

Latency, Sensorimotor Feedback and Virtual Agents: Feedback Channels for Motor Learning Using the ICSPACE Platform

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OBJECTIVE

- Effective motor skill learning requires sensorimotor learning based on appropriate multimodal feedback (e.g., Magill & Anderson, 2012)
- We developed a virtual environment that allows to boost the learning process with different kinds of augmented feedback and coaching strategies (de Kok et al., 2015; Waltemate et al., 2015)
- Here, we present research on effects of (a) feedback delay (cf. Tsakiris et al., 2006) as well as (b) nonverbal (cf. Sigrist et al., 2014) and (c) verbal feedback strategies (cf. Anderson et al., 2014)

LATENCY

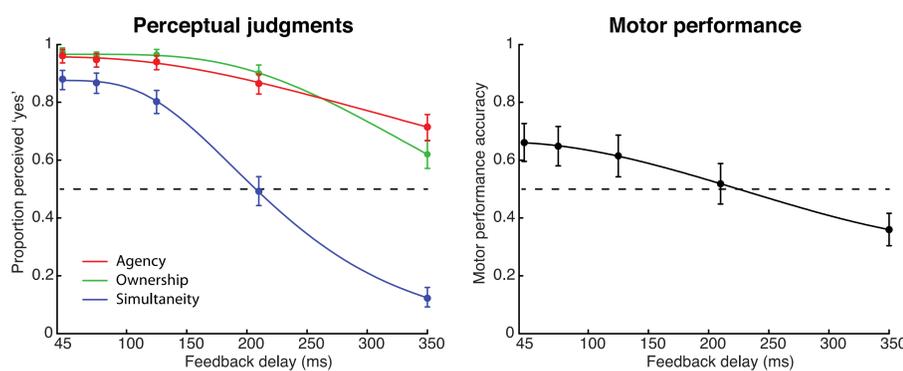
Aim: to investigate the impact of delay on perceptual judgments (sense of agency, sense of body ownership, simultaneity perception), motor performance and their Interaction during full-body action inside a Cave Automatic Virtual Environment.

Task



Participants (N=10) had to mimic the movements of an avatar. Their own avatar responded with delays ranging from 45 to 350ms across trials.

Results



Generalized linear mixed models (GLMM) with delay as fixed effect

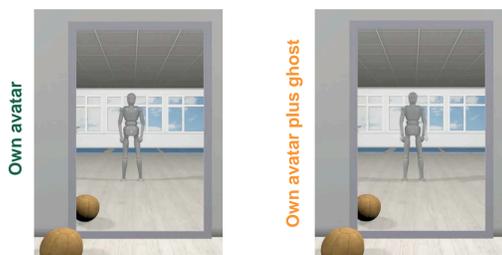
Conclusions

- Motor performance and simultaneity perception are affected by latencies above 75ms.
- Sense of agency and ownership start declining at a latency higher than 125ms, and they do not break down even at the highest tested delay.
- Participants perceptually infer the presence of delays more from their motor error than from the actual level of delay.

Whether or not participants notice a delay in a virtual environment might depend more on the motor task and their performance than on the actual delay.

NONVERBAL FEEDBACK

Aim: to examine the impact of different nonverbal feedback strategies during observation on coachee's cognitive representation and motor performance of a complex motor action in early skill acquisition



- Feedback was provided whilst executing the squat
- Own avatar** condition: Participants observed their own avatar performing their own movement in a virtual mirror
- Own avatar plus ghost** condition: Participants observed their own avatar performing their own movement plus an avatar of a skilled person performing a correct squat, superimposed on their own avatar, in a virtual mirror

Design

Design of the pilot study (N = 15)

	Pre-test	Acquisition	Post-test	Retention-test
	Day 1	Day 1	Day 1	Day 2
Own avatar condition	SDA-M	Squat practice with mirrored action	DTW	SDA-M
Own avatar plus ghost condition	SDA-M	Squat practice with mirrored + ghost action	DTW	SDA-M

Note: SDA-M: structural dimensional analysis of mental representation; DTW: dynamic time warping; number of squats during test sessions: 2 x 5 squats; number of squats during acquisition: 6 x 5 squats.

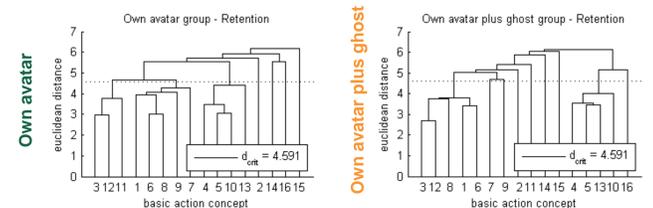


Preliminary results showed a trend for the 'own avatar plus ghost' group to outperform the 'own avatar only' group in both motor performance and cognitive representation variables.

Results

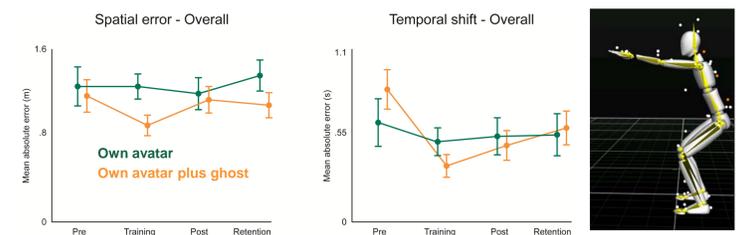
Cognitive representation

(SDA-M; Schack, 2012)



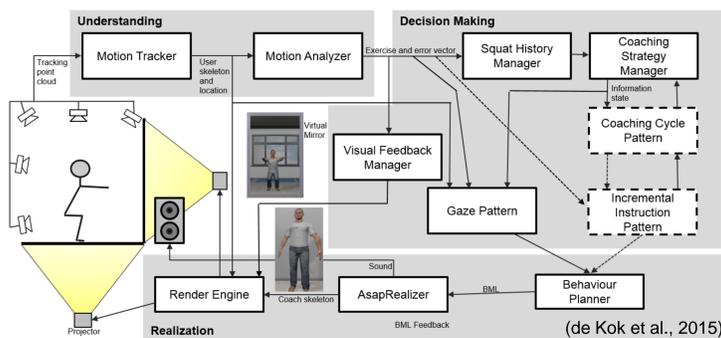
Motor performance

(DTW; Müller, 2007)



VERBAL FEEDBACK AND VIRTUAL AGENTS

Aim: to build a virtual coach capable of providing complete training sessions with incremental instructions to improve motor skill performance.



The coach needs to decide what part of the skill to put in focus, what instruction – in terms of tone of speech, nonverbal behavior and content – would be most helpful and how to keep the coachee motivated. In these decisions we adapt to the expertise level of the coachee.

Wizard-of-Oz Setup

In the Wizard-of-Oz setup we are able to compare a training session with the virtual coach with a session with a real coach. In this setup the coach is located in a similar lab setup (left) and represented by an scanned avatar in the virtual coaching environment (right). Gestures and speech are mirrored on the avatar, allowing for natural interaction between coach and coachee.



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