might contribute to increased suicide risk and b) contribute to the growing literature concerning dimensional, transdiagnostic risk factors and mechanisms underlying suicide risk and behavior.

**Strengths and limitations**

This study was strengthened by our use of a large sample and theoretically informed constructs known to be associated with suicide risk. Our inclusion of constructs related to ASD traits, specifically social communication difficulties, RRBIs, and associated cognitive challenges represents a novel contribution to the literature. Nonetheless, the cross-sectional nature of the study limits our ability to infer causality. Findings are also limited due to reliance on self-report measures, including psychiatric diagnoses, and use of an online survey for data collection. Although our findings were generally consistent with the literature and theoretical background, it will be important to replicate our findings taking into consideration these methodological limitations. Future research will benefit from administration of cognitive assessments to better elucidate the effect of cognitive processes on suicide risk and more comprehensive, questionnaire and performance-based quantitative measures designed to capture strengths and weaknesses across different domains of social functioning, such as the SEL web [83] and the Stanford Social Dimensions Scale [84]. Suicide risk was assessed using the DSM-5 suicidal ideation screener incorporated into the cross-cutting symptom measure [67, 85], which was selected as it is relatively straightforward to administer using large scale online methodology, and because the presence of suicidal ideation has been shown to increase the likelihood of a suicide attempt [86]. However, the use of a single indicator or suicide risk limits our findings [87, 88]. Future research would benefit from a more comprehensive assessment of suicide risk and behavior.

**Future directions**

Executive dysfunction, including cognitive rigidity and poor decision-making, may be a trait vulnerability for suicide risk [89]. Our findings concerning rumination, depression, and
suicidal ideation suggests an inter-relationship among these three constructs. Response Styles Theory [90] posits that rumination is a cognitive response to depressed mood. Our findings indicate that, although associated with depression and suicidal ideation, rumination itself is not predictive of suicidal ideation scores. Future research is required to disentangle the associations among these factors, and to understand better the potential contribution of repetitive thinking to suicide risk and behavior. Ultimately, this calls for the development of including genetic and biological, cognitive, and social elements (i.e., bio-psycho-social model) underlying suicide risk. The first step in this process is to identify those individual mechanisms and to demonstrate their links to suicide behavior.

Conclusions
Despite the aforementioned limitations, our study demonstrated the potential role of ASD traits, particularly social communication difficulties and cognitive rigidity/insistence on sameness, and difficulties in broad cognitive domains associated with the ASD phenotype, as potential transdiagnostic factors underlying suicide risk. Our approach represents a shift away from disorder-specific research in an attempt at uncovering common mechanisms and risk factors for suicide behavior in individuals with no psychiatric diagnosis, individuals with diagnoses of one or more common psychiatric disorders, and individuals who may not have a formal diagnosis but who present with subthreshold symptomatology. These findings provide a roadmap for further longitudinal research and identify potential targets for intervention and clinical practice.

Supporting information
S1 Appendix. Scale items and ratings. Items for each of the constructs used in the study. (DOCX)
S1 Table. Participant distribution. Distribution of participants between US States and the District of Columbia. (DOCX)

Acknowledgments
We thank the individuals who participated in this study. DWE and MU designed the survey and collected the data. DH completed the literature review. DH and MU conceived of the report and prepared the tables. DH completed the data analysis and interpretation. DH and MU wrote the report, incorporating comments from all authors. MAS and DWE critically revised the report. All authors reviewed and approved the final submitted version.

Author Contributions
Conceptualization: Darren Hedley, Mirko Uljarević.
Data curation: David W. Evans.
Formal analysis: Darren Hedley.
Funding acquisition: Darren Hedley, David W. Evans.
Investigation: Darren Hedley, David W. Evans.
Methodology: Darren Hedley, Mirko Uljarević, David W. Evans.
Project administration: David W. Evans.
Writing – original draft: Darren Hedley.
Writing – review & editing: Darren Hedley, Mirko Uljarević, Ru Ying Cai, Simon M. Bury, Mark A. Stokes, David W. Evans.

References

1. World Health Organization. Preventing suicide: A global imperative (Vol. 2020). Geneva: World Health Organization; 2014.

2. O’Connor RC, Portzky G. Looking to the future: A synthesis of new developments and challenges in suicide research and prevention. Frontiers in Psychology. 2018; 9:2139. https://doi.org/10.3389/fpsyg.2018.02139 PMID: 30538647

3. Insel T, Cuthbert B, Garvey M, Heinissen R, Pine DS, Quinn K, et al. Research domain criteria (RDoC): toward a new classification framework for research on mental disorders. Am J Psychiatry. 2010; 167:748–51. https://doi.org/10.1176/appi.ajp.2010.09091379 PMID: 20595427

4. National Institute of Mental Health. Mechanisms underlying suicide risk: Integrating RDoC to inform novel and personalized intervention research. Maryland: National Institute of Mental Health; 2008.

5. Constantino JN, Todd RD. Autistic traits in the general population: a twin study. Archives of General Psychiatry. 2003; 60:524–30. https://doi.org/10.1001/archpsyc.60.5.524 PMID: 12745295

6. Evans DW, Leckman JF, Carter A, Reznick JS, Henshaw D, King RA, et al. Ritual, habit, and perfectionism: The prevalence and development of compulsive-like behavior in normal young children. Child Development. 1997; 68:58–68. PMID: 9084125

7. Gallyer AJ, Stanley IH, Day TN, Joiner TE. Examining the interaction of autism spectrum disorder-related traits and unit cohesion on suicide risk among military personnel. J Affect Disord. 2020; 271:59–65. https://doi.org/10.1016/j.jad.2020.03.092 PMID: 32312698

8. Eisner LR. A transdiagnostic model of suicidal ideation and suicide attempts. 2010. https://scholarlyrepository.miami.edu/oa_dissertations/358. Accessed 24 Aug 2020.

9. Joiner TE, Brown JS, Wingate LR. The psychology and neurobiology of suicidal behavior. Annual Review of Psychology. 2005; 56:287–314. https://doi.org/10.1146/annurev.psych.56.091103.070320 PMID: 15709937

10. Kessler RC, Berglund P, Borges G, Nock M, Wang PS. Trends in suicide ideation, plans, gestures, and attempts in the United States, 1990–1992 to 2001–2003. JAMA. 2005; 293:2487–95. https://doi.org/10.1001/jama.293.20.2487 PMID: 15914749

11. Kessler RC, Chiu WT, Demler O, Merikangas KR, Walters EE. Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. Archives of General Psychiatry. 2005; 62:617–27. https://doi.org/10.1001/archpsyc.62.6.617 PMID: 15939839

12. Hjelmeland H, Knizek BL. Suicide and mental disorders: A discourse of politics, power, and vested interests. Death Studies. 2017; 41:481–92. https://doi.org/10.1080/07481187.2017.1332905 PMID: 28535129

13. Cassidy S, Bradley P, Robinson J, Allison C, McHugh M, Baron-Cohen S. Suicidal ideation and suicide plans or attempts in adults with Asperger’s syndrome attending a specialist diagnostic clinic: A clinical cohort study. Lancet Psychiatry. 2014; 1:142–7. https://doi.org/10.1016/S2215-0366(14)70248-2 PMID: 26360578

14. Hirvikoski T, Middendorfer-Rutz E, Boman M, Larsson H, Lichtenstein P, Bölte S. Premature mortality in autism spectrum disorder. Br J Psychiatry. 2016; 208:232–8. https://doi.org/10.1192/bjp.bp.114.160192 PMID: 26541693

15. Pelton MK, Crawford H, Robertson AE, Rodgers J, Baron-Cohen S, Cassidy S. A measurement invariance analysis of the Interpersonal Needs Questionnaire and Acquired Capability for Suicide Scale in autistic and non-autistic adults. Autism in Adulthood. 2020; 2:193–203. https://doi.org/10.1089/aut.2019.0055 PMID: 32954219

16. Rodriguez-Seijas C, Gadow K D, Rosen T E., Kim H, Lerner MD, Eaton NR. A transdiagnostic model of psychotic symptom co-occurrence and autism spectrum disorder. Autism Res. 2019; 13:579–90. https://doi.org/10.1002/aur.2228 PMID: 31647197

17. Upthegrove R, Abu-Akel A, Chisholm K, Lin A, Zahid S, Pelton M, et al. Autism and psychosis: Clinical implications for depression and suicide. Schizophr Res. 2018; 195:80–5. https://doi.org/10.1016/j.schres.2017.08.028 PMID: 28823724

18. De Crescenzo F, Postorino V, Siracusano M, Riccioni A, Armando M, Curatolo P, et al. Autistic symptoms in schizophrenia spectrum disorders: A systematic review and meta-analysis. Frontiers in Psychiatry. 2019; 10:78–8. https://doi.org/10.3389/fpsyt.2019.00076 PMID: 30846948
19. Abu-Akel A, Allison C, Baron-Cohen S, Heinke D. The distribution of autistic traits across the autism spectrum: evidence for discontinuous dimensional subpopulations underlying the autism continuum. Mol Autism. 2019; 10:e24. https://doi.org/10.1186/s13229-019-0275-3 PMID: 31149329

20. Robinson EB, St Pourcain B, Anttila V, Kosmicki JA, Bulik-Sullivan B, Grove J, et al. Genetic risk for autism spectrum disorders and neuropsychiatric variation in the general population. Nat Genet. 2016; 48:552–555. https://doi.org/10.1038/ng.3529 PMID: 2698691

21. Rai D, Culpin I, Heuvelman H, Magnunsson CMK, Carpenter P, Jones HJ, et al. (2018). Association of autistic traits with depression from childhood to age 18 years. JAMA Psychiatry. 2018; 75:835–43. https://doi.org/10.1001/jamapsychiatry.2018.1323 PMID: 29898212

22. Rosbrook A, Whittingham K. Autistic traits in the general population: What mediates the link with depressive and anxious symptomatology? Res Autism Spectr Disord. 2010; 4:415–24.

23. Stanley H, Day TN, Gallyer AJ, Shelef L, Kalla C, Gutierrez PM, et al. Autism-related traits and suicide risk among active duty U.S. military service members. Psychol Serv. 2020. https://doi.org/10.1037/ser0000418 PMID: 32105121

24. Glenn CR, Cha CB, Kleiman EM, Nock MK. Understanding suicide risk within the Research Domain Criteria (RDoC) Framework: Insights, challenges, and future research considerations. Clin Psychol Sci. 2017; 5:568–92. https://doi.org/10.1177/2167702616686854 PMID: 28670505

25. Glenn CR, Kleiman EM, Cha CB, Deming CA, Franklin JC, Nock MK. Understanding suicide risk within the Research Domain Criteria (RDoC) framework: A meta-analytic review. Depress Anxiety. 2018; 35:65–88. https://doi.org/10.1002/da.22666 PMID: 29064611

26. Cuthbert BN. The RDoC framework: facilitating transition from ICD/DSM to dimensional approaches that integrate neuroscience and psychopathology. World Psychiatry. 2014; 13:28–35. https://doi.org/10.1002/wps.20087 PMID: 24497240

27. McCoy TH Jr, Pellegrini AM, Perlis RH. Research Domain Criteria scores estimated through natural language processing are associated with risk for suicide and accidental death. Depress Anxiety. 2019; 36:392–99. https://doi.org/10.1002/da.22882 PMID: 30710497

28. Cassidy S, Bradley L, Shaw R, Baron-Cohen S. Risk markers for suicidality in autistic adults. Mol Autism. 2018; 9:e42. https://doi.org/10.1186/s13229-018-0226-4 PMID: 30083306

29. Hedley D, Uljarevic M. Systematic review of suicide in Autism Spectrum Disorder: Current trends and implications. Current Developmental Disorders Reports. 2018; 5:65–76.

30. Hedley D, Uljarevic M, Foley KR, Richdale A, Trollor J. Risk and protective factors underlying suicidal ideation in Autism Spectrum Disorder. Depress Anxiety. 2018; 35:648–57. https://doi.org/10.1002/da.22759 PMID: 29659141

31. Zahid S, Upthegrove R. Suicidality in Autistic Spectrum Disorders: A systematic review. Crisis. 2017; 8:237–46

32. Hand BN, Benevides TW, Carretta HJ. Suicidal ideation and self-inflicted injury in Medicare enrolled autistic adults with and without co-occurring intellectual disability. J Autism Dev Disord. 2020; 50:3489–8:237–46

33. Baron-Cohen S, Wheelwright S, Skinner R, Martin J, Clubley E. The autism-spectrum quotient (AQ): Evidence from Asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. J Autism Dev Disord. 2001; 31:5–17. https://doi.org/10.1023/a:1005653411471 PMID: 11439754

34. Ruzich E, Allison C, Smith P, Watson P, Auyeung B, Ring H, et al. Measuring autistic traits in the general population: a systematic review of the Autism-Spectrum Quotient (AQ) in a nonclinical population sample of 6,900 typical adult males and females. Mol Autism. 2015; 6:e2.

35. Colvert E, Tick B, McEwen F, Stewart C, Currans SR, Woodhouse E, et al. Heritability of Autism Spectrum Disorder in a UK population-based twin sample. JAMA Psychiatry. 2015; 72:415–23. https://doi.org/10.1001/jamapsychiatry.2014.3028 PMID: 25738232

36. Stergiakouli E, Davey Smith G, Martin J, Skuse DH, Vuchtbauer W, Ring SM, et al. Shared genetic influences between dimensional ASD and ADHD symptoms during child and adolescent development. Mol Autism. 2017; 8:e18. https://doi.org/10.1186/s13229-017-0131-2 PMID: 28392908

37. Cassidy S, Gould K, Townsend E, Pelton M, Robertson AE, Rodgers J. Is camouflaging autistic traits associated with suicidal thoughts and behaviours? Expanding the Interpersonal Psychological Theory of Suicide in an undergraduate student sample. J Autism Dev Disord. 2020; 50:3638–48. https://doi.org/10.1007/s10803-019-04323-3 PMID: 31820344

38. Pelton MK, Cassidy SA. Are autistic traits associated with suicidality? A test of the interpersonal-psychological theory of suicide in a non-clinical young adult sample. Autism Res. 2017; 10:1891–904. https://doi.org/10.1002/aur.1828 PMID: 28685996

39. Joiner TE. Why people die by suicide. Cambridge: Harvard University Press; 2005.
40. American Psychiatric Association. Diagnostic and statistical manual of mental disorders (5th ed.). Washington: American Psychiatric Association; 2013.

41. Unruh KE, Bodfish JW, Gotham KO. Adults with autism and adults with depression show similar attentional biases to social-affective images. J Autism Dev Disord. 2020; 50:2336–47. https://doi.org/10.1007/s10803-018-3627-5 PMID: 29882107

42. Fazakas-DeHoog LL, Rnic K, Dozois DJA. A cognitive distortions and deficits model of suicide ideation. Europe’s Journal of Psychology. 2017; 13:178–93. https://doi.org/10.5964/ejop.v13i2.1238 PMID: 28580021

43. Litinsky AM, Haslam N. Dichotomous thinking as a sign of suicide risk on the TAT. J Pers Assess. 1998; 71:368–78. https://doi.org/10.1207/s15327752ja7103_6 PMID: 933942

44. Pu S, Setoyama S, Noda T. Association between cognitive deficits and suicidal ideation in patients with major depressive disorder. Scientific Reports. 2017; 7:e11637. https://doi.org/10.1038/s41598-017-12142-8 PMID: 28912439

45. Keenan EG, Gotham K, Lerner MD. Hooked on a feeling: Repetitive cognition and internalizing symptomatology in relation to autism spectrum symptomatology. Autism. 2018; 22:814–24. https://doi.org/10.1177/1362361317709603 PMID: 2874248

46. Nolen-Hoeksema S. The role of rumination in depressive disorders and mixed anxiety/depressive symptoms. J Abnorm Psychol. 2000; 109:504–11. PMID: 11016119

47. Miranda R, Nolen-Hoeksema S. Brooding and reflection: rumination predicts suicidal ideation at 1-year follow-up in a community sample. Behav Res Ther. 2007; 45:3088–95. https://doi.org/10.1016/j.brat.2007.07.015 PMID: 17825248

48. Smith JM, Alloy LB, Abramson LY. Cognitive vulnerability to depression, rumination, hopelessness, and suicidal ideation: multiple pathways to self-injurious thinking. Suicide and Life-Threatening Behavavior. 2006; 36:443–53.

49. Demurie E, Roeyers H, Sonuga-Barke E. Temporal discounting of monetary rewards in children and adolescents with ADHD and autism spectrum disorders. Dev Sci. 2012; 15:791–800. https://doi.org/10.1111/j.1467-7687.2012.01178.x PMID: 23106733

50. Geurts HM, Verte S, Oosterlaan J, Roeyers H, Sergeant JA. How specific are executive function deficits in attention deficit hyperactivity disorder and autism? J Child Psychol Psychiatry. 2004; 45:836–54. https://doi.org/10.1111/j.1469-7610.2004.00276.x PMID: 15056314

51. Karalunas SL, Hawkey E, Gustafsson H, Miller M, Langhorst M, Cordova M, et al. Overlapping and distinct cognitive impairments in Attention-Deficit/Hyperactivity and Autism Spectrum Disorder without intellectual disability. J Abnorm Child Psychol. 2018; 46:1705–16. https://doi.org/10.1007/s10802-017-0394-2 PMID: 29450820

52. Ozonoff S, Jensen J. Brief report: Specific executive function profiles in three neurodevelopmental disorders. J Autism Dev Disord. 1999; 29:171–7. https://doi.org/10.1023/a:1023052913110 PMID: 10382139

53. Bos DJ, Silverman MR, Ajodan EL, Martin C, Silver BM, Brouwer GJ, et al. Rigidity coincides with reduced cognitive control to affective cues in children with autism. J Abnorm Psychol. 2019; 128:431–41. https://doi.org/10.1037/abn0000423 PMID: 31045398

54. Crandall A, Allsop Y, Hansom CL. The longitudinal association between cognitive control capacities, suicidality, and depression during late adolescence and young adulthood. J Adolesc. 2018; 65:167–76.

55. Stewart JG, Glenn CR, Esposito EC, Cha CB, Nock MK, Auerbach RP. Cognitive Control Deficits Differentiate Adolescent Suicide Ideators From Attempters. J Clin Psychiatry. 2017; 78:614–21. https://doi.org/10.4088/JCP.16m10647 PMID: 28199073

56. Evans DW, Lusk LG, Slane MM, Michael AM, Myers SM, Ulijarevič M, et al. Dimensional assessment of schizotypal, psychotic, and other psychiatric traits in children and their parents: Development and validation of the Childhood Oxford-Liverpool Inventory of Feelings and Experiences on a representative US sample. J Child Psychol Psychiatry. 2018; 59:574–85. https://doi.org/10.1111/jcpp.12827 PMID: 29083029

57. Evans DW, Ulijarevič M, Lusk LG, Loth E, Frazier T. Development of two dimensional measures of restricted and repetitive behavior in parents and children. J Am Acad Child Adolesc Psychiatry. 2017; 56:51–8. https://doi.org/10.1016/j.jaac.2016.10.014 PMID: 27993229

58. Buhrmester M, Kwang T, Gosling SD. Amazon’s Mechanical Turk: A new source of inexpensive, yet high-quality data? In: Kazdin AE, editor. Methodological issues and strategies in clinical research. Washington: American Psychological Association; 2016. p. 133–9.

59. Buhrmester MD, Talafir S, Gosling SD. An evaluation of Amazon’s mechanical Turk, its rapid rise, and its effective use. Perspect Psychol Sci. 2018; 13:149–54. https://doi.org/10.1177/1745691617706516 PMID: 29928846
60. Palan S, Schitter C. Prolific.ac—A subject pool for online research. Journal of Behavioral and Experimental Finance. 2018; 17:22–7.

61. Qualtrics. Qualtrics version 2.16 [computer program]. Utah: Qualtrics; 2017.

62. United States Census Bureau. State and county QuickFacts 2010, 2014. United States Census Bureau. 2019. https://quickfacts.census.gov. Accessed Apr 16, 2020.

63. Kessler RC, Berglund P, Demler O, Jin R, Merikangas KR, Walters EE. Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. Archives of General Psychiatry. 2005; 62:593–602. https://doi.org/10.1001/archpsyc.62.6.593 PMID: 15939837

64. Allison C, Auyeung B, Baron-Cohen S. Toward brief "Red Flags" for autism screening: The Short Autism Spectrum Quotient and the Short Quantitative Checklist for Autism in toddlers in 1,000 cases and 3,000 controls [corrected]. J Am Acad Child Adolesc Psychiatry. 2012; 51:202–12. https://doi.org/10.1016/j.jaac.2011.11.003 PMID: 2265366

65. Evans DE, Rothbart MK. Developing a model for adult temperament. J Res Pers. 2007; 41:868–88.

66. Berle D, Starecicv V, Moses K, Hannan A, Milicevic D, Sammut P. (2011). Preliminary validation of an ultra-brief version of the Penn State Worry Questionnaire in 1,000 cases and 3,000 controls [corrected]. J Am Acad Child Adolesc Psychiatry. 2012; 51:202–12. https://doi.org/10.1016/j.jaac.2011.11.003 PMID: 22265366

67. Narrow WE, Clarke DE, Kuramoto SJ, Kraemer HC, Kupfer DJ, Greiner L, et al. DSM-5 field trials in the United States and Canada, Part III: development and reliability testing of a cross-cutting symptom assessment for DSM-5. Am J Psychiatry. 2013; 170:71–82. https://doi.org/10.1176/appi.ajp.2012.12071000 PMID: 23111499

68. Narrow WE, Kuhl EA. Dimensional approaches to psychiatric diagnosis in DSM-5. J Ment Health Policy Econ. 2011; 14:197–200. PMID: 22345361

69. Clarke DE, Kuhl EA. DSM-5 cross-cutting symptom measures: a step towards the future of psychiatric care? World Psychiatry. 2014; 13:314–6. https://doi.org/10.1002/wps.20154 PMID: 25273306

70. Little RJA. A test of missing completely at random for multivariate data with missing values. J Am Stat Assoc. 1988; 83:1198–202.

71. Tabachnick BG, Fidell LS. Using Multivariate Statistics (5th ed.). Massachusetts: Allyn & Bacon; 2007.

72. Efron B, Tibshirani R. An Introduction to the Bootstrap. Florida: Chapman & Hall/CRC; 1993.

73. Cohen J, Cohen P, West SG, Aiken LS. Applied multiple regression/correlation analysis for the behavioural sciences, 3rd ed. New Jersey: Lawrence Erlbaum Associates; 2013.

74. Hedley D, Uljarević M, Cai RY, Bury SM, Stokes MA, Evans DW. Transdiagnostic predictors of DSM-5 suicide risk [raw dataset, Version 1]. OSF. 2020. https://doi.org/10.17605/OSF.IO/C2AP3

75. Nigg JT. On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. Psychology Bulletin. 2000; 126:220–46. https://doi.org/10.1037/0033-2909.126.2.220 PMID: 10748641

76. Nolen-Hoeksema S, Wisco BE, Lyubomirsky S. Rethinking rumination. Perspect Psychol Sci. 2008; 3:400–24. https://doi.org/10.1111/j.1745-6924.2008.00088.x PMID: 26158958

77. Knight MJ, Baune BT. Social cognitive abilities predict psychosocial dysfunction in major depressive disorder. Depress Anxiety. 2019; 36:54–62. https://doi.org/10.1002/da.22844 PMID: 30211866

78. LeMoult J, Joormann J, Sherdell L, Wright Y, Gotlib IH. Identification of emotional facial expressions following recovery from depression. J Abnorm Psychol. 2009; 118:828–33. https://doi.org/10.1037/a0018944 PMID: 19899852

79. Hedley D, Uljarević M, Wilmot M, Richdale A, Dissanayake C. Social support, depression and suicidal ideation in adults with Autism Spectrum Disorder. J Autism Dev Disord. 2017; 47:3669–77. https://doi.org/10.1007/s10803-017-3274-2 PMID: 28861661

80. Hedley D, Uljarević M, Wilmot M, Richdale A, Dissanayake C. Understanding depression and thoughts of self-harm in autism: A potential mechanism involving loneliness. Res Autism Spectr Disord. 2018; 46:1–7.

81. Hudson CC, Hall L, Harkness KL. Prevalence of depressive disorders in individuals with Autism Spectrum Disorder: A meta-analysis. J Abnorm Child Psychol. 2019; 47:165–75. https://doi.org/10.1007/s10803-019-04084-z PMID: 31190198

82. Uljarević M, Hedley D, Foley KR, Magiati I, Cai RY, Dissanayake C, et al. Anxiety and depression from adolescence to old age in Autism Spectrum Disorder. J Autism Dev Disord. 2020; 50:3155–65 https://doi.org/10.1007/s10803-019-04084-z PMID: 31190198

83. Russo-Ponsaran NM, Lerner MD, McKown C, Weber RJ, Karls A, Kang E, et al. Web-based assessment of social-emotional skills in school-aged youth with Autism Spectrum Disorder. Autism Res. 2019; 12:1260–71. https://doi.org/10.1002/aur.2123 PMID: 31081292
84. Phillips JM, Ujarevic M, Schuck RK, Frazier TW, Schapp SS, Solomon, EM, et al. Development of the Stanford Social Dimensions Scale (SSDS): Initial validation in autism spectrum disorder (ASD). Mol Autism. 2019; 10:e48.

85. American Psychiatric Association. DSM-5 self-rated level 1 cross-cutting symptom measure-adult. 2013. https://www.psychiatry.org/psychiatrists/practice/dsm/educational-resources/assessment-measures. Accessed Aug 24, 2020.

86. Lewinsohn PM, Rohde P, Seeley JR. Adolescent suicidal ideation and attempts: Prevalence, risk factors, and clinical implications. Clin Psychol. 1996; 3:25–46.

87. Hom MA, Joiner TE, Bernert RA. Limitations of a single-item assessment of suicide attempt history: Implications for standardized suicide risk assessment. Psychol Assess. 2016; 28:1026–30. https://doi.org/10.1037/pas0000241 PMID: 26502202

88. Millner AJ, Lee MD, Nock MK. Single-item measurement of suicidal behaviors: validity and consequences of misclassification. PLoS ONE. 2015; 10:e0141606. https://doi.org/10.1371/journal.pone.0141606 PMID: 26496707

89. Weiner L, Flin A, Causin J-B, Weibe S, Bertschy G. (2019). A case study of suicidality presenting as a restricted interest in autism spectrum disorder. BMC Psychiatry. 2019; 19:e126. https://doi.org/10.1186/s12888-019-2122-7 PMID: 31029170

90. Nolen-Hoeksema S. Responses to depression and their effects on the duration of depressive episodes. J Abnorm Psychol. 1991; 100:569–82. https://doi.org/10.1037//0021-843x.100.4.569 PMID: 1757671