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Author/s:
Allott, K;Gao, CX;Fisher, C;Hetrick, SE;Filia, KM;Menssink, JM;Herrman, HE;Rickwood, DJ;Parker, AG;McGorry, PD;Cotton, SM

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DR. CAROLINE X GAO (Orcid ID : 0000-0002-0987-2759)

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The Neuropsychological Symptoms Self-Report (NSSR): Psychometric properties in an adolescent and young adult mental health cohort

Running title: Psychometric properties of NSSR

Kelly Allott[1,2*], Caroline X. Gao[1,2,3*], Caroline Fisher[4,5], Sarah E Hetrick[6], Kate M Filia[1,2], Jana M Menssink[1,2], Helen E Herrman[1,2], Debra J Rickwood[7,8], Alexandra G Parker[1,2,9], Patrick D Mcgorry[1,2], and Sue M Cotton[1,2]

[1]Orygen, Parkville, VIC, Australia

[2]Centre for Youth Mental Health, The University of Melbourne, Parkville, VIC, Australia

[3]Department of Epidemiology and Preventive Medicine, School of Public Health and Preventive Medicine, Monash University, Melbourne, Australia

[4]Department of Psychology, Royal Melbourne Hospital, Melbourne Health, Parkville, VIC, Australia

[5]The Melbourne Clinic, Richmond, Melbourne, VIC, Australia

[6]Department of Psychological Medicine, University of Auckland, Auckland, New Zealand

7headspace National Youth Mental Health Foundation, VIC, Australia

[8]Faculty of Health, University of Canberra, ACT, Australia

[9]Institute for Health and Sport, Victoria University, Melbourne, VIC, Australia

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*Joint first authorship

Background: Subjective cognitive symptoms are common in young people receiving mental health treatment and are associated with poorer outcomes. The aim of this study was to determine the psychometric properties of the Neuropsychological Symptoms Self-Report (NSSR), an eight-item measure recently developed to provide a snapshot of young people's perceived change in cognitive functioning in relation to mental health treatment. **Method:** The sample included 633 youth aged 12-25 years (M_{age}=18.2, 66.5% female, 88.6% Australian-born) who had sought mental health treatment in primary *headspace* services. At three-months follow-up participants completed the NSSR and self-report measures of depression and anxiety. **Results:** Excellent internal consistency was found: Cronbach's alpha=0.93. The NSSR had negative correlations with self-reported anxiety (r=-0.33, p<0.001) and depression (r=-0.48, p<0.001) symptoms, suggesting a link with affective symptoms, but still independence of constructs. Exploratory and confirmatory factor analyses supported a single-factor model. Item response theory (IRT) analysis suggested good model fit (homogeneity, data integrity, scalability, local independence and monotonicity) for all items. There was some evidence of measurement non-invariance (for item thresholds) by sex and age, but not diagnosis. IRT models also supported briefer six- and three-item versions of the NSSR. **Conclusion:** In busy clinical practice, clinicians need a rapid and reliable method for determining whether cognitive symptoms are of concern and in need of further assessment and treatment. Study findings support the NSSR as a brief, psychometrically-sound measure for assessing subjective cognitive functioning in adolescents and young adults receiving mental health treatment.

Key Practitioner Message

- Subjective cognitive symptoms are common in young people receiving mental health treatment and are associated with poorer outcomes.
- This study evaluated the psychometric properties of a new instrument, Neuropsychological Symptoms Self-Report (NSSR), in measuring subjective cognitive functioning in youth with mental ill health.
- This study shows that the NSSR has sound sensitivity, structure, and internal consistency.

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- The NSSR can be used as brief tool to identify individuals who may be at risk of incomplete recovery and in need of further assessment and tailored treatment.

Keywords: cognitive symptoms; subjective; youth; depression; anxiety; psychometrics; unidimensional; classic test theory; item response theory

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Introduction

Mental illness is the major health issue facing young people globally, responsible for 45% of the overall disease burden in those aged 10-24 years (Gore et al., 2011). The peak onset of mental disorder occurs in adolescence and young adulthood, with over 75% of mental disorders emerging before the age of 25 years (Caspi et al., 2020; Kessler, Bergland, Demler, Jin, & Walters, 2005). If not adequately assessed and treated early, mental health outcomes are poor, including lower levels of vocational achievement, workforce participation, earning capacity and living standards later in life (Gibb, Fergusson, & Horwood, 2010; Patton et al., 2014).

Subjective self-reported cognitive concerns, complaints or symptoms (such as losing one's train of thought, forgetting important information, or having trouble concentrating) are common in people presenting for mental health treatment, including adolescents and young adults (Cha et al., 2018; Fisher, Goodall, Simmons, Allott, & Hetrick, 2016; McIntyre et al., 2019; Morey-Nase et al., 2019; Srisurapanont et al., 2018). It is well documented that self-reported subjective cognitive functioning is not significantly correlated with objectively measured cognitive performance (Carrigan & Barkus, 2016; Moritz, Ferahli, & Naber, 2004; Petersen, Porter, & Miskowiak, 2019; Srisurapanont, Suttajit, Eurviriyanukul, & Varnado, 2017). The degree of subjective cognitive impairment accounts for a significant proportion of variance in interpersonal and vocational functioning, particularly in mood disorders (Manit et al., 2017; Petersen et al., 2019; Sumiyoshi et al., 2019). In fact, some studies of people with depression have shown that subjective cognitive functioning better predicts social and occupational functioning than objective cognition (Ott et al., 2016; Sumiyoshi et al., 2019). Subjective cognitive impairments are also known to correlate with affective symptoms (Allott et al., 2020; Srisurapanont et al., 2018) and therefore, often resolve with a reduction in these symptoms. However, residual subjective cognitive impairments are relatively common after a mood episode (Conradi, Ormel, & de Jonge, 2011) and are associated with incomplete recovery and subsequent relapse (Saragoussi et al., 2017). Thus, it is important that mental health clinicians monitor subjective cognitive functioning in their young clients during or following a course of treatment, in order to determine whether additional therapeutic support for cognition is indicated (Bryce & Allott, 2019; Knight & Baune, 2018; McIntyre et al., 2019; Miskowiak et al., 2018).

The Neuropsychological Symptom Self-Report (NSSR) is a brief eight-item self-report questionnaire that was developed to assess subjective changes in cognitive functioning in youth who are receiving or have received a course of treatment for their mental ill health

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(Allott et al., 2020; Fisher et al., 2016). The eight items were selected based on our clinical experience and on the areas of cognition affected in adolescent depression as identified in previous research (e.g., Baune, Czira, Smith, Mitchell, & Sinnamon, 2012; Brooks, Iverson, Sherman, & Roberge, 2010; Goodall et al., 2018; Maalouf et al., 2011). The items were written in plain language and tested through a series of focus groups, including young people with lived experience of mental illness, mental health practitioners and academics, and items were refined based on this feedback (Fisher et al., 2016). The respondent indicates on each item whether they perceive improvement, worsening, or no change in cognitive function since commencing treatment (or over a specified period of time). The NSSR differs from other measures of subjective cognition because responses reflect perceived *change* over a period of time (i.e., during treatment) via cross-sectional retrospective self-report. Thus, there is no need for a baseline, or pre-treatment, administration of the measure to estimate change, which is advantageous for minimising client burden, particularly when they are mentally unwell or new to receiving mental health care as is often the case for young people.

The first study to examine the use of the NSSR was conducted in a sample of young people aged 12-25 (N=50) who were receiving treatment (primarily psychological therapy) for depression (Fisher et al., 2016). Participants with mild to moderate depression more often perceived their cognitive function to have improved since commencing treatment, compared to those with moderately severe to severe depression (Fisher et al., 2016). More recently, the NSSR was administered to a larger independent cohort of young people aged 12-25 (N=656) after they had been enrolled in treatment at a primary care mental health setting (Allott et al., 2020). Approximately a quarter to one-third of the sample reported subjective improvement in their cognitive functioning after three months of treatment. However, a small proportion of participants reported subjective decline in cognitive functioning since commencing treatment. A reduction in depressive and anxiety symptoms over three months was found to be associated with subjective improvement in cognitive functioning at the three-month follow-up, whereas an increase in depressive and anxiety symptoms was associated with worse subjective cognitive functioning at the follow-up (Allott et al., 2020). In both studies, the NSSR was anecdotally easy for young people to complete and missing data were minimal. To our knowledge, these are the first studies to examine subjective cognitive functioning in youth, including those under the age of 18, receiving mental health care. These preliminary studies suggest that the NSSR may be an efficient and sensitive tool for monitoring subjective cognitive functioning within youth mental health services.

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Nevertheless, the psychometric properties of the NSSR have not yet been evaluated, which was the purpose of the current study. The study had two specific aims. The first aim was to use classic test theory as well as item response theory (IRT) principles to examine the internal consistency, associations with related measures, dimensionality, individual item properties, as well as measurement invariance of the NSSR in a cohort of young people receiving treatment from a primary mental health service. The second aim was to use IRT to determine the optimal questions to include in shorter six-item and three-item versions of the NSSR.

Method

Design, setting and participants

This study involved analysis of three-month follow-up data from a cohort study examining characteristics and outcomes of young people presenting for mental health treatment: the comprehensive outcome measurement for youth (Y-COM) study (Filia et al., 2021). Participants were recruited from three metropolitan and two regional *headspace* centres across Australia. *headspace* is a federally-funded primary care service for people aged 12-25 years experiencing, or at risk of developing, mental or substance use disorders (McGorry et al., 2007; D. Rickwood et al., 2019; D. J. Rickwood, Telford, Parker, Tanti, & McGorry, 2014). Young people presenting to the study *headspace* centres for the first appointment with concerns about mental health or substance use-related problems were considered eligible for the study.

Measures

A questionnaire pack containing 18 self-report and clinician-rated measures was administered in the primary Y-COM study; only those measures relevant to the current study are reported here. Demographic characteristics of relevance to this analysis included age and sex assigned at birth (participants reporting intersex were too few to be included as a separate group in the analysis). Primary diagnoses based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth edition (DSM-5; American Psychiatric Association, 2013) were obtained from the participant's medical record.

Neuropsychological Symptom Self-Report (NSSR)

Subjective cognitive functioning was assessed at three-month follow-up using the NSSR (Allott et al., 2020; Fisher et al., 2016). The NSSR is an eight-item self-report questionnaire that assesses an individual's subjective changes in cognitive functioning (e.g., thinking speed, memory, concentration) since commencing treatment (items listed in Table 1). It takes five minutes to complete. For each item, on a three-point scale the participant indicates whether their cognitive functioning is (i) better than – scored as +1, (ii) the same as – scored as 0, or

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(iii) worse than before they started treatment – scored as -1; for the current study, this period was over the previous three months. The item total score is calculated as the mean score of the eight items, with a score <0 indicating deterioration and a score >0 indicating improvement in subjective cognitive functioning.

Depression and Anxiety

Given that cognitive symptoms are inherent to depression and anxiety, we evaluated convergence of affective symptoms with the NSSR (Lam et al., 2018). Depressive symptoms were measured using the Patient Health Questionnaire (PHQ9; Kroenke, Spitzer, & Williams, 2001), a nine-item self-report instrument for measuring depression severity over the previous two weeks. The PHQ9 has excellent internal consistency (Cronbach's α of 0.86-0.89) and using a threshold score of 10, the PHQ9 has a sensitivity of 88% and a specificity of 88% for major depression (Kroenke et al., 2001). Anxiety symptoms were measured using the Generalised Anxiety Disorder scale (GAD7; Spitzer, Kroenke, Williams, & Löwe, 2006), a seven-item self-report instrument for measuring generalised anxiety disorder symptoms over the previous two weeks. The GAD7 has excellent internal consistency (Cronbach's α of 0.92), has strong convergent validity with the Beck Anxiety Inventory (r=0.76, p<0.001) and using the threshold score of 10, the GAD-7 has a sensitivity of 89% and a specificity of 82% for GAD (Seo & Park, 2015). The PHQ-9 and GAD7 have been validated for use in adolescents and predictive validity is strong, as higher scores are associated with poorer functioning (Kroenke et al., 2001; Mossman et al., 2017; Sinclair-McBride, Morelli, & Gusman, 2018).

Procedure

Recruitment for the study occurred from September 2016 to April 2018. Research assistants were embedded within each *headspace* centre to identify eligible study participants. Advertisements were also placed around centre waiting rooms to increase visibility of the study to potential participants. Written informed consent was obtained from all participants and a parent/guardian for participants aged <18 years (unless considered mature minors as determined by the clinical staff). Following consent, participants completed a comprehensive questionnaire of self-report measures via tablet devices under the supervision of a research assistant and participated in a brief semi-structured clinical interview. Participants were contacted three months' post-baseline to complete the follow-up assessment (the focus of the current study), again via tablet device or via an online link provided to them. Participants were reimbursed AU$30 after each assessment. All procedures were reviewed and approved

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by the University of Melbourne Human Research Ethics Committee, and the Human Ethics and Advisory Group (1645367.1).

Statistical Analysis

Analyses were conducted using **R** version 4.0.2 (2020-06-22). Descriptive statistics, such as means (standard deviations) and percentages (counts) were used to characterise the total cohort.

Classic Test Theory

The item total scores on the NSSR were displayed using histograms. Individual item response patterns were visualised using a chord diagram. Due to the ordinal scale of the instrument, inter-item correlations were evaluated using polychoric correlation coefficients (r_{pc}, *polychoric* function from *psych* package), and item-total correlations were estimated using polyserial correlation coefficients (r_{ps}, using *polyserial* function from *psych* package) (Holgado-Tello, Chancon-Moscoso, Barbero-Garcia, & Villa-Abad, 2010). The average inter-item correlation should be ≥0.3 and preferably >0.4 for good reliability (Clark & Watson, 1995). Pairwise correlations were also visualised using multidimensional scaling (MDS) network plots (Jones, Mair, & McNally, 2018) to identify whether there were any sub-clusters of items. Internal consistency between NSSR items was evaluated using Cronbach's alpha (α) based on r_{pc} correlations, with values above 0.7 considered acceptable, and closer to 0.9 considered ideal (Tavakol & Dennick, 2011).

Pearson Product Moment correlation coefficients (r) were used to explore the direction and magnitude of associations between the NSSR and self-reported depression and anxiety as measured respectively by the PHQ9 and GAD7 at follow-up (same time when the NSSR was administered). Correlation coefficients (r) were also estimated between the NSSR and changes in anxiety and depression symptoms between baseline and follow-up. Due to the large differences in the level of affective symptoms at baseline, these were estimated separately for those who reported lower versus higher levels of affective symptoms at baseline (equal/above or below the cut-off score of 10 for both PHQ9 and GAD7). A correlation coefficient with a value >0.70 indicates a high correlation, and coefficients with values of 0.50-0.70 and <0.50 indicate moderate and low correlations, respectively (Carlson & Herdman, 2010; Mukaka, 2012).

Principal component analysis (PCA), exploratory factor analysis (EFA), and confirmatory factor analysis (CFA), were used to explore the factor structure of the NSSR. PCA was first conducted based on the pairwise r_{pc} coefficients (using *princomp* function from *stats* package). EFA was then carried out using *fa.parallel* and Very Simple Structure *(VSS)*

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functions from *psych* package. CFA was used to compare fitting statistics between one-factor and two-factor models (using *cfa* function from *lavaan* package) with diagonally weighted least squares (WLSMV) estimator for ordinal variables (Li, 2016). Model fitting was evaluated using chi-square (χ^2) goodness of fit statistics, root mean square error of approximation (RMSEA), Tucker Lewis Index (TLI) and the comparative fit index (CFI).

Item Response Theory

Both non-parametric and parametric IRT models were used to further investigate the psychometric characteristics of the NSSR. The general difference between IRT and classic test theory is that IRT models both the latent trait of individuals (in our case, the latent factor of subjective changes in cognitive functioning), as well as how items measure the latent trait differently (Gierl & Bisanz, 2001). This is commonly achieved via modelling the probability of endorsing an item as a function of the latent trait of the individual, the item difficulty (where the item differentiates the spectrum of the latent trait, also referred to as item location) and item discriminability (how efficiently the item separates latent traits, also referred to as item slope) (van den Linden & Hambleton, 2013). Considering the psychometric properties of the NSSR via IRT allows us to identify possible differential measurement properties of items, how individuals respond to items differently and efficiently reducing the number of items without compromising measurement validity.

Mokken non-parametric analysis (using *Mokken* package) was used to broadly evaluate item homogeneity, data integrity, scalability, local independence and monotonicity (Van der Ark, 2007). Kernel smoothing methods (using *KernSmoothIRT* package) were also used to visualise option characteristic curves (OCC) and expected item scores (EIS) (Mazza, Punzo, & McGuire, 2014). Graded response models (GRM; parametric IRT model for ordinal viarable) (Samejima, 1968) were then fitted using *mirt* package (Chalmers, 2012). GRM is a generalisation of the 2PL model for polytomous items. It models the conditional probability for choosing the kth or above response level of item i, given the latent trait θ as well as the item location or difficulty parameters (thresholds, $\beta_{k,i}$) and discrimination parameter (slope, α_i):

$$P(x \geq k \mid \theta) = \frac{exp\left(\alpha_i(\theta - \beta_{k,i})\right)}{1 + exp\left(\alpha_i(\theta - \beta_{k,i})\right)}$$

In our case, all items have three unique responses; hence, two threshold parameters were estimated for each item. The thresholds can be interpreted as the cut-off values for the trait level to respond on or above the response level, therefore, indicating the "difficulty" of the

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item in evaluating the latent trait. The slope parameter represents the item's efficiency in discriminating latent traits (the higher the slope parameter, the more the item is sensitive to changes in the latent trait level). The best questions for the six-item and three-item shorter versions of the NSSR were selected from IRT models with maximum information.

Measurement invariance by sex, age (12-17 years versus 18-25 years) and primary diagnosis (anxiety and/or depression versus other diagnoses) were further evaluated using the IRT model by sequentially comparing model fitting with different level of parameter constraints (configural model with models constraining equal slope, thresholds, mean and variance) as well as differential item function (DIF) for individual items (Thissen, Steinberg, & Wainer, 1993). Fit statistics, including M2 statistics (Maydeu-Olivares & Joe, 2006), RMSEA, TLI and CFI were used to compare models. ANOVA (likelihood ratio tests) were used to compare nested models.

Results

Cohort Characteristics

This study involved analysis of data from 633 participants (of 665 participants in the follow-up study) with complete information on all NSSR items. Nine participants with clinical assessments only, or potentially identifiable information were excluded, as well as 23 participants with incomplete NSSR data. Participants' characteristics are displayed in Table 2. The mean age of the cohort was 18.2 years, with slightly less than half of the participants under the age of 18. The cohort included more females than males. About three-quarters of participants were diagnosed with an anxiety disorder, depressive disorder, or both. On average, self-reported depressive symptoms were within the mild to moderate range and generalised anxiety symptoms were within the mild range.

Classic Test Theory

The distributions of NSSR total scores (cohort mean: 0.19; SD:0.42) are displayed in Figure 1 for the total sample and by sex and age group; 49.8% of the participants scored over 0, 33.3% scored 0 and 16.9% scored under 0. Males and those aged 18-25 scored higher compared with females and those aged 12-17, respectively. Paired choice of individual NSSR items is displayed in a Chord diagram (see Figure S1 in Supporting Information). The item with the highest proportion of improvement was "Motivation", and the lowest proportion of improvement was "Memory". Most of the participants who experienced improvement in one item reported either improvement or no change with the other items.

Internal Consistency

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The correlations between individual NSSR items are listed in Table 3. The pairwise r_{pc} coefficients varied from 0.50 (between "Wakefulness" and "Organisation") to 0.77 (between "Thinking speed" and "Working memory"). The average inter-item correlation was 0.63, which is considered good. Item-total r_{ps} coefficient was lowest for "Wakefulness" (r_{ps}=.80, p<0.001) and highest for the item "Thinking speed" (r_{ps}=.97, p<0.001). Using a network plot (see Figure S2), no clear additional clusters can be identified within the items. The NSSR had excellent internal consistency (Cronbach's α of 0.93).

Association with Affective Symptoms

Negative correlations (r=-0.33, p<0.001) were found between the NSSR and GAD7 and between the NSSR and PHQ9 (r=-0.48, p<0.001). Although significant, these correlations suggest low to moderate levels of association between the NSSR and affective symptoms (Carlson & Herdman, 2010) (see Table S1). A similar level of correlation was observed between the NSSR and changes in affective symptoms, particularly among those who reported a higher level of affective symptoms before treatment (see Table S1). Among participants who reported PHQ9 ≥10 at baseline, the correlation between NSSR and changes in PHQ9 was found to be -0.48 (p<0.001), compared with -0.32 (p<0.001) among those who reported PHQ9 <10 at baseline. These correlations indicate that the more severe the affective symptoms, then the more likely that there are subjective cognitive problems, and improvement in subjective cognitive symptoms is associated with improvement in affective symptoms.

Factor Structure

PCA suggested that the first dimension explained 68.1% of total variance and the second dimension explained 7.4% of the variance (see Figure S3). On the second dimension, the items "Motivation", "Wakefulness", "Organisation" and "Attention" deviated slightly from the other four items. EFA models (eigenvalue over 1, VSS and Velicer's minimum average partial [MAP] test) all suggested one latent factor. Parallel analysis suggested three latent factors; however, the eigenvalues of simulated and actual models of two and three latent factors were very similar. One-factor and two-factor models were further compared with CFA (see Table S2 and Figure S4). CFA results showed similar model fitting indices between the one-factor and two-factor model, with a very high correlation between two latent factors (r=0.93) in the two-factor model. In this case, a one-factor model is preferred over a two-factor model for simplicity. Thus, both EFA and CFA supported the unidimensionality of the NSSR.

Item-Response Theory

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The non-parametric IRT model suggests a high level of data integrity (less than 5% of records with Guttman errors over the threshold), high level of item homogeneity (coefficients of homogeneity >0.45 for all items), high scalability, and no violation of monotonicity (results not shown and can be requested). The Kernel smooth plot of expected item scores and OCC are provided in Figures S5 and S6. In the OCC plot, the cut-offs of the dominant group as well as the slopes of the individual item group are similar across items. The expected item score plots suggest almost identical linear associations between expected item score and expected item total score. This suggests similar difficulty and discriminability across items.

Results from parametric IRT (GRM) are displayed in Table 4. This suggests excellent discrimination of all items; as suggested by Baker (2001) α above 1.7 is considered very good discrimination. The item thresholds (see β_1 and β_2 in Table 4) index was found to be similar across items, except for a slightly higher cutoff for the improvement category of the "Memory" item (indicating it is more difficult to observe improvement at follow-up). Item trace plots and item information plots are provided in Figure 2. As shown in Figure 2(B), the item information was lowest for "Wakefulness" (lowest precision) and highest for "Thinking Speed" (highest precision). Item selection based on highest information suggests that the best six-item model excludes "Wakefulness" and "Motivation", and the best three-item instrument was found to include "Memory", "Thinking speed" and "Working memory" (Figure 3).

Measurement Invariance

DIF testing results are shown in Table 5. There was no evidence that the discrimination parameters (slopes) differ by sex and age group. However, ANOVA suggested measurement non-invariance of threshold parameter by sex and age group. Although ANOVA is sensitive to sample size, decreases in model fitting indices were also observed in the equal slope and intercept model (i.e., small *p*-value for M2 statistics indicating poor model fit), which suggests a degree of measurement non-invariance. DIF test suggests that the threshold non-invariance is common for most of the items except for the items "Attention" and "Organisation" (results not shown). The fitted parameters of equal slope models by sex and age group are provided in Tables S3 and S4 in the Supporting Information. The estimated thresholds were higher for females and 12-17 year olds across all items, which suggests that higher level responses were more likely to be endorsed (more likely to report deterioration and less likely to report improvement), which could be related to differences in response

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behaviours or underlying distribution of the latent trait. There was no evidence of measurement non-invariance observed by primary diagnostic group.

Discussion

In this study, we sought to evaluate the psychometric properties of the NSSR, a brief self-report measure of perceived change in subjective cognitive functioning since commencement of mental health treatment. To our knowledge, no other study has validated a measure of subjective neuropsychological functioning in adolescents and young adults receiving mental health treatment. Within this large sample of youth, at three months' post commencement of mental health treatment (primarily for depression and anxiety), the NSSR demonstrated excellent internal consistency with all eight items meaningfully contributing to the reliability of the measure. In our clinical sample, the item total score was not substantially skewed, providing good statistical properties in cases where normality is required (Clark & Watson, 1995). The NSSR detected that 17% of the sample had experienced subjective decline in their cognitive functioning since having commenced treatment. Given that residual subjective cognitive difficulties are associated with poorer functioning and increased risk for relapse in adults (Saragoussi et al., 2017; Srisurapanont et al., 2018), this finding suggests the NSSR may sensitively detect young people who are at risk of incomplete recovery and in need of further cognitive assessment or adjustment to their current treatment.

Low to moderate correlations were found between the NSSR and self-reported affective symptoms, as well as changes in affective symptoms (anxiety measured by GAD7 and depression by PHQ9). The finding of a relationship between subjective cognitive and mood symptoms is unsurprising given that cognitive symptoms are cardinal features of affective mental health conditions, and this is consistent with previous studies examining the association between subjective cognitive functioning and affective symptoms in adults (Chang et al., 2015; Lam et al., 2018; Srisurapanont et al., 2018). A previous study from the same sample, indicated that the NSSR is sensitive to self-reported changes in affective symptoms measured over two time-points during treatment (Allott et al., 2020). This low to moderate level of association suggests that the subjective cognitive symptoms also partially diverge from affective symptoms, which validates the need to measure this domain independently from affective symptoms.

In a previous study involving the same cohort, the estimated effect size associated with changes in symptoms of depression and anxiety were similar across all items of the NSSR, which suggested that subjective cognitive functioning may be a unitary construct (Allott et al., 2020). The exploratory and confirmatory factor analysis supported the unidimensionality

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of the NSSR. Other studies in adults using different measures of subjective cognition have reported similar findings. For example, studies using the Subjective Cognitive Impairment Scale (SCIS) in adults with first-episode schizophrenia (Chang et al., 2015), the Perceived Deficits Questionnaire-Depression (PDQ-D) in middle-aged adults with depression (Lam et al., 2018), and the Massachusetts General Hospital Cognitive and Physical Functioning Questionnaire (CPFQ) in adults with major depressive disorder and generalised anxiety disorder (Fava, Iosifescu, Pedrelli, & Baer, 2009) all reported single-factor models, suggesting subjective cognitive functioning may represent a unitary construct transdiagnostically and across the lifespan. This is in contrast to the multifactorial structure of objective cognitive functioning (Agelink van Rentergem et al., 2020; Thompson et al., 2019) and suggests that a relatively brief measure may be ample to capture a young person's subjective experience of their cognitive functioning.

The IRT analysis suggested comparable "difficulty" and discriminability across items, which again supports the use of unweighted item means or the total score as a marker of the single latent factor (subjective change in cognitive functioning). Through IRT we found support for the utility of even briefer six- and three-item versions of the NSSR. The three-item version includes the memory, thinking speed and working memory items, which are among the most typical cognitive complaints reported by people with depression and anxiety (Ebert et al., 2017; Hill et al., 2016; Lam et al., 2012; Morey-Nase et al., 2019). Quick and reliable assessment of cognitive concerns is considered ideal within busy primary and tertiary clinical practice (McAllister-Williams et al., 2017). Missing data within the NSSR were rare (the vast majority of the 23 participants with missing data had withdrawn from completing the whole questionnaire battery within the study and not only the NSSR), which speaks to the feasibility of using this tool with this younger age group. Another advantage of the NSSR over existing self-report measures is that it only requires a single administration to assess perceived change in cognition, which is appealing to clinicians working with young people in busy clinical practice. Thus, the NSSR shows promise as a clinically-useful tool for rapidly identifying the need for further assessment or adjustment to the treatment plan.

Non-invariance in response patterns was observed based on sex and age, but not diagnosis. Females and those aged 12-17 were more likely to report a decline and less likely to report improvement in their cognitive functioning (compared with males and those aged 18-25), despite having commenced treatment within three months. This suggests that either female and younger participants had differential reporting behaviours, or improvements in subjective cognitive function are harder to achieve in these groups. Partial support for the latter

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hypothesis comes from a large Australian cohort study of young people, which monitored subjective quality of life using MyLifeTracker and found that younger male adolescents aged 12 to 14 years needed to reach higher scores to achieve clinically significant change compared to those aged 15-25 years (Kwan & Rickwood, 2020). Hence, while attention to cognition concerns should be paid to all young people receiving mental health treatment, our data suggest females and younger adolescents may be especially affected. Alternatively, females and younger people may have a heightened awareness of their subjective cognition. Further research is needed to test these competing explanations.

The main limitation of this study was that we did not include another measure of subjective cognitive function to evaluate convergent validity. However, of note, wakefulness and motivation are two items of the NSSR that, on face value, seem to be most general to psychopathology and these were the two items with the weakest contribution in the IRT analyses. This provides some tentative evidence for the specificity of the NSSR to subjective neuropsychological function, as opposed to general psychopathology, although further convergent and divergent validity studies are needed to confirm this. The second limitation is that we did not include measures of objective cognitive functioning to determine discriminant validity. Although it is now well documented that subjective and objective cognitive functioning are poorly correlated in adults (Petersen et al., 2019; Srisurapanont et al., 2017), this is yet to be confirmed in adolescents and younger adults. Finally, test-retest reliability was not assessed.

Conclusion

In conclusion, our study shows that the NSSR has sound sensitivity, structure, and internal consistency. It can provide a rapid and clinically-useful snapshot of subjective changes in cognition, which in this case was assessed after having received three months of treatment for mental ill health, identifying individuals who may be at risk of incomplete recovery and in need of further assessment and tailored treatment. Future research should aim to measure convergent and divergent validity and the predictive validity of the NSSR in determining response to treatment, as well as the utility and validity of the NSSR (including the six- or three-item version) in older age groups and in people with more severe mental illnesses.

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Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article:

Figure S1. Chord diagram of NSSR items.

Figure S2. Network plot of polychoric correlation between NSSR items.

Figure S3. PCA using polychoric correlation (A) Scree plot (B) PCA plot of first two-dimensions.

Figure S4. CFA plot (A) One-factor (B) Two-factor CFA.

Figure S5. Kernel smoothing estimation of expected item score for individual NSSR item.

Figure S6. Kernel smoothing estimation of OCC for individual NSSR item.

Table S1. Correlation of NSSR with PHQ-9 and GAD-7 follow-up scores and score changes between baseline and follow-up.

Table S2. Fitting statistic of one-factor CFA and two-factor CFA.

Table S3. Estimated coefficients of the equal slope model from DIF test by sex.

Table S4. Estimated coefficients of the equal slope model from DIF test by age group.

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Ethical information

All procedures of the study were reviewed and approved by the University of Melbourne Human Research Ethics Committee, and the Human Ethics and Advisory Group (1645367.1). Written informed consent was obtained from all participants and a parent/guardian for participants aged <18 years (unless considered mature minors as determined by the clinical staff).

Correspondence

Kelly Allott, Orygen, Parkville, VIC, Australia; Email: kelly.allott@orygen.org.au

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Table 1

Neuropsychological Symptom Self-Report (NSSR) items, abbreviations and scores

Items	Abbreviation	Worse than before I started treatment	Same as before I started treatment	Better than before I started treatment
My ability to stay awake during the day has been	Wakefulness	-1	0	1
My ability to pay attention and concentrate has been	Attention	-1	0	1
The speed of my thinking has been	Thinking speed	-1	0	1
My memory has been	Memory	-1	0	1
My ability to think of words and get words out when speaking has been	Verbal fluency	-1	0	1
My planning and organisation skills have been	Organisation	-1	0	1
My ability to think about more than one thing at a time has been	Working Memory	-1	0	1
My motivation to do activities	Motivation	-1	0	1

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has been

Table 2

Characteristics of 633 participants with complete NSSR items

	Overall (N=633)
Age in years	
Mean (SD)	18.2 (3.3)
Age 12-17	279 (44.1%)
Age 18-25	354 (55.9%)
Sex at birth	
Female	421 (66.5%)
Male	212 (33.5%)
Country of birth	
Australia	552 (88.6%)
Other	71 (11.4%)
Missing	10
Aboriginal or Torres Strait Islander	
No	514 (96.3%)
Yes	20 (3.7%)
Missing	99
Primary diagnosis	
Depression	106 (17.2%)
Anxiety	177 (28.8%)
Depression and Anxiety	184 (29.9%)
Other	148 (24.1%)
Missing	18
Patient Health Questionnaire-9 (Mean, SD)	9.82 (6.47)
Generalised Anxiety Disorder-7 (Mean, SD)	7.94 (5.48)

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Table 3

Pairwise polychoric correlations (p_{pc}) depicting inter-item correlations on the NSSR and item-to-total polyserial correlations (r_{ps})

	Wakefulness	Attention	Thinking speed	Memory	Verbal fluency	Organisation	Working memory	Motivation	NSSR total score
Wakefulness	1								0.80
Attention	0.65	1							0.93
Thinking speed	0.61	0.73	1						0.97
Memory	0.53	0.68	0.73	1					0.89
Verbal fluency	0.53	0.64	0.71	0.67	1				0.85
Organisation	0.50	0.59	0.66	0.58	0.57	1			0.84
Working memory	0.57	0.72	0.77	0.68	0.65	0.69	1		0.93
Motivation	0.58	0.71	0.63	0.55	0.54	0.66	0.62	1	0.84

* p<0.001 for all pairwise correlation coefficients

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Table 4

Coefficients estimated from the Graded Response Model (parametric IRT for ordinal variables)

	α*	β_1^	β_2^
Wakefulness	1.88	-1.75	0.82
Attention	3.16	-1.45	0.62
Thinking speed	3.72	-1.60	0.80
Memory	2.55	-1.51	1.12
Verbal fluency	2.27	-1.60	0.72
Organisation	2.13	-2.00	0.59
Working memory	2.99	-1.84	0.68
Motivation	2.31	-1.54	0.30

* item discrimination parameter (slope, log-odds of choosing a higher level of response category associated with one standard deviation increase in latent traits).

^ item thresholds (cut-off parameters to categorize the latent traits into the observable ordinal items, e.g., β_2 of 0.85 for wakefulness can be interpreted as participants with a latent trait score 0.85 standard deviation above the mean is associated with reporting "Better than before" relative to "Same as before" and "Worse than before")

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Table 5

Results from differential item functioning (DIF) testing for sex, age group and primary diagnosis

Model	M2	df	p-value	RMSEA	TLI	CFI	ANOVA*		
							$X2_{\Delta}$	df_{Δ}	p-value
By sex									
Configural	33.69	24	0.090	0.025	0.992	0.995			
Equal slopes	52.39	32	0.013	0.032	0.987	0.990	11.67	8	0.167
Equal slope and threshold	71.65	46	0.009	0.030	0.989	0.987	28.44	14	0.012
Equal slope, intercept and mean	76.50	47	0.004	0.032	0.987	0.985	5.98	1	0.015
Equal slope, intercept, mean and variance	77.96	48	0.004	0.031	0.988	0.985	1.04	1	0.309
By age group (12-17 vs 18-25)									
Configural	36.37	24	0.051	0.029	0.993	0.996			
Equal slope	43.82	32	0.080	0.024	0.995	0.996	13.61	8	0.092
Equal slope and threshold	83.97	46	0.001	0.036	0.988	0.986	43.35	14	<0.001
Equal slope, intercept and mean	95.06	47	<0.001	0.040	0.985	0.983	4.13	1	0.042
Equal slope, intercept, mean and variance	90.19	48	<0.001	0.037	0.987	0.985	1.10	1	0.295
By primary diagnosis (anxiety and/or depression vs other)									
Configural	41.94	24	0.013	0.035	0.98	0.988			
Equal slope	47.11	32	0.041	0.028	0.987	0.990	14.47	8	0.070
Equal slope and threshold	63.09	46	0.048	0.025	0.99	0.989	13.81	14	0.464
Equal slope, intercept and mean	61.52	47	0.076	0.022	0.992	0.990	1.15	1	0.283
Equal slope, intercept, mean and variance	60.94	48	0.099	0.021	0.993	0.991	1.073	1	0.300

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*ANOVA tests were used to compare nested models sequentially: (1) equal slope with configural model (2) equal slope and thresholds model with equal slope model, (3) equal slope, thresholds and mean model with equal slope and thresholds model (4) equal slope, thresholds, mean and variance with equal slope, intercept and mean mode

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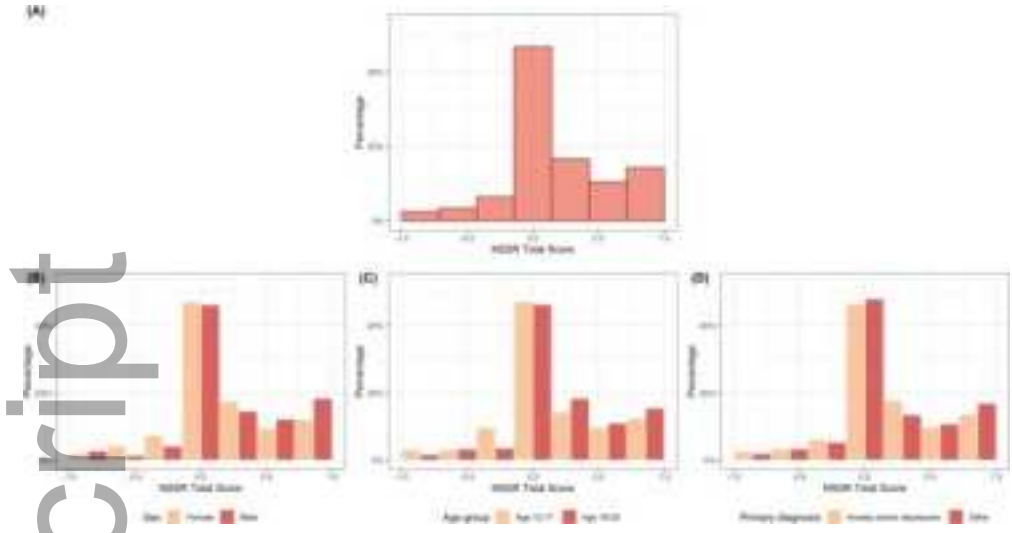

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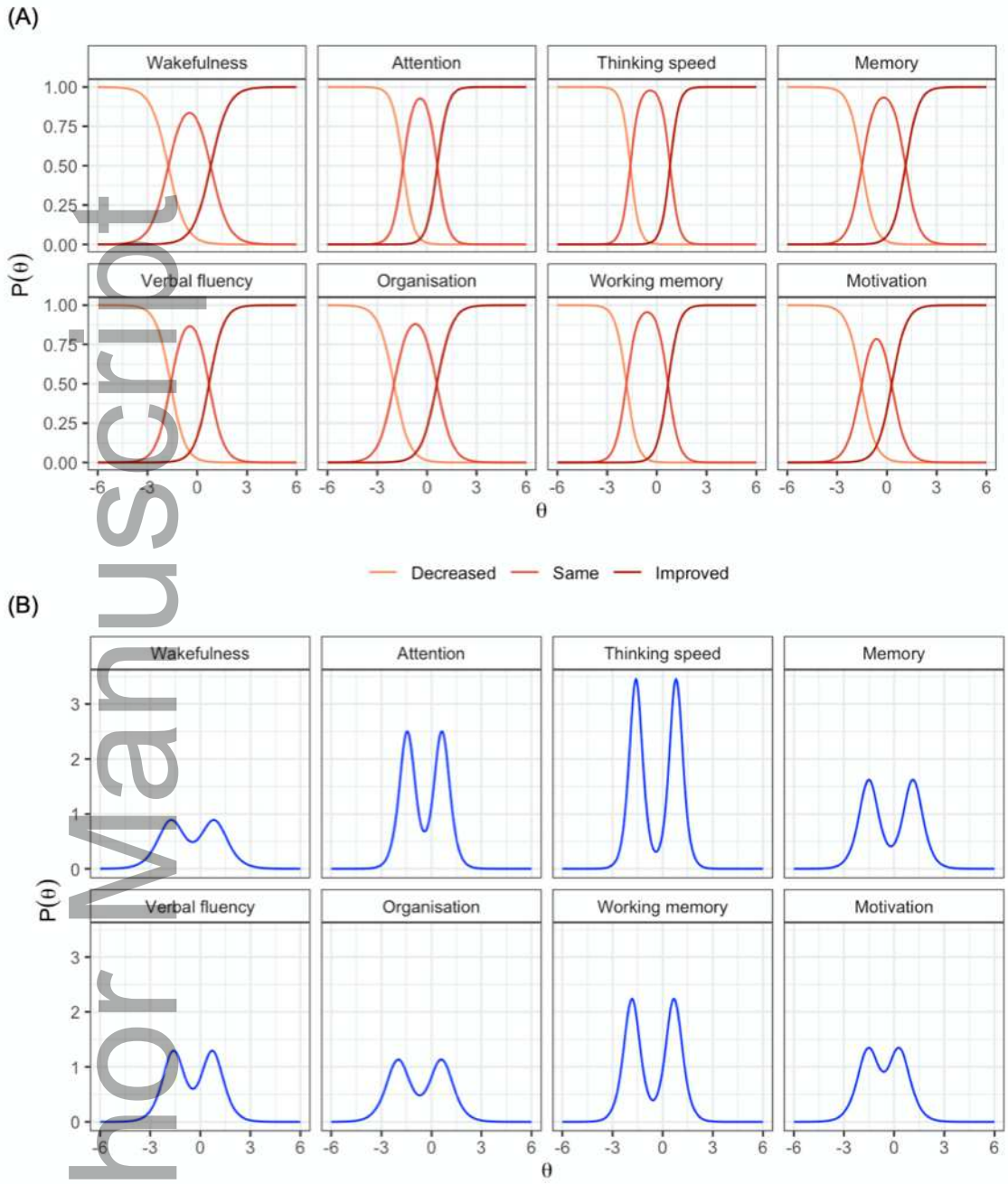

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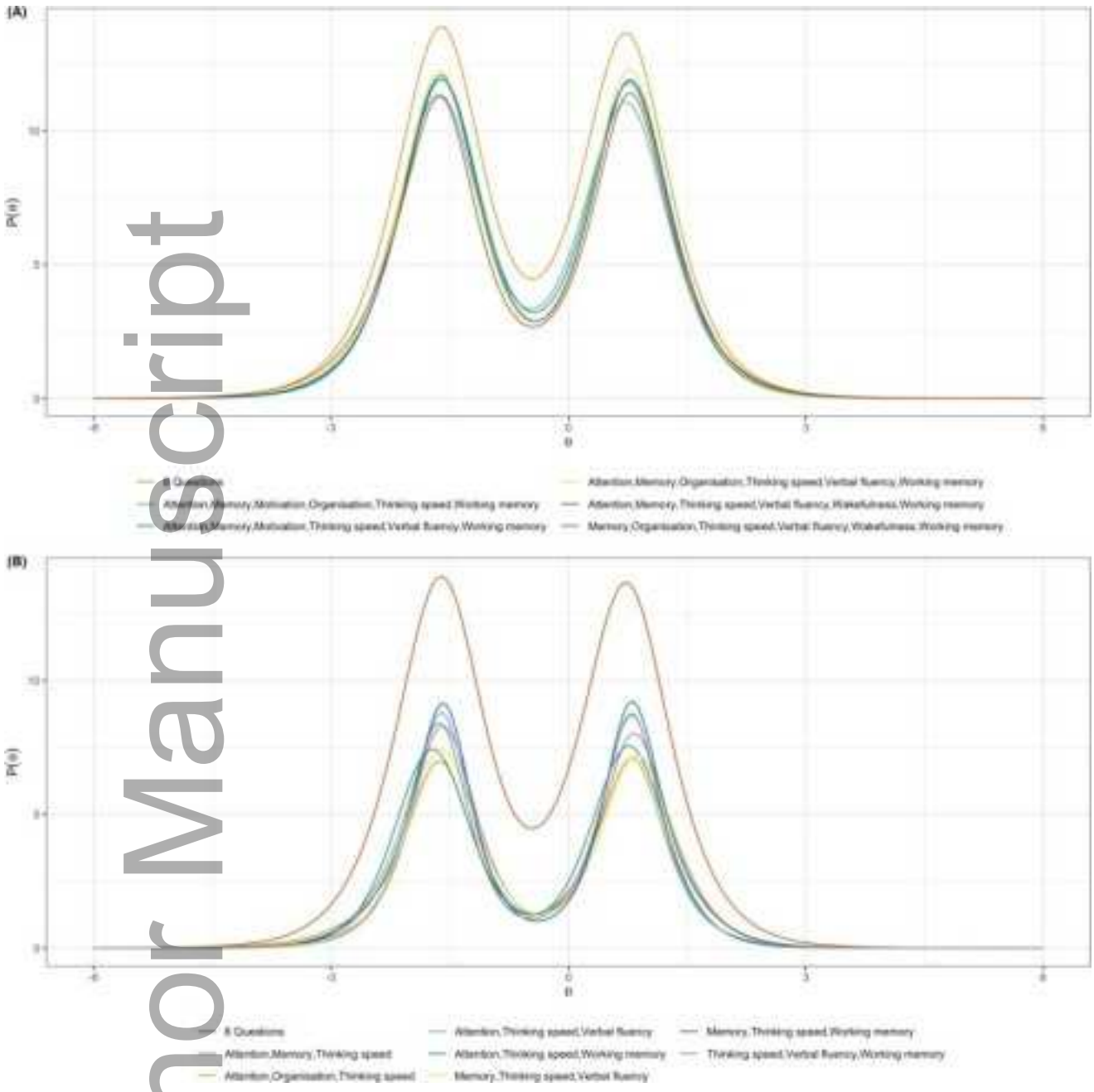

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