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Exploring Virtual Reality and Doppelganger Avatars for the Treatment of Chronic Back Pain

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Cognitive-behavioral models of chronic pain assume that fear of pain and subsequent avoidance behavior contribute to pain chronicity and the maintenance of chronic pain. In chronic back pain (CBP), avoidance of movements often plays a major role in pain perseverance and interference with daily life activities. In treatment, avoidance is often addressed by teaching patients to reduce pain behaviors and increase healthy behaviors. The current project explored the use of personalized virtual characters (doppelganger avatars) in virtual reality (VR), to influence motor imitation and avoidance, fear of pain and experienced pain in CBP. We developed a method to create virtual doppelgangers, to animate them with movements captured from real-world models, and to present them to participants in an immersive cave virtual environment (CAVE) as autonomous movement models for imitation.

Study 1 investigated interactions between model and observer characteristics in imitation behavior of healthy participants. We tested the hypothesis that perceived affiliative characteristics of a virtual model, such as similarity to the observer and likeability, would facilitate observers' engagement in voluntary motor imitation. In a within-subject design (N=33), participants were exposed to four virtual characters of different degrees of realism and observer similarity, ranging from an abstract stickperson to a personalized doppelganger avatar designed from 3d scans of the observer. The characters performed different trunk movements and participants were asked to imitate these. We defined functional ranges of motion (ROM) for spinal extension (bending backward, BB), lateral flexion (bending sideward, BS) and rotation in the horizontal plane (RH) based on shoulder marker trajectories as behavioral indicators of imitation. Participants' ratings on perceived avatar appearance were recorded in an Autonomous Avatar Questionnaire (AAQ), based on an explorative factor analysis. Linear mixed effects models revealed that for lateral flexion (BS), a facilitating influence of avatar type on ROM was mediated by perceived identification with the avatar including avatar likeability, avatar-observer-similarity and other affiliative characteristics. These findings suggest that maximizing model-observer similarity may indeed be useful to stimulate observational modeling.

Study 2 employed the techniques developed in study 1 with participants who suffered from CBP and extended the setup with real-world elements, creating an immersive mixed reality. The research question was whether virtual doppelgangers could modify motor behaviors, pain expectancy and pain. In a randomized controlled between-subject design, participants observed and imitated an avatar (AVA, N=17) or a videotaped model (VID, N=16) over three sessions, during which the movements BS and RH as well as a new movement (moving a beverage crate) were shown. Again, self-reports and ROMs were used as measures. The AVA group reported reduced avoidance with no significant group differences in ROM. Pain expectancy increased in AVA but not VID over the sessions. Pain and limitations did not significantly differ. We observed a moderation effect of group, with prior pain expectancy predicting pain and avoidance in the VID but not in the AVA group. This can be interpreted as an effect of personalized movement models decoupling pain behavior from movement-related fear and pain expectancy by increasing pain tolerance and task persistence. Our findings suggest that personalized virtual movement models can stimulate observational modeling in general, and that they can increase pain tolerance and persistence in chronic pain conditions. Thus, they may provide a tool for exposure and exercise treatments in cognitive behavioral treatment approaches to CBP.