Accordingly, we reconstructed a Newtonian spectroscope and duplicated, as nearly as possible, his first experiments with the spectrum. Using slit widths of 0.8 to 1.5 mm (according to his nebulous "a twentieth part of an inch or narrower") and a 60° glass prism, we observed blurred but definite solar absorption lines at the positions of the Fraunhofer *E* (iron), *b* (magnesium), *F* (hydrogen), *g* and possibly *H* (calcium) lines.

Further experiments were made with a lead acetate solution–filled "prismatick vessel" made from ordinary glass and having prism angles of 55°, 55°, and 70°. The *E*, *F*, and *g* lines were observed with the use of this crude prism.

In most of these experiments optical imperfections in the system caused random lines and spots to appear in the continuum on the screen. These lines and spots were, however, readily traceable to their sources because they changed position with respect to the fixed colors when slight shifts in the position of the elements of the optical train were made. Only the absorption lines maintained a constant position with respect to the colors.

It should be noted that the absorption lines, as we observed them, were visible only when the optical parts of the experimental system were aligned so as to provide maximum dispersion and resolution of the spectrum produced. This was not surprising, in view of the crudeness of the apparatus. Since conditions requisite for the best viewing of either colors *or* lines are necessarily identical and since Newton's primary interest during this stage of his investigations was the nature of color, it was assumed that his experiments were carried out under conditions as near optimum as the situation would permit. This assumption is supported by Newton's general attitude toward the attainment of optical excellence (*1*, p. 72):

> The lens also ought to be Good, such as may serve for optical Uses, and the Prism ought to have a large Angle. . . Being made from Glass free from Bubbles and Veins, with its sides not a little convex or concave. . . but truly Plane, and its Polish truly elaborate, as in working optick-glasses.

With the probability that Newton *did* see the lines, there arises the question: Why didn't he mention them? It seems unlikely that a skilled observer of Newton's stature could have failed to note their presence, and his silence on this matter must be presumed to be due to other causes. Possibly he ascribed the lines to optical imperfections in his spectroscope, or perhaps he was so engrossed in the major aspect of his studies—the nature of color—that he dismissed the lineation as a secondary phenomenon. Perhaps he considered the lines to be interference phenomena with which he was familiar:

> I placed another Knife by this so that their edges might be parallel and look towards one another, and that the beams of light might fall upon both the Knives, and some part of it pass between their edges. . . . as the Knives approached one another. . . . Fringes began to appear . . . on either side of the direct light.

Perhaps the explanation for his silence on the subject of spectral lines can be found in the psychology of the man himself. Newton was by nature suspicious, introverted, and sensitive. He was reticent in the extreme in releasing information about his studies and was determined that his scientific works should include nothing but observations. In addition, he was beset by critics, notably Robert Hooke, and it is probably not coincidental that the *Opticks* was published in 1704—the year following Hooke's death. In this context, it is not unreasonable to speculate that spectral lines were first observed by Newton, but since he was not able to defend or even consistently reproduce them, he simply refused to mention the fact of their presence.

There are other possibilities, perhaps more consistent with Newton's reputation as an impartial and accurate observer of what he saw. He may have assumed that the lines were the natural boundaries of the colors, as did Wollaston some 130 years later. He may have been so beset with optical imperfections, despite his attempts to achieve excellence, that the lines were either unnoticeable in the welter of other marks in the spectrum, or obscured by them entirely. *Opticks* certainly gives reason to believe that he eventually achieved a fair degree of clarity in his results, but this by no means rules out the possibility that the majority of his experiments were beset with problems. The body of *Opticks* deals with successes, not failures.

Finally there is the remote possibility that he simply overlooked the lines in the excitement and novelty of the more vivid and reproducible phenomena which he saw and attempted to understand.

We have no way of knowing that Newton actually saw the lines. In duplicating his experiments, our results indicate that they would have been visible, and rather vividly so, under some circumstances. According to *Opticks,* many of Newton's experiments were apparently carried out under such circumstances. We can only say, "We saw the lines," and wonder why Sir Isaac Newton failed to achieve the distinction of being the founder of the science of spectroanalysis, in addition to his other achievements (*4*).

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Laterality of Verbal Intelligence in the Brain

Abstract. Patients with left-hemisphere epilepsy and their speech mechanism abnormally located in the right cerebral hemisphere are more similar in their verbal ability to ordinary patients with right-hemisphere epilepsy than to those with left-hemisphere epilepsy.

Commonly the cerebral mechanism for speech is localized in the left hemisphere. This report is on the intelligence of nine patients found to be the reverse of normal: when sodium amytal was injected into the carotid arteries their speech was disorganized on the right side.

The apparent reason for their reversed localization was that they had suffered damage to the left hemisphere early in life. They were epileptic patients being considered for possible neurosurgery on the left hemisphere to relieve them of their seizures, and the "amytal aphasia test" (*1*) was part of the diagnostic procedure. Usually a right-handed patient who shows epileptiform activity near the left temporal leads on the electroencephalogram (EEG) will also have postictal dysphasia. That is, after a seizure the patient will often have difficulty in naming objects although able to speak, for example, "This is a, er . . . I know what

it is. . . ." Seven of these nine patients gave no evidence of this phenomenon although eight had disorders involving the left temporal area.

Damage to one hemisphere of an adult has different effects on intelligence depending on the side of the lesion; the scores of patients with lesions in the left hemisphere are more reduced on the verbal subtests of the Wechsler-Bellevue scale than on the nonverbal tests (*2*). The purpose of the present study was to answer the question: Do these right-hemisphere speech (RHS) cases resemble cases with left-hemisphere epilepsy and postictal dysphasia, or cases with right-hemisphere epilepsy and no postictal dysphasia?

Of 66 patients given the amytal test, 45 were classified as having their speech mechanism localized in the left hemisphere; for nine cases the test was deemed indeterminate, and 12 cases were found to have speech impaired from the injection on the right (*3*). Three of the latter were excluded from this study for these reasons: there was no localization of the epileptic disorder in one case; one case had already undergone a temporal lobe resection of limited therapeutic success; the other had an epileptic focus in the right hemisphere and had postictal dysphasia. The remaining group of nine RHS cases contained six males and three females. The averages (and standard deviations) of their ages and IQ's were 31.2 (9.6) years and 87.5 (17.5), respectively. All but two males wrote with the left hand.

Two comparison groups of right-handed patients with unilateral epilepsy were selected from a file of several hundred cases that had been tested with form I of the Wechsler-Bellevue intelligence scale; the selection was made so that the sex distribution, average age, and IQ would be the same as in the RHS group. The average age and IQ (and standard deviations) of the nine cases with right-hemisphere epilepsy were 30.8 (9.0) years and 87.8 (14.8), of the nine cases with left-hemisphere epilepsy, 30.8 (10.9) years and 87.2 (11.8). All these cases with left-hemisphere epilepsy had postictal dysphasia (one case provided doubtful evidence, but both the amytal test and the EEG were clear); none of the cases with right-hemisphere epilepsy did.

The epileptic disorder was not unequivocally restricted to one hemisphere in all 27 cases according to the EEG; however the final neurological diagnoses were such that unilateral surgery could be attempted or advised in 20 cases, and in the other seven there was no doubt about the side of the disorder.

Table 1 shows the average weighted scores for each of the three groups of patients on each of the eleven subtests of the intelligence test. On the vocabulary subtest the score of the cases with right-hemisphere epilepsy is identical to that of the RHS cases with left-hemisphere epilepsy; both groups scored better than the group with ordinary left-hemisphere epilepsy. The vocabulary test often has the highest loading on the "verbal factor" in studies of this type of intelligence test (*4*). The three other tests with high factor loadings on verbal intelligence showed the same relationship (Information, Comprehension, and Similarities). The sum of the scores on these four subtests was compared with the sum on the other seven for each patient by dividing the latter sum by the former. The average value for the cases with right-hemisphere epilepsy was 1.49; the RHS cases averaged 1.47, and the cases with left-hemisphere epilepsy averaged 1.88. The difference between the averages of the last two groups was significant ($t = 2.89$, df $= 16$, $p < .02$).

The average age of onset of neurological disorders was lower in the RHS group (3.8 years) than in the group with left-hemisphere epilepsy (13 years) which may explain why the latter group still had their speech on the left. There was some right-sided muscle smallness in four of the RHS cases, but for seven of them the left hemispheres may have had the relatively circumscribed disorders suggested by the EEG.

The data indicate that when the right hemisphere is required to develop speech after the fashion of a normal left hemisphere, it also becomes more involved with the verbal factor in intelligence (*5*).

Table 1. Mean weighted scores for three types of patients on the Wechsler-Bellevue subtests. LHE and RHE indicate ordinary cases with left- and right-hemisphere epilepsy, respectively; RHS refers to cases with left hemisphere epilepsy but with right hemisphere speech.

Subtest	Mean weighted scores		
	LHE	RHS	RHE
Vocabulary	6.2	8.6	8.6
Information	6.8	8.0	9.0
Comprehension	7.3	8.4	8.8
Similarities	7.6	8.2	8.4
Picture Completion	6.8	7.4	6.8
Arithmetic	5.8	5.6	6.5
Picture Arrangement	7.7	7.1	6.4
Digit Span	8.3	7.1	8.2
Block Design	7.7	7.1	7.2
Object Assembly	9.4	8.6	7.8
Digit Symbol Substitution	6.7	5.4	6.1

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5. Acknowledgement is due Dr. E. Laskowski who performed the amytal tests and Dr. M. Baldwin, clinical director of the National Institute of Neurological Diseases and Blindness, who encouraged this psychological research on his patients.

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Surface Textures of Sand Grains: An Application of Electron Microscopy

Abstract. Crushed quartz was subjected to wind, ball mill, and shaking-table action to simulate eolian and beach conditions. Electron microphotographs of these surfaces were then compared with those of grain surfaces which had been frosted naturally, and the correspondence between them was good. Thus, the transportation history of many sand deposits may be identified by this technique.

During transportation, sedimentation and compaction, sand grains may be subjected to mechanical abrasion and/or chemical action (*1*), which produces microscopically irregular surfaces that appear to be frosted. This is one of the more characteristic surface textures of sand grains, but its precise causes and geologic significance are not fully understood. To the best of our knowledge, the submicroscopic surface textures of sand grains have not been examined systematically, although Biederman (*2*) has shown that solution pits in aqueous sand follow crystallographic form as opposed to the irregular collision pits