

Bimodal Information Increases Spontaneous Interpersonal Synchronization of Goal Directed Upper Limb Movements

Noy, D. ¹, Mouta, S. ², Lamas, J. ³, Santos, J. A. ⁴

¹ Department of Basic Psychology, School of Psychology, University of Minho, Portugal;

² Center of Computer Graphics, Portugal; INESC TEC Instituto de Engenharia de Sistemas e Computadores, Portugal;

³ Centro Algoritmi, School of Engineering, University of Minho, Portugal; Center of Computer Graphics, Portugal

⁴ Centro Algoritmi, School of Engineering, University of Minho, Portugal; Department of Basic Psychology, School of Psychology, University of Minho, Portugal; Center of Computer Graphics, Portugal

When interacting with each other, people often synchronize spontaneously their movements, e.g. during pendulum swinging, chair rocking [5], walking [4][7], and when executing periodic forearm movements [3]. Although the spatiotemporal information that establishes the coupling, leading to synchronization, might be provided by several perceptual systems, the systematic study of different sensory modalities contribution is widely neglected. Considering a) differences in the sensory dominance on the spatial and temporal dimension [5], b) different cue combination and integration strategies [1][2], and c) that sensory information might provide different aspects of the same event, synchronization should be moderated by the type of sensory modality. Here, 9 naïve participants placed a bottle periodically between two target zones, 40 times, in 12 conditions while sitting in front of a confederate executing the same task. The participant could a) see and hear, b) see, c) hear the confederate, d) or audiovisual information about the movements of the confederate was absent. The couple started in 3 different relative positions (i.e., in-phase, anti-phase, out of phase). A retro-reflective marker was attached to the top of the bottles. Bottle displacement was captured by a motion capture system. We analyzed the variability of the continuous relative phase reflecting the degree of synchronization. Results indicate the emergence of spontaneous synchronization, an increase with bimodal information, and an influence of the initial phase relation on the particular synchronization pattern. Results have theoretical implication for studying cue combination in interpersonal coordination and are consistent with coupled oscillator models.

Acknowledgments: [Supported by Fundação Bial (Grant 77/12) and Fundação para a Ciência e Tecnologia - FCT:SFRH/BD/88396/2012; EXPL/MHC-PCN/0162/2013; FCOMP-01-0124-FEDER-022674 and PEst-C/CTM/U10264/2011; FCOMP-01-0124-FEDER-037281 and PEst-C/EEI/LA0014/2013. This work was financed by FEDER grants through the Operational Competitiveness Program – COMPETE]

[1] Elliot, M. T., Wing, A. M., Welchman, A. E. (2010). Multisensory cues improve sensorimotor synchronization. *European Journal of Neuroscience*, 31, 1828-1835.

[2] Ernst, M. O., & Bühlhoff, H. H. (2004). Merging the senses into a robust percept. *Trends in Cognitive Sciences*, 8(4), 162–169.

- [3] Mörtl, A., Lorenz, T., Vlaskamp, B. N. S., Gusrialdi, A., S, Schubö, Hirsche (2012). Modeling inter-human movement coordination: synchronization governs joint task dynamics. *Biol Cybern* 106, 241-259.
- [4] Nessler, J. A., & Gilliland, S. J. (2009). Interpersonal synchronization during side by side treadmill walking is influenced by leg length differential and altered sensory feedback. *Human Movement Science*, 28(6), 772–785.
- [5] Repp, B. H. (2005). Sensorimotor synchronization: a review of the tapping literature. *Psychonomic Bulletin & Review*, 12(6), 969–992.
- [6] Schmidt, R. C., & Richardson, M. J. (2008). Dynamics of interpersonal coordination. In *Coordination: Neural, behavioral and social dynamics* (pp. 281–308). Springer.
- [7] Zivotofsky, A. Z., Gruendlinger, L., & Hausdorff, J. M. (2012). Modality- specific communication enabling gait synchronization during over-ground side-by-side walking. *Human movement science*, 31, 1268–1285.