This is an excerpt from a report on The Unity of Consciousness and Sensory Integration conference at Brown University in November of 2011, written by Kevin Connolly, Craig French, David M. Gray, and Adrienne Prettyman, and available at http://networksensoryresearch.utoronto.ca/Network_for_Sensory_Research.html

4. Is the Mechanism of Sensory Integration Spatio-Temporal?

So far, we have discussed various ways to model the unity of consciousness, but what about ways to model sensory integration? Consider a case of sensory integration in a single modality like vision. When presented with a visual array containing a red circle and a green square, one popular view is that the visual system binds the feature *red* to the circle (and not the square) in part because that feature and that shape are located in the same space at the same time. Likewise, co-location in space or time may explain how we integrate features into the same object or event across modalities. Space and time could potentially provide an amodal framework shared across the senses (a view suggested by Farid Masrour), and so would be well-poised to explain sensory integration. David Chalmers noted that several discussions from our meeting pointed to space and time as the "glue" of multi-sensory integration. Less metaphorically, they suggest that the mechanisms of sensory integration are universally spatial or temporal. Call this the Space-Time hypothesis (ST).

Whether or not ST turns out to be true, spatial and temporal mechanisms certainly play a significant role in sensory integration. David Eagleman gave one example of time's crucial role in sensory integration. He argued that we create multi-sensory events by calibrating our expectations about how synchronous stimuli are perceived across sensory systems (see Eagleman, 2008, p. 133). Furthermore, Pawan Sinha presented some evidence for the importance of spatial perception, particularly perception of motion, for integrating visual features into objects (and that account might be extendable to multimodal cases as well). Mohan Matthen

went on to note that an *observer's* motion in space can also help to integrate features into objects, as when an observer walks around to locate a smell or sound source.

Some challenges arise for ST, however, when we consider objects of perception that are not obviously spatially located. Sounds, smells, and tastes are arguably aspatial (for a discussion of this, see O'Callaghan, 2011, pp. 147-49). If this turns out to be right, then the integration of auditory, olfactory and gustatory features into multisensory objects are probably not explicable in terms of a spatial mechanism. Berit Brogaard and Carolyn Dicey Jennings raised similar challenges for vision. In association synaesthesia, for instance, subjects report a strong association between, e.g., a number and a color, but the color is not spatially located. Other suggested examples of visual objects that are not spatially located include an undifferentiated visual ganzfeld, or a free-floating color flash. In response to these examples, proponents of ST argued that the latter two visual features are located in space and time: the many points of a ganzfeld are each localizable within the visual field, and likewise with the free-floating flash. Furthermore, association synaesthetes arguably do not have a sensory experience of color, as evidenced by the fact that they do not show a pop-out effect in visual search.

Notably, each of the proposed challenges to ST involves a sensory experience of an object that is not spatially localized. No one, however, proposed an example of a sensory experience that does not occur for a perceived duration of time. The absence of counterexamples may reflect a closer connection between sensory experience and perceived duration, as opposed to spatial location. Even if some sensory objects are not located in space, perhaps time provides the glue of multisensory integration.

References

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