Binocular Depth Reversals Despite Familiarity Cues: An Artifact?

When pictures are placed in a stereoscope so that an impression of depth is given, such depth is inverted when the two pictures are reversed from left to right. Such inversion, however, does not occur in all cases, especially when photographs of faces are displayed. "Cognitive" factors are then assumed to override the binocular disparity cues of stereopsis. A. van den Enden and H. Spekreijse (*1*) offer a different explanation for the lack of inversion of faces. They note that a stereoscopic picture of a face offers two different sets of cues to depth, namely, binocular disparity and texture perspective—gradients of texture produced by depth. Only the former set of cues is reversed when the two views of the face are interchanged between the eyes. The latter, or texture perspective, signals depth independent of eye of input. The authors therefore reason that depth inversion does not occur in the case of faces in the pseudoscopic situation because of a conflict between texture perspective and stereopsis. Texture perspective wins out. The authors test their hypothesis by altering the texture perspective in such a way as to abolish depth cues from it in the stereogram of a face. They show that a pseudoscopically presented picture of such a face now looks hollow, like a mask viewed from the back.

There is one immediate difficulty with their explanation. Ordinarily, if we view an actual mask of a face from the back, so that it should look hollow, it appears as a normal face instead. Viewing the mask from the back reverses both binocular disparity and texture perspective, and yet the face does not look hollow, even though the authors must predict from their theory that it should. How then do we explain the hollow appearance of the pseudoscopically viewed face in which the authors have altered the texture perspective? We have observed that if spots are scattered randomly on the inside of a hollow mask it too ceases to look like a normal face and assumes the correct hollow appearance. It seems that the addition of extra binocular disparity cues will in the end overcome an interpretation of a visual scene on the basis of other factors. We believe this is the explanation of the authors' results. The authors made their stereogram by using the method of Georgeson (*2*). In this method a matrix of spots is projected (using a slide projector) on a three-dimensional object from a position close to the viewpoint of the observer. Stereophotographs of the object are then made with cameras near the projection point. This method does indeed eliminate texture perspective as the authors state, but it also increases the number of cues of binocular disparity, as each spot, stereophotographed, will match in the two eyes to signal its correct depth. It is this increase in the binocular disparity signals from the dots that confounds the test of the authors' hypothesis and forms the more plausible interpretation of their experimental results. However, our objection to the authors' interpretation of their results does not constitute support for the explanation the authors try to disprove. We, like the authors, do not believe that high-level cognitive factors play a role, since we (*3*) [and others (*4*)] have observed that even complex "nonsense" objects such as lumps of clay or a crumpled newspaper will resist pseudoscopic inversion.

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2. M. A. Georgeson, *Perception* **8**, 585 (1979).

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Van den Enden and Spekreijse (*1*) say that they have demonstrated that cognition is not a relevant factor in the resistance to depth reversal of face stereograms when the left- and right-eye views are interchanged. They postulate that pseudoscopy fails "because the disparity of texture perspective cannot be reversed in the same way as the disparity of edges." Texture perspective (a monocular depth cue) is indeed unaffected by interchanging the views. The disparity of texture perspective (as defined by van den Enden and Spekreijse) is not reversed in the interchanged view, but no evidence is presented that it serves as a depth cue. Therefore, the source of the conflict they allude to is missing. Furthermore, correct texture perspective and nonconflicting disparity of texture perspective are not sufficient to overcome the familiarity effect when one evaluates a hollow face (the inside of a mold of a face) (*2*). Nevertheless, with the additional projected "neutral" texture they generated most observers can obtain detailed reversed shape in depth (*3*).

The texture provided by van den Enden and Spekreijse resulted in a strong, unintentional, binocular cue, the disparity of the projected texture elements. Texture disparity is reversed in the interchanged view just as is the disparity of edges (*4*). This disparity of texture elements is directly correlated with the depth or the reversed depth in stereoscopic or pseudoscopic views, respectively. The abundance of texture disparity cues, rather than the masking of natural texture perspective, may account for the perception of reversed depth in their stereograms.

"Neutral" texture without the disparity artifact could be produced to test their hypothesis by two techniques. (i) Obtain the stereopair of the face without projecting the texture on it. Then remove the model, project the texture on to a screen fronto-parallel to the cameras, and double-expose the two cameras to the texture. The texture in both images will be neutral, will mask the natural texture, and will carry no disparity cues related to the face. (ii) A technique based on the shadow sterograms (*5*) uses only one camera and two illumination lights. Project the texture onto the model, and obtain two photographs from the same camera with the illumination for each coming from one of two different source positions. The resultant shadow stereograms will have neutral perspective texture without the disparity.

If any of the two proposed modified pseudostereograms result in reversed perception of the face, some role for texture perspective in this phenomenon will have been demonstrated. The interpretation of van den Enden and Spekreijse is confounded by the artifactual binocular texture disparity cue.

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REFERENCES AND NOTES

1. A. van den Enden and H. Spekreijse, *Science* **244**, 959 (1989).
2. R. L. Gregory, *The Intelligent Eye* (McGraw-Hill, New York, 1970), pp. 124–136.
3. A result that is in contrast with the report of Georgeson (*4*). He found, with the same method, that monocularly recognizable facial features must be eliminated to enable reversed perception.
4. M. A. Georgeson, *Perception* **8**, 585 (1979).
5. A. Medina, *J. Opt. Soc. Am. A* **6**, 309 (1989).

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Response: There is no doubt that the disparity of individual texture elements contributes to the perception of the reversed