

Title: Dyslexia: Links with schizotypy and neurological soft signs

Abstract

Abnormalities in language processing, psychological distress and subtle neurodevelopmental features called Neurological soft signs (NSS), are expressed by people with dyslexia and those scoring highly on schizotypy. We investigated whether the expression of NSS, distress and schizotypy predicted dyslexia status. Participants (N=96, 48 dyslexic) selected to be age and sex matched, completed the Schizotypal Personality Questionnaire, General Health Questionnaire, Neurological Evaluation Scale, and the National Adult Reading Test (NART; a measure of verbal intelligence). Dyslexia status was predicted by higher total NSS and Disorganised schizotypy scores in the absence of NART. However, even with the inclusion of NART, Disorganised schizotypy remained a significant predictor. The findings suggest that disorganized features of schizotypy could be a significant factor for those with dyslexia. Conversely, more attention needs to be given to developmental language disorders in those who score highly on schizotypy.

Keywords: dyslexia, schizotypy, psychosis continuum, neurological soft signs, mixed handedness.

Introduction

Dyslexia is a neurodevelopmental disorder (Habib, 2000) characterized by difficulties with fluent and accurate word recognition, poor spelling and poor phonological abilities (Lyon, Shaywitz, & Shaywitz, 2003). Neurological factors reflecting neurodevelopmental abnormalities, such as neurological soft signs (NSS), are of interest in adults with dyslexia. NSS are assessed through behavioural tasks covering motor coordination, sensory integration, and sequencing of complex motor acts (Buchanan & Heinrichs, 1989). NSS reflect connective tract abnormalities in the brain (Mittal et al., 2013), and those with dyslexia express greater levels of NSS in comparison to those who do not have dyslexia (Karande et al., 2007; Roongpraiwan, Ruangdaraganon, Visudhiphan, & Santikul, 2002).

However, NSS are not unique to dyslexia and are also found at elevated rates in mental health disorders such as schizophrenia (Bachmann, Degen, Geider, & Schroder, 2014; Bora, Akgul, Ceylan, & Ozerdem, 2018; Chan et al., 2018). Indeed, schizophrenia and dyslexia share overlapping pathogenetic mechanisms, specifically neurodevelopmental factors, language disorders and neurocognitive impairment (Bersani, Maneschi, Tarolla, & Pancheri, 2006; Condray, 2005; Jamadar et al., 2013; Leonard et al., 2008; Trulioff, Ermakov, & Malashichev, 2017; Whitford, O'Driscoll, & Titone, 2018). For instance, a higher prevalence of reading impairment (Revheim et al., 2006; Roberts et al., 2012), and dyslexia (Revheim et al., 2014) are reported in first degree relatives of patients with schizophrenia. NSS in patients with schizophrenia may be independent of symptom presentation, illness course and medication (Bachmann & Schroder, 2017). Therefore, NSS comprise a neurodevelopmental vulnerability marker for psychosis risk and consequently should

be present at higher rates in those who express schizotypy, a hypothetical proneness to psychosis expressed in the general population. Indeed, NSS are elevated in those who express schizotypal traits when compared to average or low scoring individuals in some studies (Barkus, Stirling, Hopkins, & Lewis, 2006; Barrantes-Vidal et al., 2003; de Leede-Smith et al., 2017; Theleritis et al., 2012) but not others (Chan et al., 2018).

There are other similarities between schizotypy and dyslexia including the presence of mixed handedness (Annett, 1996; Barrantes-Vidal et al., 2013; Richardson, 1994; Richardson & Stein, 1993; Tsuang, Chen, Kuo, & Hsiao, 2016) and lateral asymmetry (Asai, Sugimori, & Tanno, 2009, 2011; Berretz, Wolf, Güntürkün, & Ocklenburg, 2020; Kershner, 2020). Longitudinal studies indicate that children diagnosed with developmental language disorders have higher risk for developing schizophrenia or schizotypal traits and have reduced functioning in adulthood, when compared to the general population and non-language disordered siblings (Clegg, Hollis, Mawhood, & Rutter, 2005; Mouridsen & Hauschild, 2008). Two previous studies have reported that positive schizotypy is increased in those with dyslexia compared to controls (Richardson, 1994; Richardson & Stein, 1993). Positive schizotypy reflects a propensity towards unusual perceptual experiences and unusual beliefs. Therefore, this finding seems somewhat surprising, given that negative schizotypy (interpersonal difficulties, flattened affect, anhedonia) are usually associated with neurodevelopmental disruptions (Barrantes-Vidal et al., 2003; Lacerda et al., 2007). Phenomenologically, disorganized schizotypy, reflecting disorganization of thinking and behaviour, could be considered most similar to aspects of dyslexia. Elevated NSS have been related to the positive schizotypy (Barkus et al., 2006), negative (or

interpersonal) schizotypal traits (Barrantes-Vidal et al., 2003; Theleritis et al., 2012), or both negative and positive schizotypy (Kaczorowski, Barrantes-Vidal, & Kwapil, 2009) or overall schizotypy (Bollini et al., 2007; Mechri et al., 2010). Given that only two studies have considered whether schizotypal features are elevated in those with dyslexia it requires further attention, including the investigation of NSS as a neurodevelopmental factor.

The aims of this study were two-fold. First, to determine whether those with dyslexia have increased levels of NSS, schizotypy, mixed handedness, and lower verbal intelligence relative to healthy controls. Mixed handedness has been included given that it is thought to be over represented in people who score highly on schizotypy and those who have dyslexia (Annett, 1996; Barrantes-Vidal et al., 2013; Richardson, 1994; Richardson & Stein, 1993; Tsuang et al., 2016). Increased psychological distress has been previously associated with a dyslexia diagnosis (Undheim & Sund, 2008; Wilson, Deri Armstrong, Furrrie, & Walcot, 2009), therefore level of distress will be included from an exploratory perspective. We also included having had an imaginary companion as a demographic factor which could provide further indication of the experiences captured by schizotypy (Fernyhough, Watson, Bernini, Moseley, & Alderson-Day, 2019). This was also included on an exploratory basis. Secondly, we aimed to investigate the factors which predict dyslexia diagnostic status. It was expected that NSS, as a fundamental component of neurodevelopmental aberration, would predict dyslexia status. Based on previous research (Richardson, 1994; Richardson & Stein, 1993) the cognitive-perceptual schizotypal dimension and handedness were also expected to predict dyslexia status. Verbal intelligence is lower in those with dyslexia (van Bergen et al., 2014), therefore it was expected to be

strongly predictive of dyslexia status and was included in the current study to ensure we had one variable where group differences were highly predictable based on previous research.

Method

Participants

Complete data was available from 96 participants (72% female; average age: 25.12 (SD 10.33) years; range between 17 and 66 years). Participants with dyslexia and controls were recruited from an undergraduate population as well as the general community using both electronic means and posters placed in key public areas. Of the study sample, 48 participants had a diagnosis of dyslexia from a qualified psychologist, this was necessary for inclusion in the study.

Forty-eight participants without a diagnosis of dyslexia or any other learning disorder were then age and sex matched to the dyslexia sample from a larger data set (de Leede-Smith et al., 2017). These participants were selected at random from the dataset, with the only criteria that they were age and sex matched on a case by case basis with the participants recruited with dyslexia. For one participant with dyslexia, it was not possible to match on both age and sex therefore a match was made on age. Participants with dyslexia were recruited through the Student Support Services at the University of Wollongong, this means that they were all enrolled in university at the time of the study. To receive support from the university services they would have been assessed by an educational psychologist to confirm their dyslexia status.

Across both groups, participants were excluded if they reported neurological abnormalities, psychotic illness or were not able to speak the English language fluently. Controls could not have a diagnosis of any developmental disorder.

Measures

Participants were asked to self-report a number of different questions in order to characterize the demographic profile of the sample including whether they had had an imaginary companion as a child.

Neurological Soft Signs (NSS)

The Neurological Evaluation Scale (NES) (Buchanan & Heinrichs, 1989) comprises 26 behavioural tasks scored on a 3-point scale; 0 (no abnormality), 1 (mild but definite impairment), or 2 (present). Total scores can range between 0 and 76. Fourteen of the items are assessed bilaterally, however, as in previous studies, bilateral items were summed (Theleritis et al., 2012).

NSS are scored on the basis of dysfunction in three areas: *Sensory Integration* (SI; audio-visual integration, stereogenesis, graphesthesia, extinction, right-left orientation), *Motor-Coordination* (MC; tandem walk, rapid alternating movements, finger-thumb opposition, finger-to-nose test) and the *Sequencing of Complex Motor Acts* (SCMA; fist-ring test, fist-edge-palm test, Ozeretski test, rhythm tapping). There are additional items which do not contribute to these subscales, but still contribute to the total NES score, including: synkinesis, convergence, gaze impersistence, glabellar reflex, snout reflex, grasp reflex, suck reflex. Handedness was measured by asking participants their hand preference (right/left) for 9 activities. Hand preference was

determined by summing responses: a score of 7 or higher indicates preference for that hand, however a score below 7 indicates mixed hand preference.

Schizotypy

The Schizotypal Personality Questionnaire (SPQ) (Raine, 1991) has 74 items requiring responses of yes or no, these are summed to a total score as well as three dimensions (Cognitive-Perceptual (SPQCP), Interpersonal (SPQI), Disorganised (SPQD)).

National Adult Reading Test (NART)

The National Adult Reading Test (NART) (Nelson & Willison, 1991) was used to measure verbal ability and confirmation of group membership. Participants read aloud 50 words with irregular spelling. As per the instructions in the original manual, participants read the whole list of words and the discontinuation rule was not used. Higher scores indicate more words were correctly pronounced (NART Correct).

Psychological distress

The General Health Questionnaire (GHQ) (Goldberg & Hillier, 1979) captured current psychological distress. This questionnaire comprises 28 items covering psychological health over the previous two weeks. Items were scored from 0-3, with total scores ranging from 0-84. Higher scores represent higher levels of psychological distress. A total score of 23-24 has been indicated as the threshold for the presence of clinical distress (Sterling, 2011).

Procedure

Ethical approval for the study was gained from the university Humanities and Social Sciences Human Research Ethics Committee, all participants provided written informed consent. Participants with dyslexia and controls were approached through multiple means including the Psychology research participation program, student learning support services, flyers, posters, word of mouth and snowballing. The SPQ and demographic questions were completed online by participants. Individuals diagnosed with dyslexia were offered the opportunity to complete these measures face-to-face so questions could be read out. No participants requested this method of questionnaire completion. Participants came onto campus to complete the NES, NART, and GHQ, all of which took approximately 50 minutes. Individuals with dyslexia were financially compensated and students from the School of Psychology received course credit.

The NES was administered to participants by four trained evaluators. To assess inter-rater reliability 20 participants were jointly rated, whereby one rater was paired up with each of the other raters. Consistency in ratings was upheld, correlation coefficients for subscale and total NSS scores ranged between .71 and .98. Raters were not blind to dyslexia status for NES scoring.

Statistical Analysis

Descriptive statistics were performed using SPSS 21 (IBM., 2013). All variables met the +/- 2 guidelines for the skewness statistic, with the exception of age and NES SCM which both had high kurtosis. Both these variables were transformed, however the distributions were not improved. Therefore, for ease of interpretation and comparison with other studies, the original scores will be used. Furthermore,

multivariate statistics are sufficiently robust to withstand minor violations of normality (Tabachnick & Fidell, 2007).

Independent Samples *t* tests (two tailed) and chi-square tests were used to evaluate demographic group differences between participants with Dyslexia and Controls for continuous variables and categorical variables, respectively. A MANCOVA was used to determine whether schizotypy scores could account for group differences in NSS scores. Finally, Enter method Binary Logistic Regression was used to determine the unique contributions of the previously significant variables from the *t* tests and chi-squares.

Data is available from the corresponding author on reasonable request.

Results

Dyslexia and Demographic factors

In Table 1 the demographic factors and relevant test statistics are displayed. Across the demographic factors, unsurprisingly there were no group differences for age and sex between those with dyslexia and those without. Similarly, there were no group differences found for living arrangements, use of health services within the last 12 months nor handedness. However, adults with dyslexia were significantly more likely to have had an imaginary companion as a child.

Dyslexia, Psychological Factors and Neurological Soft Signs

The descriptive statistics and results from statistical analyses for the psychological factors and neurological soft signs testing are also displayed in Table 1. The

participants in the Dyslexia group did not differ from the Controls for the GHQ, SPQCP, SPQI, NESSI and NESMC scores. However, participants with dyslexia had higher scores on the SPQD, NEST and NESSCMA and fewer words correct for the NART.

Insert Table 1 about here.

Secondary Analysis: Dyslexia, Schizotypy and Neurological Soft Signs

Given there are studies which report an association between schizotypy and elevated neurological soft signs, we investigated whether group differences in neurological soft signs could be accounted for by schizotypy. Since the groups only differed significantly on SPQD, this was placed as a covariate in a MANCOVA with the NES total and subscales as the DV and dyslexia status as the IV. However, this analysis did not reveal any instances where SPQD was a significant covariate, neither did its inclusion alter the pattern of results reported above therefore the analyses are not reported here.

Predicting Dyslexia group membership

Logistic Regression Enter Method was used to examine the factors which predicted Dyslexia group membership. The selection of variables was based on the significant results from the statistical analysis reported above, this minimized the number of variables included to provide a parsimonious analysis indicating which variables provided unique variance in predicting dyslexia group membership. Variables were placed into the model in a number of blocks so that the addition of each variable could be tracked for how it influenced the overall variables significantly included in

the regression model. In Block One, Imaginary Companions was entered; Block Two saw the addition of SPQD; the two NES subscales showing significant differences were entered in Block Three; and, finally, NART Correct responses were added in Block Four. The variables were placed in this order to reflect the type of factor being included. For instance, Block One was a demographic variable; Block Two the individual differences; and, Block Three was the neurological soft signs. These variables were included according to their theoretical importance, starting with the exploratory demographic variable assumed to account for the least variance. Given that we assumed that NART Correct Responses would account for the largest amount of variance this was placed in the model last. This allowed for the variance attributable to all other variables to be explored prior to the inclusion of NART Correct Responses.

The results from the analysis are displayed in Table 2. Block One was significant (*Nagelkarke* $R^2: 0.08$; $\chi^2=6.07$, $df=1$, $p=0.010$) and correctly predicted 33% of participants from the Dyslexia group and 87.5% of Controls correctly. Having had an imaginary companion predicted positive dyslexia status. Block Two was also significant (*Nagelkarke* $R^2: 0.24$; $\chi^2=19.18$, $df=2$, $p=0.000$) and correctly identified 66.7% of the Dyslexia group and 70.8% of Controls. With the inclusion of SPQD, having had an imaginary companion was no longer significant, having higher SPQ Disorganised scores predicted having a dyslexia diagnosis. Block Three was also significant (*Nagelkarke* $R^2: 0.35$; $\chi^2=29.55$, $df=1$, $p=0.000$), and successfully predicted 68.8% of people from the Dyslexia group and 77.1% of the Control group. Having higher SPQ Disorganised and NES Total scores were associated with being in the Dyslexia Group. Finally, Block Four was also significant (*Nagelkarke* $R^2: 0.46$;

$\chi^2=40.13$, $df=1$, $p=0.000$), predicting 72.9% of people from the Dyslexia group and 75% Controls. Unsurprisingly, lower correct number of words on NART were associated with being in the Dyslexia group while having higher SPQ Disorganised scores remained a significant predictor. The changes in the chi-square values across each block with the addition of new variables were all significant above the 0.050 significance level.

Insert Table 2 about here.

Discussion

Summary of findings

There were two aims for the present study. First, to determine whether those with dyslexia had higher NSS, schizotypy, mixed handedness, and lower verbal intelligence when compared to age and sex matched controls. We found that participants with dyslexia had higher Total neurological soft signs, higher scores for difficulties in Sequencing of Complex Motor Acts, higher Disorganised schizotypy scores, and lower verbal intelligence when compared to age and sex matched controls. Contrary to expectations, there was no difference in the distribution of handedness between our participant groups, perhaps further in depth assessment of the type of dyslexia is needed in future studies (Annett, 2011). Our second aim was to determine which variables provided a unique contribution to predicting dyslexia status. As expected NART scores were a highly significant predictor, with only Disorganised schizotypy remaining as a significant unique predictor once NART was included. Prior to the inclusion of NART, total NSS and disorganized schizotypy scores both provided unique variance in predicting membership in the dyslexia group.

Our secondary analyses demonstrated that Disorganised schizotypy could not account for the differences between the groups for the expression of NSS, suggesting perhaps that within our sample the presence of heightened NSS in those with dyslexia was not related to disorganized thoughts or behaviour. Concerning the exploratory variables included in the study, those with dyslexia did not have higher psychological distress nor were they more likely to have sought help from a physician in the last 12 months, but they were more likely to have had an imagery companion when compared to the controls.

Neurological Soft Signs

NSS in adults have been proposed as indicators of neurodevelopmental abnormality (I. Bombin, Arango, & Buchanan, 2005; Igor Bombin, Arango, & Buchanan, 2003). In adults and children with dyslexia, differences in white matter connections have been reported (when compared to controls) in the left inferior frontal gyrus and left temporoparietal regions (Deutsch et al., 2005; Ganzer, Broning, Kraft, Sack, & Thomasius, 2016; Rimrodt, Peterson, Denckla, Kaufmann, & Cutting, 2010), areas also linked to the expression of NSS (H. Zhao, Guo, Niu, Zhong, & Zhou, 2015; Q. Zhao et al., 2014). Further studies need to investigate whether structural differences in the brain in those with dyslexia are related to NSS.

In the current study, Sequencing of Complex Motor Acts soft signs was specifically elevated in those with dyslexia, suggesting that in dyslexia the sensory and complex motor pathways are not functioning as efficiently as they otherwise should.

Neurodevelopmental problems underlying higher levels of motor sequencing may

explain the overlap between dyslexia and developmental coordination disorder (DCD) observed in previous studies (McPhillips, Hepper, & Mulhern, 2000; O'Hare & Khalid, 2002). DCD is characterized by extreme difficulties in the ability to illicit motor skills at an age appropriate level (APA, 2013). Similar to NSS and dyslexia, the neural origins of DCD are believed to involve dysfunctions of the subcortical network, with the cerebellum-thalamus-basal ganglia circuit specifically implicated (Zwicker, Missiuna, Harris, & Boyd, 2011). Therefore, it is possible that the current results reflect coordination difficulties in those with dyslexia.

Schizotypy and Imaginary companions

Disorganised schizotypy and having had an imaginary companion were expressed at higher levels in the Dyslexia group compared to Controls. The finding of differences for disorganised schizotypy, contradicts previous studies suggesting that it is cognitive perceptual schizotypy which is elevated in those with dyslexia (Richardson, 1994; Richardson & Stein, 1993). By contrast, the endorsement of experiences of imaginary companions is in line with the unusual perceptual and social-emotional experiences captured by the positive aspects of schizotypy. Having had an imaginary companion as a child could reflect a propensity for experiences with vivid imagery (Fernyhough et al., 2019). This could be related to the cognitive organization found in people with dyslexia (from a perceptual perspective) or might reflect difficulties in the social domain (through a need for meaningful social connection). There was also a trend for those with dyslexia to have higher scores on the Interpersonal dimension from the SPQ. Perhaps with a larger sample size this difference would have reached significance. These findings require further investigation. Disorganised schizotypy, as captured by the SPQ, comprises items which relate to the organization of thoughts,

behaviours and appearance. It is possible that those with dyslexia experience loosened trails of thought which subjectively are experienced as unplanned and difficult to follow. However, higher scores on disorganised schizotypy could also reflect disorganised behaviour and unusual appearance. This is extended, to some extent, on the Interpersonal dimension from the SPQ, which also includes anhedonia. Although coordination difficulties could contribute to a perceived unusual appearance in those with dyslexia, other elements of behaviour and appearance are not widely considered.

Previous research has pointed towards a neurodevelopmental overlap between language disorders, dyslexia and psychosis (Becker et al., 2012; Bersani et al 2006; Condray, 2005). Given that placing disorganized schizotypy as a covariate in a MANCOVA did not remove the group differences for neurological soft signs, it is possible that the neurological soft signs and schizotypal traits co-occur in those with dyslexia. In a larger sample, it would be beneficial to determine whether schizotypal traits correlate with neurological soft signs in a differential pattern in those with dyslexia compared to controls. In addition, future studies could benefit from having a control group matched on verbal intelligence as well as an age-sex matched group. This would help to take into account possible associations between lower verbal intelligence and neurodevelopmental factors. Given that those with dyslexia are vulnerable to developing psychopathology (Clegg et al., 2005; Tsuang et al., 2016), future research also needs to consider the role of schizotypal traits in elevating risks for depression and anxiety (Alexander-Passe, 2006; Willcutt & Pennington, 2000).

Limitations

Although the results of this study support and extends previous research, this research was not without its limitations. The primary limitation faced was the cross-sectional nature of the study. It would have been beneficial to have had multiple time points for the measurement of distress and schizotypy in our samples to determine the temporal sequence of these variables, and also to note any fluctuations over time, particularly in response to stress. The addition of more symptom-like scales which capture unusual perceptual experiences and beliefs could be an addition to the more stable trait-like schizotypy measures. It is possible that the measure of psychological distress used was not sufficiently sensitive for the current sample and a more malleable measure would be useful in future studies. Factors such as family support (Carawan, Nalavany, & Jenkins, 2016), a good understanding of dyslexia and a positive attitude towards it (Terras, Thompson, & Minnis, 2009) might have been operating in our sample given that they were predominantly enrolled in university (Singer, 2008), and, could explain why we did not find differences related to distress between those with and without dyslexia in our sample. Having a clear indication of which participants were community members and which were recruited through the university would have been beneficial to tease these differences apart and understand the potentially protective effects of a supportive educational context. Another limitation of the current study was the sample size. Although the number of participants provided adequate power to perform the required analyses, it would have been beneficial to investigate whether variables had moderating effects and consider the relationship between these variables in more detail.

Furthermore, it would have been beneficial to have asked participants the number of years of formal education they had received. While the majority of the sample were

enrolled in university at the time of the study, they may have gained enrolment at university through varied pathways, which could mean that their years of exposure to formal education could also differ. This also relates to a limitation in that the dyslexia status of participants was not confirmed by the researchers, rather we relied on the diagnosis that they had received in order to gain access to support through the university services. The amount paid to people with dyslexia was not considered sufficient to be an inducement to take part by the ethics committee; therefore, it seems unlikely that people would have fabricated their dyslexia status. However, to add additional rigor to the design future studies should confirm the dyslexia profile of their participants. Finally, the use of self-report measures with a dyslexic sample has inherent limitations. Although the offer was made to read out measures verbally if required, no participants took up this offer. Since many of the participants diagnosed with dyslexia were currently enrolled in tertiary education, it is probable that they are not in need of assistance with reading and have developed their own compensatory strategies in this area. Yet it is also possible that questions may have been misinterpreted due to the inherent deficits in reading that are associated with dyslexia.

Conclusion

Those diagnosed with dyslexia had higher levels of disorganized schizotypy, neurological soft signs, as well as lower verbal intelligence and were more likely to have had an imaginary companion, compared to age and sex matched controls. Dyslexia status was predicted by higher levels of Disorganised schizotypy and decreased verbal ability. These findings suggest that dyslexia shares neurodevelopmental risk variants in common with the psychosis continuum. Further

research with longitudinal methods is required to understand the mechanisms involved in these neurodevelopmental phenomena.

Conflicts of Interests: The authors do not have any conflicts to declare.

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Table 1: Demographic, clinical statistics (mean, SD) and frequencies of Dyslexia and Control groups.

	Dyslexia (N=48)	Controls (N=48)	Test statistics and p value (χ^2/t , df, p value, Cohen's d*)
Demographic factors mean (SD)			
Sex (%F)	71	73	0.05, 1, 0.82
Age	25.17 (10.54)	25.08 (10.17)	0.04, 94, 0.97
Living arrangements (% Parents:Siblings: Partner:Friends: Acquaintances: Alone)	42:2:19:23:8:6	54:6:21:13:2:4	5.31, 5, 0.38
Health service use within last 12 months (% Y)	56	69	1.30, 1, 0.25
Handedness (% Right:Left:Mixed)	79:8:13	90:8:2	3.88, 2, 0.14
Imaginary Companion (% Y)	33	13	5.90, 1, 0.02
Psychological factors and Neurological Soft Signs mean (SD)			
GHQ	26.42 (15.62)	25.54 (14.73)	0.28, 94, 0.78, 0.06
SPQCP	11.63 (7.68)	9.63 (7.55)	1.29, 94, 0.20, 0.26
SPQI	13.92 (8.07)	11.06 (7.56)	1.79, 94, 0.08, 0.37
SPQD	9.69 (4.28)	5.90 (4.36)	4.30, 94, 0.00, 0.88

NEST	13.25 (4.47)	9.63 (3.89)	4.24, 94, 0.00, 0.86
NESSI	2.42 (1.30)	2.08 (1.29)	1.26, 94, 0.21, 0.26
NESMC	1.52 (1.23)	1.48 (1.32)	0.16, 94, 0.87, 0.03
NESSCMA	1.73 (2.05)	0.88 (1.12)	2.53, 72.87, 0.01, 0.51
NART Correct	21.46 (6.96)	27.77 (5.58)	4.90, 94, 0.00, 1

Calculated when relevant; Significant differences between dyslexia and control groups at the $p < .05$ level are highlighted in **bold.*

Table 2: Binary Logistic Regression: Prediction of Dyslexia group membership as Outcome Variable.

Variable	B (SE)	Wald	Df	Sig.	ExpB	LCI	UCI
Block One ($x^2=6.07, df=1, p=0.010$)							
Imaginary Companion (Yes)	-1.25 (0.53)	5.52	1	0.02	0.29	0.10	0.81
Block Two ($x^2=13.10, df=1, p=0.000$)							
Imaginary Companion (Yes)	-0.88 (0.57)	2.33	1	0.13	0.42	0.14	1.28
SPQD	-0.18 (0.05)	11.32	1	0.001	0.84	0.75	0.93
Block Three ($x^2=10.37, df=1, p=0.006$)							
Imaginary Companion (Yes)	-0.94 (0.62)	2.34	1	0.13	0.39	0.12	1.30
SPQD	-0.15 (0.06)	7.14	1	0.008	0.86	0.77	0.96
NEST	-0.15 (0.08)	4.03	1	0.045	0.86	0.74	1.00
NESSCMA	-0.12 (0.21)	0.36	1	0.55	0.88	0.59	1.33
Block Four ($x^2=10.58, df=1, p=0.001$)							

Imaginary Companion (Yes)	-0.57 (0.67)	0.73	1	0.39	0.57	0.15	2.09
SPQD	-0.17 (0.06)	7.43	1	0.006	0.85	0.75	0.95
NEST	-0.09 (0.08)	1.33	1	0.25	0.91	0.78	1.07
NESSCMA	-0.11 (0.22)	0.25	1	0.62	0.90	0.58	1.38
NART Correct	0.15 (0.05)	8.33	1	0.004	1.16	1.05	1.28

Key: LCI: SPQD: SPQ Disorganised; NEST: NES Total; NESSCMA: NES

Sequencing of Complex Motor Acts; Lower Confidence Interval; UCI: Upper

Confidence Interval; ExpB: exponentiation B coefficient (odds ratio); significant

findings are presented in bold.