Learning rhythm in or out of social context in virtual reality

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Introduction. Humans can spontaneously or intentionally synchronise their movements with external rhythms. Complex sensorimotor synchronisation skills acquisition, such as the capacity to produce musical rhythms, may critically depend on interactive coordination (Kirschner & Tomasello, 2009), and is probably learnt by imitating social partners (Ramsey et al., 2021). However, this hypothesis remains to be validated by determining whether people process rhythm better with someone or on their own, and whether this difference is due to motor imitation of social partners or social non-verbal communication (gaze, facial expressions). Contrary to a real human, a virtual partner allows assessing interpersonal coordination with fine-tuned manipulation of controlled parameters across conditions and participants (Fairhurst et al., 2013). We investigated whether the social context, simulated with virtual reality (VR), improves synchronisation and learning of drumming patterns. We hypothesized that both will be more enhanced with a human-like partner, providing non-verbal communicative cues, than without implicit social information.

Methods. Healthy participants (thirty-two adults, thirty-two 8- to 12-year-old children) were included in the study. Since spontaneous production rate is a crucial factor that determines synchronisation (Desbernats et al., 2023), participants were first instructed to play a spontaneous regular rhythm that sounded natural to them with VR drums. Then, all participants drummed in synchronisation in four social conditions: virtual human-shaped partners with non-verbal communication such as gaze and facial expressions (interactive condition), faceless partners (intermediate condition), drumsticks moving alone (non-interactive condition), or an auditory-only context (control condition). Last, an interference task of drumming in synchronisation with a metronome was performed by the participants before they repeated the initial sequence to test short-term learning (recall stage). Participants were also asked to complete questionnaires about cybersickness, virtual immersion and interaction, handedness, and rhythmic activities (e.g., dancing). The timing of the hits was estimated by the coordinates of accelerometers from the VR system. Asynchronies, i.e., elapsed time between the drumming and the stimulus sequence, were computed as a metric of synchronisation accuracy. For the recall stage, the asynchronies resulted from subtracting the timing of the drumming and the timing of the target sequence. Participants' eye movements were recorded with the VR system's eye-tracker to determine whether visual attention was beneficial for interactive synchronisation. Linear mixed models with the social context conditions were applied to the asynchronies and the average gaze direction, with spontaneous tempo as covariable.

Results. To date, we have run pilot experiments. We expect that asynchronies will be reduced by social context (interactive < intermediate < non-interactive < control), while participants' gaze will be more directed to the non-verbal cues in the interactive condition and towards movement in the intermediate and non-interactive conditions.

Conclusion. This study aims at refining mechanisms sustaining sensorimotor synchronisation. The potential effect of the social context on rhythm processing may improve rhythm-based rehabilitative training for children and adults with cognitive developmental disorders, such as dyslexia (Vonthron et al., 2024), and motor neurodegenerative diseases, such as Parkinson's disease (Puyjarinet et al., 2022).

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