journal of VISION

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Volume 3, Number 9, Abstract 83, Page 83a doi:10.1167/3.9.83 http://journalofvision.org/3/9/83/ ISSN 1534-7362

Metric category spaces of biological motion

Martin A Giese — Dept. of Cognitive Neurology, University Clinic, Tuebingen, Germany

Ian M Thornton — MPI for Biological Cybernetics, Tuebingen, Germany

Shimon Edelman — Dept. of Psychology, Cornell University, Ithaca, USA

Abstract

Converging experimental evidence suggests that shape categories are mentally represented as continuous spaces that preserve the parametric similarities among individual object shapes. Here we show that perception of biologal motion likewise preserves the metric of spatio-temporal similarities among motion patterns. We presented subjects with animated patterns of point lights corresponding to trajectories generated by spatio-temporal morphing among three prototypical human locomotion patterns. Using a novel morphing algorithm that computes linear combinations of complex movement trajectories in space-time, we generated motion stimuli that corresponded to two-dimensional geometrical configurations in a parametric pattern space defined by the weights of the linear combination. Two configurations were used, one consisting of 7 patterns arranged in the form of a (T)riangle, and the other in the form of the letter L. For each configuration, observers were asked to judge the similarity between all pairs of stimuli using a comparison-of-pairs paradigm. A measure of perceived dissimilarity computed from these judgments was submitted to multidimensional scaling. The recovered 2D configurations in the reconstructed perceptual space were quantitatively compared with the configurations in the original linear morphing space. The recovered metric structure closely matched the original metric structure in the morphing space. (Coefficients of congruence 0.98 and 0.88 for T (n=14) and L (n=19); Procrustes distances 0.41 and 0.96; corresponding to bootstrap-estimated d' equivalents between 2.99 and 8.15). We recovered a very similar metric structure from the neural responses of a physiologically plausible model of biological motion recognition. We conclude: (a) The visual system represents related categories of locomotion in a common metric space that reflects spatio-temporal similarities of motion trajectories. (b) These representations can be realized with known cortical mechanisms.

History

Received August 22, 2003; published October 22, 2003

Citation

Giese, M. A., Thornton, I. M., & Edelman, S. (2003). Metric category spaces of

biological motion. *Journal of Vision*, *3*(9), 83a, http://journalofvision.org/3/9/83/, doi:10.1167/3.9.83.

Keywords

None

On-Line Presentation

None

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