Towards the Evaluation of Kinesthetic Empathy in Virtual Reality

Roosa Piitulainen
Elisa D. Mekler
roosa.piitulainen@aalto.fi
elisa.mekler@aalto.fi
Aalto University
Espoo, Finland

ABSTRACT

As part of a new H2020 FET Proactive project, we are looking to evaluate social dance experiences in virtual reality (VR). However, few existing measures appear directly applicable. In this position paper, we propose kinesthetic empathy (KE) as a framework with which to approach the social aspect of MR interactions. We review some evaluation methods that are currently used, and which may be employed to operationalize KE. We conclude with open questions and challenges that warrant further discussion.

CCS CONCEPTS

• **Human-centered computing** → **Virtual Reality**; *User studies; Empirical studies in HCI*.

KEYWORDS

kinesthetic empathy, dance experience

1 INTRODUCTION

January 2021 marked the launch of the H2020 FET Proactive project CAROUSEL+, which aims to combine AI and MR technologies to create social dancing experiences that allow users to interact with other users and virtual characters. Dance is an activity enjoyed by many people worldwide [21]. It has strong effects on physiological and psychological well-being, combining the benefits of physical exercise with heightened sensory awareness, cognitive function, creativity, inter-personal contact and emotional expression [8, 21]. However, the global pandemic has drastically limited opportunities for social dancing. The advent of commercial VR technologies affords opportunities for bringing social dancing to *virtual* public spaces (e.g., VR Chat), providing new opportunities for creating social dancing experiences. Yet it also presents unique challenges, not only regarding technical implementation, but for evaluating the user experience.

As leaders of the evaluation work package (and relative newcomers to MR evaluation!), we are looking to establish a toolkit of methods and best practices usable by all project partners. CAROUSEL+ poses two major challenges for evaluation: What aspects of the user experience are (most) relevant to evaluate? And how to assess these aspects? In this position paper, we propose the notion of kinesthetic empathy (KE) [7] as a promising framework for studying the social and aesthetic qualities of MR dance experiences. We report which existing measures we consider potentially useful in operationalizing KE, and raise open questions and methodological challenges we hope to discuss at the workshop.

2 KINESTHETIC EMPATHY

Experiences of dancing in VR have been studied before, but most work has focused on dance performances [32] and learning dance [14, 29]. The social and aesthetic experience of dancing with others is rarely considered. We therefore look to *kinesthetic empathy* (KE) as a concept to structure our evaluation process. KE seems opportune for use in VR contexts, as it refers to relating to other people physically without necessitating physical touch [7]. Rather, KE describes our ability to "feel" or imagine the movement of other people in our own body, without necessarily moving ourselves. KE has been explored in the context of dance and performance [23, 31, 36], and as a potential intervention for teaching empathy and social awareness [6, 22, 33].

In recent years, KE has also gained traction in HCI. Miyoshi [18, 19], for instance, investigated how it could be leveraged in design, though he focuses primarily on physical objects. The notion of KE has also been investigated in the context of digital [12] or technologically enhanced performances [11]. Cuykendall et al. [7] propose a framework for generating and evaluating movement interactions that support kinesthetic empathy. Their evaluative framework consists of two parts: First, kinesthetic awareness entails focusing the user's attention and facilitating engagement as a prerequisite for KE. Second, Cuykendall et al. [7] propose "design parameters" for KE that span four main themes of KE, which fall under action prediction, which includes the user being able to decide their actions from a variety of options and anticipate the moves of other users; and action understanding, whereby the user may explore different movements and reflect on those experiences. Additionally, movability and integration are proposed as supporting factors to help develop KE. These include more physical aspects of the system such as the interaction space and alignment of the sensory facets of the experience.

Unlike some design aspects of MR systems, KE is not unique or specific to interactions with these (or any digital) systems. Rather, it describes a propensity and skill people have that can be supported or impeded by interactive systems. That said, signals that evoke KE could potentially be also enhanced or exaggerated within MR, resulting in an elevated response [24]. Approaching social interactions from the perspective of KE may be particularly relevant for VR, as it is an inherently visual environment, while (currently) limited in replicating body movements and relaying haptic sensations.

3 OPERATIONALIZING KINESTHETIC EMPATHY

Past contributions on KE in HCI have primarily remained on a conceptual level. However, to create VR dance experiences that support KE, we also require methods to systematically evaluate relevant aspects of the design. In CAROUSEL+, interactions could potentially include any combination of human(s) (mediated through their respective VR avatars), virtual character(s), and other elements of the virtual environment. To tackle this gap, we have begun exploring methods for evaluating social interactive experiences in VR and digital games, and link them to the KE concepts outlined by Cuykendall et al. [7] in an attempt to articulate preliminary operationalizations.

3.1 Kinesthetic awareness

As noted, kinesthetic awareness entails focusing the user's attention and facilitating engagement and immersion [7]. Hence, we suggest that these prerequisites for VR may be assessed using existing measures for presence [9, 28]. Conversely, physical discomfort, resulting from e.g. simulator sickness [27], could likely prevent KE. The rationale here is that if users are not sufficiently immersed in the virtual environment, or are distracted by physical discomfort, the kinesthetic awareness is disrupted.

3.2 Movability and Integration

Movability and integration are considered facilitators of KE [7] and likely also immersion and presence: it is difficult to imagine users becoming immersed in a virtual world, if their physical space restricts moving in the required way, the social setting (in the real world) is not appropriate, or the sensory channels or movement sensing are out of sync. Integration resembles the notions of perceived body ownership [25] and avatar embodiment [30]. It is not clear whether one's relationship with the avatar affects receiving social information. However, higher body ownership illusion due to more fine-grained tracking can affect how one acts in VR [37]. Assuming limited embodiment limits the available actions, this could also diminish KE. However, body ownership has also been researched from the point of view of how realistic the avatar is. One such study found that higher virtual body acceptance did not affect co-presence or social presence with full-body controlled avatars [15]. Thus, the realism of avatars might be less relevant for KE.

Toet et al. [34] recently introduced the holistic social presence questionnaire (HSPQ). The HSPQ consists of different processing levels (sensory, emotional, cognitive, behavioral, reasoning) and presence levels (spatial, social-internal, social-external). The sensory (ability to sense "*the environment without any restrictions or distortions*" [34]) and behavioral ("*I can behave [or interact] in a natural manner*" [34]) levels overlap with the notion of integration outlined by Cuykendall et al. [7]. That said, the HSPQ still awaits proper empirical validation.

3.3 Understanding and predicting actions

Understanding and predicting actions constitute KE [7]. While we found no equivalent existing measures, the autonomy and competence dimensions from the Player Experience Need Satisfaction scale [PENS, 26] seem to correspond to some extent. Being able to explore action alternatives and options, and freely decide which actions to take in a given situation may reflect user autonomy regarding their actions. Encouraging exploration and reflecting on it could also contribute to building competency in the form of knowing and mastering the available action options. Similarly, being able to successfully anticipate the actions of others and determine one's own actions such that they yield the desired result should facilitate a sense of competency. As of now, it remains to be seen whether PENS or other self-determination theory-based instruments could be used to meaningfully measure KE parameters.

3.4 Objective measures

The methods described above primarily rely on subjective self-reports. However, it is unclear to what extent KE is a conscious or unconscious state. This complicates the utility of subjective ratings, and suggests the need for observable behavioral measures. One potential way to measure KE could be comparing task completion in VR and in real world [e.g., 24]. While dancing often does not feature well-defined "tasks", such an approach might be useful to operationalize understanding and predicting actions. Observing and understanding another dancer's movement, for instance, could be investigated by comparing mimicking movements in real world and in VR. Another approach could be analyzing movement qualities (e.g., perceived effort of the movement), which has been traditionally used in dance research [5], and consequently in the context of dance therapy [13], dance-related computer systems [1], and more general HCI research [2, 17]. There are also implementations to perform such analyses automatically from motion capture data [3]. This type of movement analysis could be used to explore whether the qualities of movement change as a function of the setting (real world vs VR) or specific system features.

3.5 Social connectedness and relatedness

Finally, we need to account for the social nature of CAROUSEL+ dance experiences. While not chiefly a component of KE, we theorize that successfully supporting KE makes social interactions in VR more intuitive and successful, thus affording an increased sense of closeness between dancers, be they other users or AI-controlled agents. The notion of relatedness, for instance, as posited by self-determination theory, is frequently used in games research to measure the social quality of the player experience [26, 35] and might be adapted to our purposes. Another option is the Inclusion of the Other in the Self (IOS) questionnaire [4]: Zhou et al. [38], for instance, designed Astaire, a collocated VR dancing game that aims to foster collaborative and interdependent gameplay, physical closeness and social touch, as well as include spectators in the shared experience. To evaluate Astaire, the IOS was administered after playing, and results compared within-subjects to two other games. Results indicate higher IOS scores, as well as increased excitement and happiness for Astaire. Even though we are not primarily interested in physically collocated interactions, the IOS scale appears suitable for virtual settings as well.

4 CHALLENGES AND OPEN QUESTIONS

Although many existing measures seem to align with the concept of KE, several open questions remain. For instance, while the processing and presence levels of the HSPQ [34] form a useful frame for considering different aspects of social interaction in VR, many items refer to how "natural" the environment and other people in it appear. It is unclear what natural means in this context, and whether naturalness is actually required for meaningful social dance experiences. In fact, studies suggest that "non-natural" augmentations may enhance social interaction in VR, such as adding "sparkles" to highlight the focus of attention [24].

Next, there is some indication that immersion and social interaction may conflict in VR. For example, Hudson et al. [10] found that the effect of immersion on overall satisfaction was smaller when there was a high level of social interaction with other players. This clashes somewhat with the notion of KE outlined by Cuykendall et al. [7], which posits immersion as a prerequisite for KE. However, in another study results did not support social interaction having a negative impact on immersion in a collaborative game, while just the presence of a social entity was negatively correlated with immersion [16]. Elsewhere, social presence and naturalness of the social experience and interaction had no effect on immersion [20]. Comparing these different findings is however difficult, as they all use different measures for immersion and the social aspect. This highlights that the interplay between immersion, social facets, and other qualities of VR experiences is complicated and remains an open question. One explanation for this variation is that not the presence or amount of social interaction itself prevents immersion, but rather how that interaction is facilitated; none of the three aforementioned studies looked into such details.

In case of interaction implementation disrupting immersion, it would likely also inhibit KE. For instance, Roth et al. [24] found that in a ball passing experiment with full-body tracking the participants performed worse in VR than in real world. For a verbal task, there was no such difference, suggesting that the difficulty lies in physical collaboration. If nothing else, these findings further highlight the importance of also considering non-verbal communication when evaluating VR user experiences.

Importantly, all our suggested operationalizations for KE have yet to be employed and await empirical scrutiny. Finally, evaluating KE faces many of the same challenges as evaluating MR user experiences in general. Developing and selecting measures for subjective experiences is challenging, further complicated by the variety of scales to measure presence in VR [9] and when or where to administer questionnaires during the VR experience [28].

To sum up, as VR solutions are maturing, they provide increasingly sophisticated opportunities for social interaction. CAROUSEL+ aims to create social dance experiences in VR, yet existing measures do not adequately account for the social and aesthetic qualities of such experiences. We have identified KE as a potential framework to address this gap. While KE and its associated concepts have yet to be formally operationalized, we have highlighted some points of convergence with existing concepts and evaluation instruments used in VR and games research. Given the open questions and challenges around the topic, we look forward to discussing these at the workshop.

ACKNOWLEDGMENTS

This work has been supported by the EC through the Horizon 2020 FET Proactive program (grant agreement 101017779).

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