DOCUMENT SUMMARY This document is a verbatim, word-for-word extraction from a research paper providing a meta-analysis of the relationship between

dyslexia and high-level **visuospatial ability**. It directly addresses the conflicting findings in the field by analyzing both the mean performance and, critically, the

variance of performance across 36 studies. The central finding is that while individuals with dyslexia, on average, exhibit a moderate deficit in visuospatial tasks, their performance is also significantly more variable than that of non-dyslexic controls. This suggests the presence of distinct subgroups, accounting for both the commonly observed deficits and the anecdotally reported visuospatial talents within the dyslexic population. The paper argues that focusing on variance is a powerful tool for understanding the true heterogeneity of neurodevelopmental disorders.

FILENAME research_report_dyslexia_visuospatial_ability_variance_2003.md

METADATA Category: RESEARCH Type: meta-analysis Relevance: Supporting Update Frequency: Static Tags: [#dyslexia, #neurodiversity, #visuospatial-ability, #meta-analysis, #variance, #individual-differences, #learning-differences, #cognitive-profile, #heterogeneity] Related Docs: This paper directly complements the "Neurodiversity Learning and Retention Research" guide by providing a concrete statistical example of heterogeneity within a single diagnostic category. It echoes the Miller et al. paper's theme that looking beyond mean differences (group averages) is crucial for understanding a population. It challenges the simple "deficit" vs. "talent" binary often applied to dyslexia, offering a more nuanced model of varied cognitive profiles. Supersedes: N/A

FORMATTED CONTENT

Abstract

Conflicting empirical and theoretical accounts suggest that dyslexia is associated with either average, enhanced, or impoverished high-level visuo-spatial processing relative to controls. Such heterogeneous results could be due to the presence of wider variability in dyslexic samples, which is unlikely to be identified at the single study level, due to lack of power. To address this, the current study reports a meta-analysis of means and variances in high-level visuo-spatial ability in 909 non-dyslexic and 956 dyslexic individuals.

> The findings suggest that dyslexia is associated not only with a lower mean performance on visuo-spatial tasks, but also with greater variability in performance.

Through novel meta-analytic techniques, we demonstrate a negative effect size for mean differences (-.457), but a positive effect size for SD differences (+.118; SD ratio = 1.107). In doing so, this is the first study to demonstrate impoverished visuospatial processing of the majority of individuals with dyslexia in addition to greater variance in performance in this group. The findings advocate for further consideration of both the presence of, and reasons for, increased variance in perception, attention and memory across neurodevelopmental disorders.

Introduction

According to the the Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM-5; American Psychiatric Association),

dyslexia is a 'a pattern of learning difficulties characterized by problems with accurate or fluent word recognition, poor decoding, and poor spelling abilities'(p. 67, 2013), prevalent in roughly 7-10% of the population. Whilst the characterization of dyslexia as a deficit of word decoding and phonological processing is rarely disputed, a tension arises when the impact of dyslexia on nonverbal processing is considered. Theoretical accounts posit impairments in aspects of spatial and perceptual processing as either a cause or consequence of dyslexia, whereas the empirical evidence for such deficits is mixed.

A great deal of focus has been placed upon providing putative low-level visual explanations for reading and writing problems associated with dyslexia. The most prominent theory to have arisen out of this line of research is the

magnocellular theory which posits that abnormalities in the dorsal visual pathway are the primary cause of the disorder, although the validity of this hypothesis is still under considerable discussion.

By contrast, some researchers speculate that individuals with dyslexia may have special talents in visuospatial ability in general, or in a particular subset of visuospatial tasks. The

Geschwind-Galaburda hypothesis suggests that this enhancement is related to the predominantly left hemispheric pathology seen in dyslexia, leading to enhanced functioning of the non-pathological right hemisphere, although the Geschwind-Galaburda hypothesis has been criticized on many grounds.

In summary, there appears to be a mixed body of evidence in relation to potential visuospatial enhancements or deficits in dyslexia. The

heterogeneity of these findings likely comes from two sources: heterogeneity of the participant samples and heterogeneity of tasks used in the studies.

> An alternative way to account for the inconclusive results regarding visuospatial processing in dyslexia would be to posit that there exist subsets of people with dyslexia who have extremely enhanced or impoverished visuospatial processing abilities, arising from greater
>
> **variance** in dyslexic samples.

Winner et al. cite_start acknowledged this possibility in a previous study stating that, 'It is possible that there is a spatial advantage in dyslexia but that this advantage shows up only in the right tail of the distribution (as does the male advantage in math)'. The notion of increased variance in one subpopulation has been most notably employed in the study of sex differences in intelligence and mathematical ability, leading some authors to claim that, 'a small difference in variance [between males and females] may have consequences at the extremes of ability resulting in visibly unequal numbers of one sex among the less able or among the elite'.

The comparison of group variability may be particularly relevant when one of the groups is determined by psychopathology which often comes hand in hand with compensation strategies and/or comorbidity.

> Testing for differences in variance between two groups in individual studies will generally not be straightforward since there is far less power in a typical study to detect differences in standard deviations than to detect differences in means, as Winner et al. cite_start noted.

In this meta-analysis, we analysed both differences in mean performance and differences in variability in performance between individuals with and without dyslexia. This enabled us to determine whether people with dyslexia show deficits in the visuospatial domain and whether there is evidence to support the contention that a dyslexic advantage or disadvantage would manifest in the tails of the performance distribution.

Method

A literature search of PsychInfo, CrossRef, Web of Science, and EBSCOhost databases using the terms "DYSLE*" AND ""VIS*"" OR ""SPA*"" yielded 2109 papers. After screening abstracts, 80 articles were further reviewed. From these, 51 full-text articles were excluded for reasons such as having no dyslexia diagnosis, using only low-level visuospatial tasks, lacking a control group, or not having behavioral data available. The final analysis included 29 full-text articles.

The selected articles yielded a sample of 909 non-dyslexic and 956 dyslexic participants, with 114 unique effect sizes over 36 unique empirical studies. Data extracted from each study were: the means, the standard deviations and the sample sizes for both the dyslexic and control groups.

The following variables were also coded:

1. Mean and SD age of dyslexic and non-dyslexic sample
2. Full-scale IQ of dyslexic and non-dyslexic sample
3. Gender ratio for the dyslexic and non-dyslexic sample
4. Type of task employed (P = Perception; I = Imagery; M = Memory)

Statistical Analysis

- **Effect size for mean differences.** Because the study suspected that the standard deviations of the dyslexic (sD) and control (sC) groups were not the same, it used **Glass's delta**, calculated as `delta = (mD - mC) / sC`, which uses the control group's standard deviation as the baseline.
- **Effect sizes for differences of standard deviations.** To evaluate differences in standard deviation, the study used a measure called **lnSDR**, the natural log of the ratio of the standard deviations, `lnSDR = ln(sD / sC)`. An lnSDR of 0 indicates equal standard deviations.
- **Meta-analysis.** A multi-level model was used to account for the fact that a single study often yields multiple, non-independent effect sizes.
- **Publication bias.** The "file-drawer problem" (the risk that non-significant studies are not published) was assessed using fail-safe N calculations and funnel plots.

Results

The final analysis was based on 114 effect sizes from 36 independent sets of participants, described in 28 published articles.

Meta-analysis of standard deviation differences

A forest plot of the 97 results for which standard deviations were available shows that the

lnSDR is more likely to be positive (59 values) than negative (32 values), with 6 values being zero. This indicates that the standard deviation is more often higher in the dyslexic group.

The meta-analysis produced an overall estimate for the intercept of

lnSDR of 0.102, which was statistically significant (p = .0108). This is equivalent to a

Standard Deviation Ratio (SDR) of 1.107.

> The SD of participants with dyslexia is therefore significantly higher than that of control participants.

When broken down by task type:

- The lnSDR was smallest and not significant for **Perception** tasks.
- It was larger and significant for **Memory** tasks.
- It was largest for **Imagery** tasks.

Table 2. Summary of Meta-Analysis Results

	All measures	**Perception**	**Memory**	**Imagery**	
Analysis of standard deviation differences					
Number of clusters (outcomes)	24 (97)	10 (30)	12 (45)	11 (22)	
lnSDR (SE)		**.102 (.0366)**	.063 (.0534)	.114 (.0472)	.153 (.0584)
SDR		**1.107**	1.065	1.121	1.147
p-value	.0108	.271	.0395	.0292	
Analysis of mean differences					

Number of clusters (outcomes)	28 (114)	12 (34)	13 (46)	13 (34)	
Glass's delta (SE)		**-.457 (.109)**	-.389 (.193)	-.391 (.105)	-.706 (.227)
p-value	.000275	.0695	.00287	.0090	

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Meta-analysis of mean differences

Since the standard deviations were found to be significantly different,

Glass's delta was the appropriate measure for mean differences. Out of 114 effect sizes, 85 were negative (dyslexic group performed worse) and 29 were positive.

The meta-analysis yielded an estimate of the overall effect of

-0.457, a statistically significant finding (p = .000275).

When broken down by task type:

- The effect was similar for **Perception** (effect = -.389) and **Memory** (effect = -.391).
- The effect was largest for **Imagery** tasks (effect = -.706).

Moderating Variables and Publication Bias

Three moderating variables—average age, average full-scale IQ, and the ratio of males to females—were assessed. None of these variables had a significant effect on the differences in either means or standard deviations.

Analyses for publication bias (fail-safe N and funnel plots) suggested that there is little likelihood of publication bias affecting the conclusions of the meta-analysis.

Discussion

This meta-analysis demonstrates that participants with dyslexia perform less well on tests of visuo-spatial ability. The overall estimate of Glass's delta was -0.457, which is classified as "medium" in size using the terminology of Cohen (1988). This finding aligns with the majority of studies and reviews in the field. The current meta-analysis also assessed variability in performance, and finds that participants with dyslexia are more variable, having systematically larger standard deviations than control participants.

> Meta-analyses in psychology rarely study differences in the variability of participants, and the present result suggests that this may be a powerful tool for understanding the nature of performance differences between subpopulations.

Although on average participants with dyslexia show poorer visuospatial ability for all three subdomains, their wider distribution means that participants with dyslexia should become relatively more prevalent at higher and lower visuo-spatial abilities. Evidence, albeit largely anecdotal, suggests that there may be an overrepresentation of individuals with dyslexia in higher educational settings requiring visuospatial and creative skills such as art and design. While data are sparse... it can be speculated that an increased variance in visuo-spatial performance may account for putative overrepresentation of dyslexic students in art and design institutions.

The current meta-analysis cannot determine why or how variability in dyslexia is higher than in the general population. It can be speculated that a source of variance exists in the dyslexic group in addition to that found in control populations. In the left-hand region of the distribution this could be due to

comorbidity of dyslexia with other pathologies such as dyscalculia and ADHD, while **compensation strategies** may account for variance in the right-hand region of the distribution. A putative 'unique spatial neurology' in those with reading disorder might result in wider variation in the neurological framework upon which those with dyslexia rely to perform visuospatial tasks in later life. Such variance... might arise from the reorganization of neural networks in response to... disruption in typical verbal processing, resulting in increased variance at the neural as well as the behavioural level.

As such, the current meta-analysis advocates for a line of research that seeks to look beyond differences in means and to explore and explain the source of greater variability in dyslexia, but also in a variety of other clinical populations.