

Dyslexia and Visual-Spatial Talents: No Clear Link

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Researching strengths is a new area of research: developing operational definitions for strengths, creating standardized assessments, and conducting empirical studies may perhaps further uncover strengths.

Most research on dyslexia has explored the behavioral and neurological deficits at the core of this syndrome. Some researchers, however, have searched for possible compensatory strengths associated with dyslexia. Orton (1925) suggested that dyslexia is sometimes accompanied by spatial talents. Norman Geschwind and Albert Galaburda (1987) noted a high incidence of individuals with dyslexia in professions requiring spatial abilities, professions such as art, engineering, or architecture, and proposed a theoretical model involving the influence of testosterone on fetal brain development to account for such a link. Several case studies have described individuals with indisputable spatial talents who may also have been dyslexic (Aaron & Guillemard, 1993; Aaron, Phillips, & Larsen, 1988; Gordon, 1983; West, 1997). Three of the four dyslexics whose brains were autopsied by Galaburda, Sherman, Rosen, Aboitiz, and Geschwind (1985) were likely to have had high spatial abilities because one had been an engineer, one a sheet metal sculptor, and one had been athletically gifted. There is also a growing popular view that individuals with dyslexia have compensatory visual-spatial talents that allow them to excel in spatial activities such as computer graphics (West, 1997).

Consistent with this view, a disproportionate incidence of individuals with reading or language weakness become artists (Steffert, 1998; Winner & Casey, 1993; Winner, Casey, DaSilva, & Hayes, 1991), mathematicians (Bloom, 1985), inventors (Colangelo, Assouline, Kerr, Huesman, & Johnson, 1993), or major in math or science in college (Martino & Winner, 1995), all activities that involve spatial ability. Also consistent with this view is the finding that late-talking children have a high proportion of relatives in spatial occupations (Sowell, 1997).

What about asking the question in reverse? Do individuals with dyslexia have a higher than average incidence of spatial talents? Von Karolyi (1998) reviewed the literature and found the evidence to be mixed. We therefore investigated this question in a series of studies. We first compared 21 young adults previously diagnosed with dyslexia to 39 young adults with no such diagnosis. All were given three standardized spatial tests: the Vandenberg Test of Mental Rotation (a test of the ability to rotate mentally an image in three-dimensional space); the Rey-Ostemieth Complex Figure Test (a test of perceptual organization and visual memory in which one must copy a complex picture and then draw it from memory); and the Hidden Figures Test (a test of the ability to pick out a simple shape from a complex array). Sample items from each test are shown in Figures 1-3.

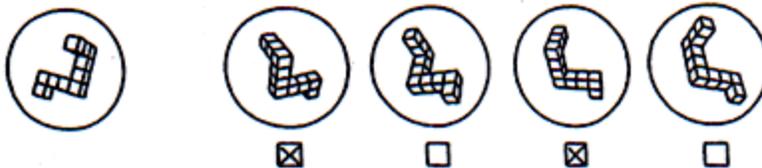


Figure 1. Sample Vandenberg item. The task is to identify the two figures on the left that are rotated versions of the target. Correct choices are shown here.

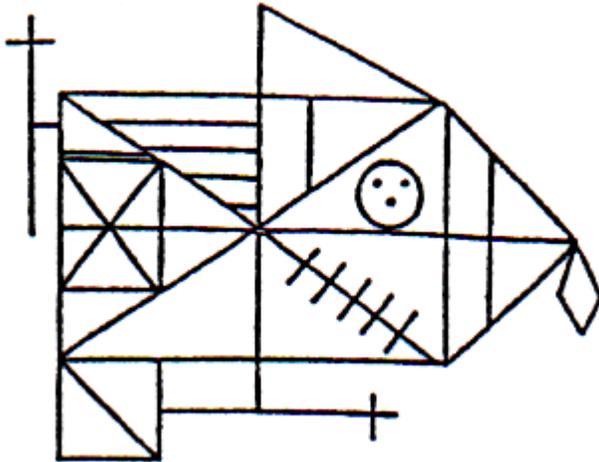
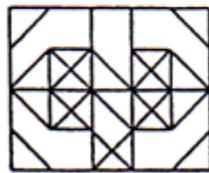
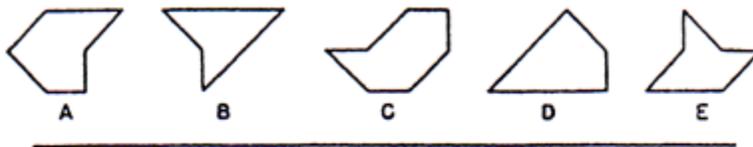


Figure 2. Rey-Osterrieth Complex Figure.



A B C D E

Figure 3. Sample Hidden Figures Test item. The task is to circle the letter under the complex shape to indicate which of the five simpler shapes is embedded in the complex shape (Correct = B).

Surprisingly, the group of individuals with dyslexia did not excel on any of these tasks. Moreover, on the Vandenberg and on one aspect of the Rey-Osterrieth - memory for the main substructures of the drawing - they performed significantly worse than the control group.

We next studied 15 high school students diagnosed with dyslexia, comparing them to 22 students with no diagnosis of dyslexia on eight spatial tasks. This time we gave all tasks in an untimed form to avoid the possibility that poor performance might be due to lack of speed rather than poor visual-spatial ability.

Vandenberg test of mental rotation

Again the Vandenberg was given, and again those with dyslexia performed worse than those without dyslexia.

Rey-Osterrieth Complex figure test

When drawing the Rey-Osterrieth figure from memory, those with dyslexia again showed significantly poorer memory for the main structures of the figure than those without dyslexia. They also scored significantly lower in organization: they were worse than the control group at recalling the major alignments and intersections of the figure. On the remaining components of the Rey (use of part-oriented vs. configurational style and recall of incidental rather than structural elements), they performed equivalently to the control group.

Archimedes' Screw

Participants were shown pictures of Archimedes' screw, a device designed to move water from a lower to a higher level. They were asked a series of questions about which way the screw would have to turn in order to raise water. To solve this task one must visualize the screw, imagine it turning, all the while imagining the effect on what would happen to the water. This kind of visualization seems to be what an inventor would need in order to imagine how a device should work.

Those in the dyslexia group performed equivalently to the control group on the first question (see Figure 4 for the questions), significantly worse than the control group on the second question, and somewhat better (but not quite significantly so, $p=.086$) than the control group on the third question.

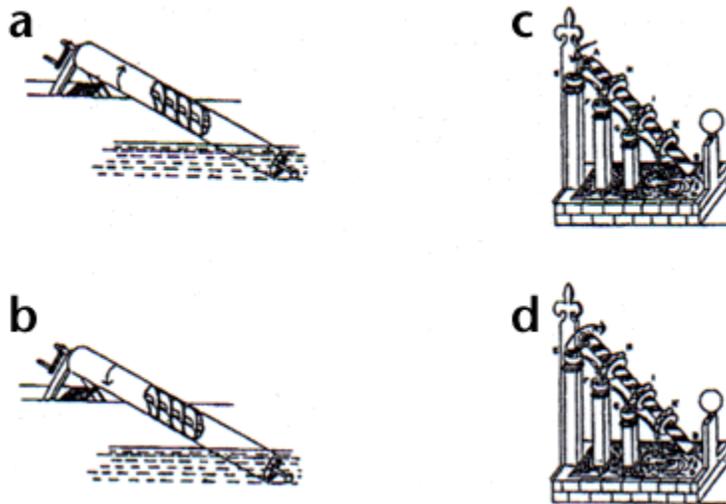


Figure 4. Archimedes Screw. (1) a vs. b: If you turn the tube one way, the water will go up. Show me the one where the water will go up (correct = a); (2) c vs. d, both incorrectly drawn with conflicting cues: The water is falling from E to F to G is making the tube turn. Which way is the tube turning? Is it turning like this (c) or this (d)? (correct = c); (3) c vs. d: If you turn the tube one way, the water will go up. Show me the one where the water will go up. (correct= d).

Pyramid puzzle

Students were given a three-dimensional puzzle that proved to be impossible to complete for almost all participants.

Drawing task

Each participant was asked to draw his or her own hand as accurately as possible. Six of the drawings were classified by two judges as showing some degree of talent: of these, two (13%) were by dyslexics and four (18%) were by control participants. Thus, despite the over-representation in art schools of individuals with dyslexia, our dyslexic participants did not stand out in their drawing ability.

Spatial word problems

Participants were given a series of orally presented word problems best solved through spatial visualization (taken from Hermelin & O'Connor, 1986). (E.g., "A painted wooden cube with an edge of 9 cm is cut up into little cubes each of a 3 cm edge. There will be 27 of these little cubes. How many of them will have only two painted sides?" The correct answer = 12.) Those with dyslexia performed significantly worse on this test than did those without.

K-Bit matrices

Participants were given matrices in which they had to complete the fourth cell of a pattern (Kaufman & Kaufman, 1990). Those with dyslexia performed significantly worse on this test than did those without. (See Figure 5.)

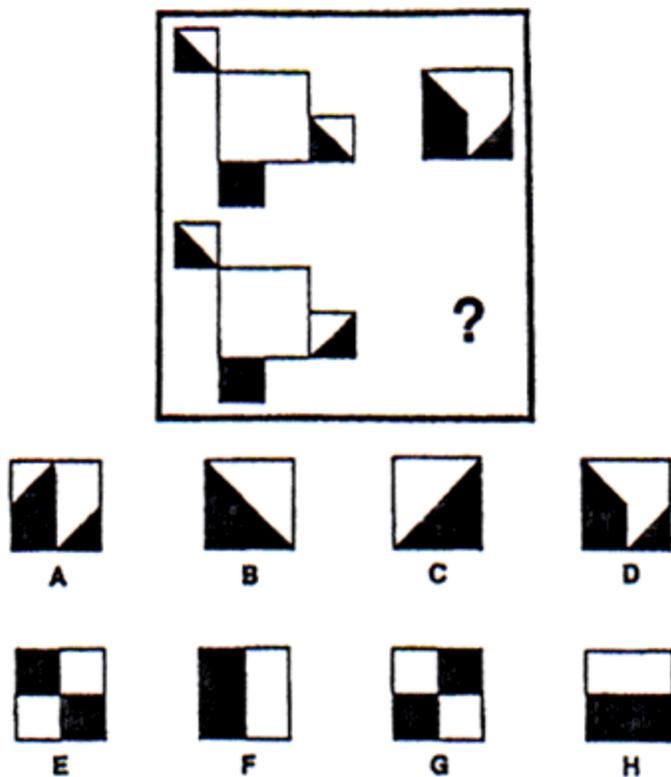


Figure 5. Sample Matrices item. The task is to determine which pattern below the incomplete matrix completes the matrix (Correct=B).

Hidden figures

As in Study 1, the hidden figures task was given, but because of the difficulty of the task for all participants, this time a simplified form was used. Again, no differences between groups were found.

Thus, we were unable to demonstrate any consistent spatial advantage for individuals with dyslexia even when speed of response no longer influenced scores. We carried out a third study, this time administering a still wider range of visual-spatial tests (again with no time restrictions except in two cases.). We tested 40 high school students diagnosed with dyslexia and compared them to 23 high school students without dyslexia.

Spatial orientation

Three tasks assessed "Spatial Orientation," the ability to imagine how an image would appear from another perspective: the Vandenberg test, the Card Rotation Test (a two-dimensional mental rotation task, with a sample item shown in Figure 6), and the Boats test (a test assessing the ability to imagine how a landscape would look from an altered orientation, a skill that would seem to be associated with navigational skill, as shown in Figure 7). Dyslexics consistently performed worse than the control group on each of these tasks.



Figure 6. Sample Card Rotation Test item. The task is to determine which of a set of 8 two-dimensional shapes are rotated versions of the target shape on the left. (Correct Is the 2nd, 5th,, 6th, and 8th choice counting from left to right).

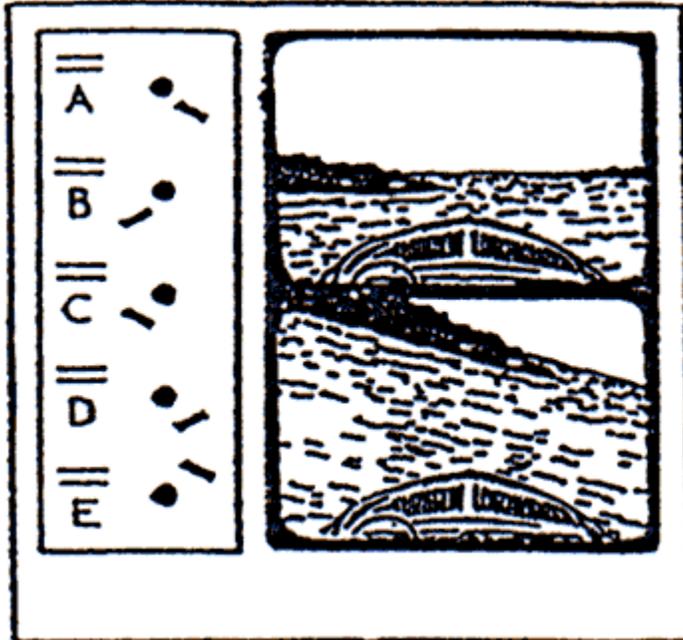


Figure 7. Sample Boats item. The task is to select the diagram on the left indicating how the position of the boat in the lower picture has changed relative to its position in the top picture. The lines stand for the prow; the dot stands for the aiming point. The prow has shifted but the aiming point has not. (Correct=B, boat has tilted downward to the left).

Spatial visualization

The Form Board Task assessed "Spatial Visualization the ability to apprehend, encode, and mentally manipulate spatial forms". (See Figure 8.) Those with dyslexia performed worse than the control group, but this difference was not quite significant ($p=.08$).

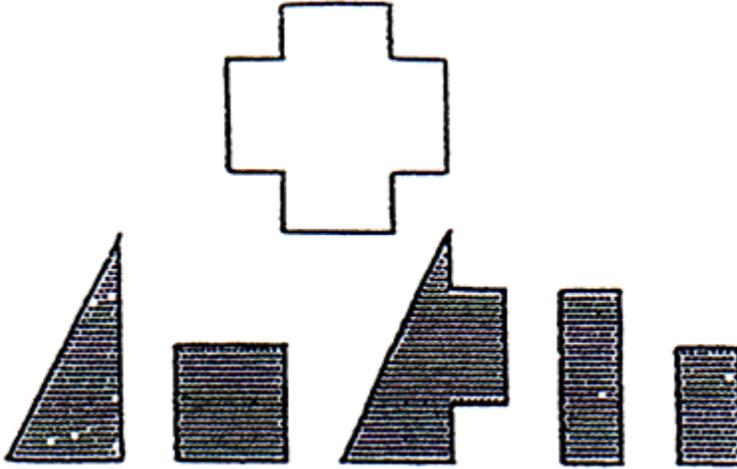


Figure 8. Sample Form Board item. The task is to indicate which of the five shaded shapes, when put together, would form the unshaded target shape (Correct= 1,3,5).

Figural flexibility

The Storage Task assessed "Figural Flexibility," here tested by the ability to come up with a variety of ways to arrange six rectangular boxes in a container. The task was to show (by drawing) how six small rectangular boxes (like the one shown in Figure 9) could be fitted into a larger box. Three possible correct responses have been drawn below so as to make this task clear to the reader. The Storage Task would seem to predict skill at packing a car trunk or rearranging one's living room furniture without having to rely on a strategy of trial and error. Those with dyslexia achieved somewhat lower scores than those in the control group, but the difference was not significant.

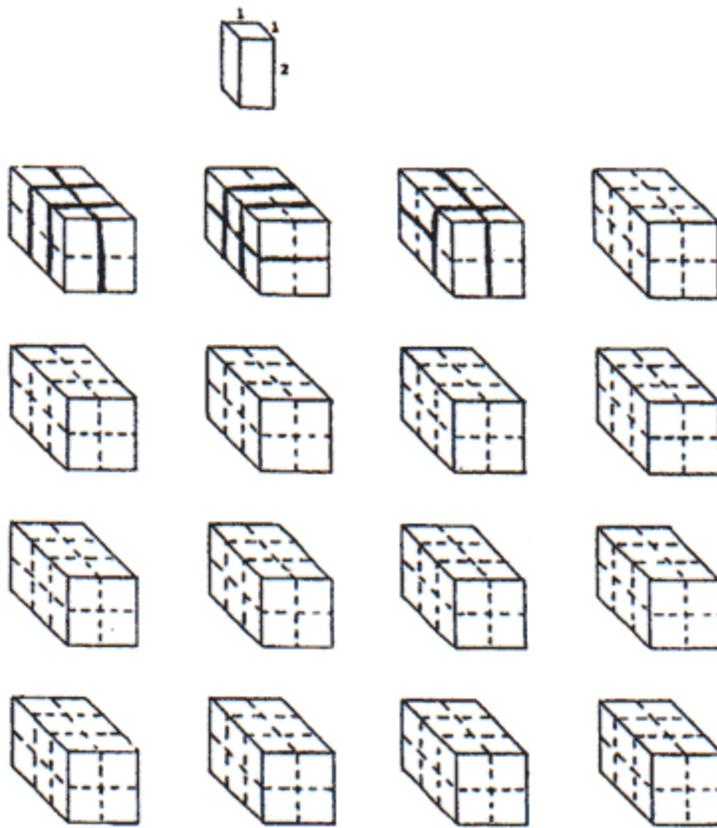


Figure 9. Sample Storage item. The task is to indicate all of the ways to arrange six rectangular boxes in a given container. Three solutions have been drawn.

Closure speed

The Gestalt Completion Task assessed "Closure Speed," the ability to unite an apparently disparate perceptual field into a unified concept (Carroll, 1993). This task requires that one look at an incomplete picture such as the one shown in Figure 10 and fill in the missing parts mentally to determine what the picture represents. Students with dyslexia performed as well as controls in imagining the completed images.



Figure 10. Sample Gestalt Completion item. The task is to identify the object that is incompletely depicted. In this case, it's a flag.

Scanning

We administered a timed letter scanning task in which the goal was to find a given letter in an array of letters as quickly as possible; a shape scanning task identical to the letter scanning task except that the goal was to find a given target shape among other shapes; and a camouflage search task where the goal was to find a hidden figure in a complex array. Dyslexics performed equivalently to controls on shape scanning but were significantly slower and less accurate on letter scanning and on the camouflage search task (Malinsky, 2000).

Reference memory

We designed a task to measure the kind of spatial memory assessed by the Morris Maze test, a test on which ectopic mice excel (Waters et al., 1997). Since dyslexia is often accompanied by neuronal ectoplas (collections of neurons in the outer part of the cerebral cortex that migrated incorrectly during the fetal period), we hypothesized that this might be a task on which our subjects would also excel. Participants were asked to imagine themselves at a specific location in their school, facing in a particular direction, and then pointing towards another location. They had to show the direction in which they would point by marking an X on a circle. Like the Morris Maze task, this task assesses the ability to recall the spatial relation between two landmarks, the one at which the individual is standing, and the one to which the individual is pointing. Unlike the Morris Maze test, this task requires the participant to respond in the abstract and using paper and pencil rather than by actually moving to a specific hidden location. Contrary to prediction, dyslexics

performed worse: Their responses were twice as far off target as those of the control group.

Impossible figures

Another task was administered to participants in both studies 1 and 3, and results were combined. This task assessed the ability to recognize a figure as "impossible," such as the one shown in Figure 11. To do this, one must attend simultaneously to various features of the figure (global rather than feature-oriented perception) and notice that these features conflict. This task was presented in timed form: We measured both response time and accuracy. While dyslexics proved no more accurate than the control students, they were significantly faster (von Karolyi, 1999). When we examined speed of responding for correct responses only, the difference in reaction time between the two groups of participants was striking: the dyslexia group ($n = 62$) averaged 2652 (1528) Ms, whereas the control group ($n = 22$) averaged 3409 (1550) Ms. Thus, on average the dyslexia group performed 1465 Ms faster than did the control group. Here, then was our one and only visual-spatial task on which dyslexics excelled!

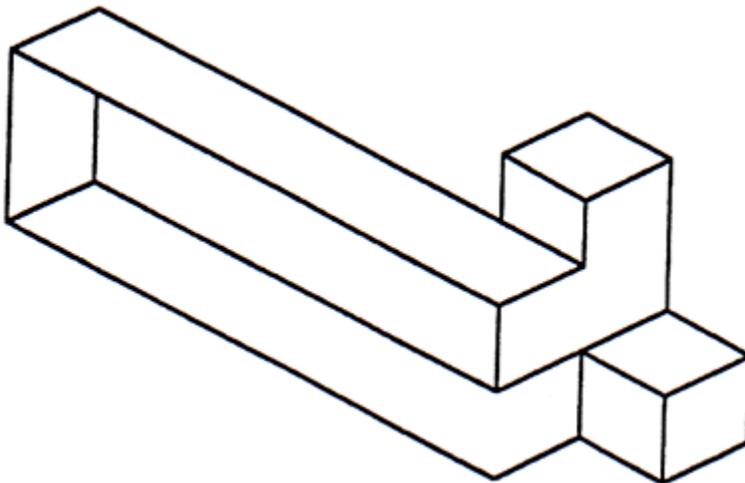


Figure 11. Sample Impossible Figure item.

Conclusions

Our studies thus far do not support the popular (and comforting) view of dyslexia as a deficit associated with compensatory visual-spatial talents. We were able to demonstrate a statistically significant ($p < .05$) spatial advantage for dyslexics on only one task: speed of recognition of impossible figures. This task requires integrating the parts of the drawing into a whole. On all other tasks, we demonstrated either a disadvantage for dyslexics or equivalence to controls.

Can these findings be reconciled with the finding of a disproportionate representation of individuals with language problems in spatial professions? We believe that the answer is yes, and there is more than one way to reconcile these apparently conflicting findings. Suppose dyslexia is accompanied by average visual-spatial abilities, as some of our results suggest. The distribution of spatial talents in the dyslexic population should then be no different from the distribution in the non-dyslexic population. Hence, there should be a subset of individuals with dyslexia with spatial talents, and this subset should be proportionally equivalent to the subset of nonreading-disabled individuals with such talents. While non-dyslexics with spatial talents might be as likely to choose a verbal as a

spatial occupation (since both avenues are wide open to them), dyslexics with spatial talents would not have the luxury of this choice. Dyslexics with spatial talents would choose spatial professions by default. Hence, we would find a disproportionate incidence of dyslexic individuals channeled into spatial fields, but no differences in spatial abilities in dyslexics versus non-dyslexics.

Suppose dyslexia is accompanied by inferior visual-spatial abilities, as some of our results also suggest. Perhaps individuals with dyslexia select spatial occupations to **avoid** verbal fields in which they have even greater deficits, fields that require extensive reading, such as law, medicine, history, etc. In other words, they may choose spatial fields by default, as the lesser of two evils.

But perhaps the case is not closed. Further research is needed before we can know whether dyslexia is accompanied by visual-spatial talents. To begin with, performance on more real-world, three-dimensional, hands-on spatial tasks must be studied. Perhaps on such tasks dyslexics excel. And other tasks requiring the kind of global perception required by the Impossible Figures task should be developed to determine whether dyslexics do really excel in "global" perception.

It is also possible that we failed to demonstrate a spatial advantage because we did not compare the performance of individuals with a specific subtype of dyslexia with non-dyslexics. It is not clear, theoretically, what such a subtype might be. Nonetheless, including a far larger sample population of dyslexics in future studies might make it possible to find such a subgroup. Until further research is carried out, the question of compensatory talents associated with dyslexia remains unresolved.

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