# Development of the numerical reasoning network found to not be vision based

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Credit: Human Brain Project

(Medical Xpress)—A small team of researchers with Johns Hopkins University has found that vision is not necessarily a requirement for being able to perform internal math or counting tasks. In their paper published in *Proceedings of the National Academy of Sciences*, the team describes experiments they carried out with sighted and blind-from-birth volunteers who underwent MRI scans while performing math tasks in their heads.

Conventional thinking has suggested that performing mathematical calculations in our heads is strongly tied to visual processing—people are able to make casual numerical estimates based on just a glance, for example. But that, of course, does not mean that blind people, even those blind from birth, are unable to perform math calculations—the assumption has been that there would be some differences. In this new effort, the researchers sought to illuminate those difference by looking at MRI scans of people as they attempted to perform math calculations in their head (the sighted people wore blindfolds).

All told, the researchers looked at such scans of 36 volunteers, 17 of which were people that had been blind since birth, which meant that they had never had the benefit of visual learning of any sort.

The researchers found no differences in brain activity between the two groups in the part of the brain that prior research has found is most involved in doing math—the intraparietal sulcus, which of course, came as a surprise. This finding suggests that math and numerical learning is independent of visual experience, which runs counter to prior findings.

There was also another surprise—the researchers found that the part of the brain normally associated with processing vision information—the visual cortex—became active in the people that had been blind since birth when they worked out math problems in their heads. The researchers have no explanation for the phenomenon, but suggest it might be due to the brain simply exploiting structures that are not being used otherwise. The scans also showed that those blind-from-birth people who did best on the math problems also had more activity going on in their visual cortices—suggesting it gave them a boost of some sort, though not enough to allow them to do any better in general than the sighted volunteers.

**More information:** Shipra Kanjlia et al. Absence of visual experience modifies the neural basis of numerical thinking, *Proceedings of the National Academy of Sciences* (2016). DOI: 10.1073/pnas.1524982113


**Abstract**

In humans, the ability to reason about mathematical quantities depends on a frontoparietal network that includes the intraparietal sulcus (IPS). How do nature and nurture give rise to the neurobiology of numerical cognition? We asked how visual experience shapes the neural basis of numerical thinking by studying numerical cognition in congenitally blind individuals. Blind (n = 17) and blindfolded sighted (n = 19) participants solved math equations that varied in difficulty (e.g., 27 − 12 = x vs. 7 − 2 = x), and performed a control sentence comprehension task while undergoing fMRI. Whole-cortex analyses revealed that in both blind and sighted participants, the IPS and dorsolateral prefrontal cortices were more active during the math task than the language task, and activity in the IPS increased parametrically with equation difficulty. Thus, the classic frontoparietal number network is preserved in the total absence of visual experience. However, surprisingly, blind but not sighted individuals additionally recruited a subset of early visual areas during symbolic math calculation. The functional profile of these "visual" regions was identical to that of the IPS in blind but not sighted individuals. Furthermore, in blindness, number-responsive visual cortices exhibited increased functional connectivity with prefrontal and IPS regions that process numbers. We conclude that the frontoparietal number network develops independently of visual experience. In blindness, this number network colonizes parts of deafferented visual cortex. These results suggest that human cortex is highly functionally flexible early in life, and point to frontoparietal input as a mechanism of cross-modal plasticity in blindness.

Press release