



Errors in constructing visual experience

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ARTICLE COMMENTARY



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Vannuscorps, Galaburda, and Caramazza report a monumental study of altered perception where a woman, Davida, sees high contrast 2D shapes rotated by 90°, 180°, or 270° or reflected across their vertical or horizontal axes. They describe many aspects of this fascinating distortion and, before going any further, may I say that we are deeply grateful to Davida for making it through months of experiments, and to the experimenters who carried out this major program with her across 2 ½ years.

It is clear that the distortions reported by Davida are shape centered and the authors highlight this by referring to the level at which the distortion emerges as the stage where “intermediate shape centered representations” (ISCR) arise.

However, Davida did not report this rotational / reflection distortion for all shapes, only medium to high contrast black and white shapes or equiluminous 2D shapes. Blurred, or low contrast 2D shapes or 3D objects were seen accurately.

Davida’s perceptual distortions are remarkable and are undoubtedly giving us invaluable information about the organization of visual processing. However, the visual system is very big and Davida’s distortions are very peculiar, so there are many possible explanations. Here I will offer some broad speculation, constrained loosely, where possible, by the details of her altered perception.

To be clear, something in Davida’s visual processes has gone astray at a stage where segmented shapes are posted into a perceptual buffer. To have these shape-centered orientation changes, the shapes must have already lost the imagistic, retinotopic format used throughout most of the visual cortex. Instead, they are probably shape “tokens” that have

several parameters attached to their shape, such as location, 3D pose, size, and, importantly, orientation. Perhaps for purposes of efficient coding the shape tokens are specified as a shape “X” with a parameter to indicate one of four possible orientations and two reflections: Davida’s reports limit these to a 0°, 90°, 180°, or 270° rotation and reflections from whatever orientation the shape actually had. Note that these orientations and reflections are anchored to the actual stimulus orientation and do not constrain the encoded angle to cardinal directions. This code could be related to simplifications of shape representations that are indifferent to vertical and horizontal reflections (e.g., Corballis, 2018).

I will assume that this code for orientation and reflection is a part of shape coding in everyone’s visual system. It is too farfetched to imagine that Davida’s visual system developed a coding allowing four-fold orientations and vertical and horizontal reflections as a one-off anomaly. Farfetched is maybe too strong, all suggestions here are necessarily farfetched to some degree, so indeed nothing is really off the table. Nevertheless, it seems more likely that Davida’s problem is not about having this code—I suggest that her odd distortions mean that we all do. Instead, she has lost what normally anchors the choice of the possible orientations and reflections to the visual data in ordinary visual systems.

We can imagine that some process determines which orientation and reflection is correct. It would check the image to verify that the locations of various parts of the shape match the locations expected for the chosen values (e.g., Cavanagh, 1991; Mumford, 1992). So, this would be the step that has failed for Davida, leaving the orientation /

reflection parameter unanchored, but not entirely unanchored because Davida's perception is odder still—she does not normally report the true orientation, instead she sees versions that are 90, 180 or 270° from it. So apparently, some checking is going on but it has been corrupted to reject rather than accept versions that match the input data.

Why would this corrupted verification be especially evident with high-contrast or equiluminous 2D shapes? I suggest that blurry shapes and 3D shapes provide more of whatever the orientation checker is after and so manage to anchor the correct version in place.

What is also remarkable about Davida's distortions is that they tell us that the visual system knows full well what the shape is. It is not a misidentification, it is a mistake in presentation. The letter "p" is posted to some conscious buffer in the wrong orientation. Her conscious identification processes then access this distorted construct and misreport the letter as, say, "d". This effect is closely related to the distortions reported by a man who saw any digit from 2 to 9 as an unrecognizable, spaghetti-like tangle of lines (Schubert et al., 2020). Note that this man's visual system must have identified the original digit as a digit in order for it to get this special spaghettification, no other shapes were affected. Somehow the stored templates for the digit shapes had been corrupted and when a digit was to be posted to conscious perception, a tangle of lines was substituted. That was all that this man could see, the initial, correct identification was unavailable to conscious vision. These unusual cases show that our conscious vision is at the mercy of this construction step. Even though the visual system knows what shapes are present, in these two individuals, it bungles their presentation, leaving conscious vision stuck with the errors.

In sum again, many thanks to Davida for her dedication. Her perceptual distortions lead to many intriguing speculations—that shape representations have an orientation and reflection parameter. Others (e.g., Corballis, 2018) have suggested that for purposes of coding efficiency, shapes are represented in a format that is invariant to left-right reversals, perhaps because this is usually irrelevant (until alphabets emerged). Davida's case suggests that there is

additional redundancy in up–down orientation. Moreover, like the case of the distorted digits, Davida's misperceptions suggest that conscious vision only has access to a final construct that is built out of identified shapes and symbols (Hochstein & Ahissar, 2002). These shape-centered tokens guide the retrieval and then posting of appropriate shapes which are placed into awareness in their proper positions, size and pose according to the token's parameters. Importantly, as Davida's experience shows us, errors in this construction process may degrade certain shapes that were properly identified at an earlier stage. Once misrepresented in this final percept, the real shape remains out of reach at pre-conscious levels.

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