Real-time visual feedback on motor performance in a dance class: Presentation of a field study concept

Mai Geisen, Nina Riedl and Stefanie Klatt

German Sport University Cologne, Am Sportpark Müngersdorf 6, Cologne, Germany

Abstract

Motor learning in dance is enhanced by providing feedback on the learner's actions. With the help of motion feedback, both experts and novices can optimize and learn the targeted motion execution of a dance choreography as well as internalize it to improve their dance performance. Novel immersive training environments make it possible to provide visual feedback to learners via screens during the execution of a motion, i.e., in real-time. In this paper, we present a study concept designed for the use of real-time visual feedback in a dance class, which is specifically aimed at facilitating the learning of a dance choreography. The concept is elaborated and implemented under the aspect of improving psychomotor learning within the MILKI-PSY project.

Keywords

real-time feedback, psychomotor learning, motion adaptation

1. Introduction

Feedback plays a vital role in helping dancers execute choreographies accurately and refining their overall dance motor skills. Within a dance class, feedback can be provided by experienced instructors who offer guidance on individual movement executions [1,2]. However, the verbal feedback of an instructor is subjective and is usually also communicated after the performance. Thus, a direct implementation of the given information in the form of an optimized motion execution is made more difficult [3,4].

Nowadays, modern technologies enable training in immersive environments, so learners can be provided with visual feedback during motion execution [5]. By receiving specific and objective feedback in real-time, learners can make necessary adjustments, refine their technique, and achieve greater precision and fluidity in executing the motion [3,6]. This work aims to present an innovative field study concept on a real-time visual feedback method for optimizing motor learning during a dance class session.

2. Related work

To date, the predominant focus of research in the field of motor learning has been on the provision of feedback after performance completion [7]. However, the direct implementation of this feedback is made more difficult, since the learner needs to notice, remember, and adjust possible mistakes after having performed the respective motion. Accurate and timely feedback has proven to be essential for athletes' motion optimization [4].

The medical- and health sectors have already provided some research on the real-time practice of psychomotor skills using immersive environments, such as surgery suture training [8] and rehabilitation of upper limb motions [9]. Moreover, research work in education and in health application fields presented useful learning methods in relation to real-time superimposition of motion visualizations [10,11].

MILeS 23: The Third International Workshop on Multimodal Immersive Learning Systems, September 4, 2023, Aveiro, Portugal

m.geisen@dshs-koeln.de (M. Geisen); n.riedl@dshs-koeln.de (N. Riedl); s.klatt@dshs-koeln.de (S. Klatt)

0000-0002-3413-4600 (M. Geisen); 0000-0002-2477-8699 (S. Klatt)

In the sports context, studies have also presented the benefits of immersive real-time feedback for sports training and performance already. For instance, a system for the provision of multimodal feedback in an immersive environment has been developed, which allows for the perception of differences between the motions of a learner's and an expert's golf swing through visual superimposition. The authors suggested this system as an effective learning tool, as it enables the imitation of the optimized motion in real-time [12]. Furthermore, an immersive sports training environment applying visual and verbal stimuli was tested for the training of squats and Tai Chi pushes. Hülsmann et al. [13] concluded that the provision of real-time feedback in the form of color indicators on the learner's avatar can be considered a useful feedback method for sports training.

3. Research approach

The novel feedback method presented in this work aims to optimize teaching and learning of a dance choreography for use in a dance class. The method includes the concept of real-time visual feedback in the form of a comparison between the targeted motion of a dance instructor and the learner's motion execution. This creates the possibility to obtain direct and precise feedback on the self-performed motion during training without having to rely solely on the subjective and time-delayed feedback of another person, i.e., the instructor. In addition, the instructor is supported as he or she often is responsible for observing and correcting the motions of many individuals at the same time within a dance class. Within a technology-enhanced field study environment, this feedback method is specifically investigated by comparing it to a conventional dance training method in real-time, i.e., during an actual dance lesson. Accordingly, it can be investigated to what extent the novel approach of real-time feedback is accepted by learners and can be used successfully. This study concept builds on innovative sports feedback methods that have previously been developed and evaluated in laboratory settings [14,15]. The aim is to now adapt this approach to a specific type of sport (dance) as well as to the actual use in the field, i.e., in a dance class. Within the framework of the new field study concept, the following question is to be answered: Can real-time visual feedback in a dance class setting be used to enhance the adaptation of learner's motions to the targeted motion executions within a dance choreography?

4. Methodology

The field study concept can be applied to existing dance groups including their own instructor. Also, individual participants with all kinds of dance experience levels can be recruited as long as within one study, participants in both groups contain very similar levels of experience for comparison. A trained dance instructor (e.g., in hip-hop dance) prepares a choreography that can vary in difficulty and duration, depending on the experience level of the participants. The concept can be applied to field studies that refer to one dance lesson of approximately one hour or on long-term investigations including a series of dance lessons over several days, weeks, or months.

During the study, three Microsoft Kinect cameras are set up, one in front of the instructor and one in front of each training method group. Thereby, motion executions of the instructor, i.e., the targeted spatially and temporally optimized performance, and of the participants, i.e., the actual performance, are captured in real-time. Each group stands in front of a big screen (approx. 90 inch) that serves as a mirror, i.e., a livestream of the participants' motions is shown. The intervention group learns the choreography by being provided with a visual superimposition of the instructor's motions (captured and transferred to the screen of the participants in real-time) and their own motions. The instructor's superimposed motions are displayed slightly transparent in order to make the differences between the two motion executions clearly visible. In addition, the instructor wears colored clothing and the participants wear black clothing. The active control group learns the dance choreography without having real-time visual feedback as support. For the control group, the screen functions exclusively as a mirror (a real mirror is not chosen in order to keep the test conditions as similar as possible for both groups). In order for the instructor to be able to observe him- or herself, as is usually the case in dance lessons, he or she views their own motion executions through a real mirror. To ensure that both groups do not see each other's screens and yet both have an equally good view of the instructor, a partition is set up between the groups and behind the instructor. The entire test setting is presented in Figure 1.

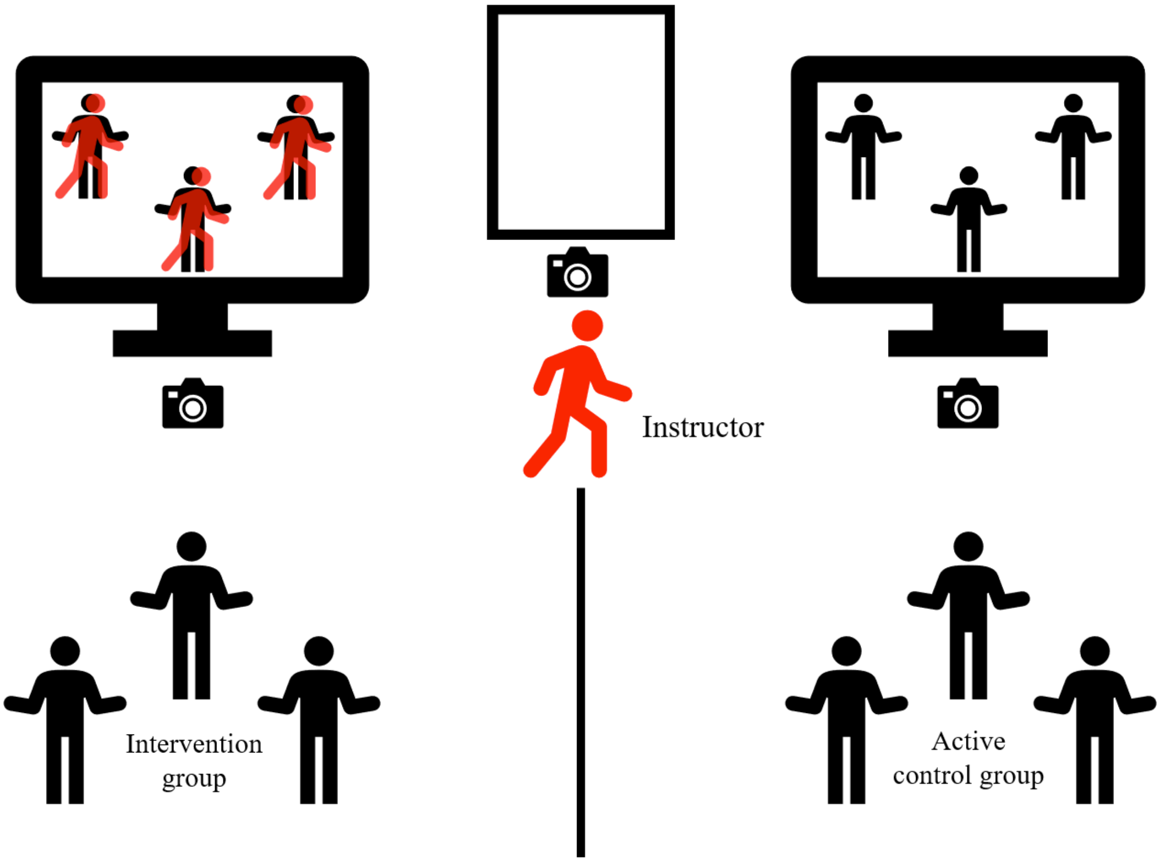

Figure 1: **Test-setting of the field study concept for real-time visual feedback on motor performance in a dance class.** The instructor stands in front of the participants and teaches them a dance choreography while being able to observe his/her own motions through a mirror. Real-time visual feedback in a form of superimposing the optimized motion of the instructor and the motion of the learners of the intervention group is shown in the screen on the left-hand side. The teaching method of the control group without any visual feedback is presented in the screen on the right-hand side, i.e., observing the own motions as if through a mirror. All persons' motions are captured by a camera for real-time visualization via the screens.

In order to compare the motor performance at the beginning of the session with the performance after the training, i.e., for measuring the learning success, both groups have to conduct a pretest and a posttest. During these tests, participants conduct the dance choreography without any additional real-time feedback. However, the instructor accompanies the participants in performing the choreography to avoid confounding effects of participants' varying memory performances. Data collection is done by capturing the motions via the Microsoft Kinect cameras. Both tests are integrated into the course of the dance lesson to match the concept of the research as a field study, i.e., an investigation in a real practical sports environment.

The variables to be investigated within this field study concept, on the one hand, refer to the spatial, motion-related characteristics, i.e., the joint angle positions, including the ankle, knee, hip, shoulder, elbow and wrist joints. On the other hand, they relate to the temporal execution of the motions of the choreography. Data analysis is done with the help of manual annotation of both variables, which is possible on the basis of the video recordings. In this way, the motion performance of the learners at both time points (pre- and posttest) can be compared with each other and the possible motion adaptation in the respective groups can be determined.

Furthermore, dance performances are usually scored with the help of a jury-system on dance competitions. Thus, in order to enable a study design that is as similar as possible to the actual training and evaluation of dance motion performances, video recordings of the captured motions are scored by trained judges in dance. Based on official scoring criteria, e.g. German evaluation criteria for championships in hip-hop dance, which include, among others, the category 'technique' with the subcategories 'technical execution' and moving to the 'beat/rhythm' [16], judges can score the performance of all participants without knowing if they had practiced with the novel feedback method or the conventional training method. The judges' scorings of every participant's performance can be averaged across each group and these scores can then be compared with each other.

5. Future work

Once the present field study concept has been applied, it will be reviewed on the basis of the implementation and results and modified if necessary. Specifically, the concept is to be further elaborated taking into account the respective needs of the dance students and instructors as well as the technical components. Based on this, further concept development and studies on motor learning in various sports are intended. Future studies should also consider not only the transfer of the innovative real-time feedback method to other disciplines, but also the development and investigation of additional sensory feedback methods (e.g., tactile and auditory).

6. Conclusion

In conclusion, the field study concept will be used for application in dance to extend research on feedback for learning and optimizing psychomotor skills in sports practice, initially tested in a dance class setting. In particular, the use of real-time sensory feedback through innovative methods and with the help of novel technologies is expected to facilitate motor learning in the future. In sports, experts as well as novices could be supported in improving their long-term sports performance. Sports instructors could be assisted in their work, especially with regard to the essential provision of feedback on motor performance.

References

[1] D. Drobny, J. Borchers, Learning basic dance choreographies with different augmented feedback modalities, Proceedings of the 28th International Conference on Human Factors in Computing Systems, Atlanta, Georgia USA, 2010. doi:10.1145/1753846.1754058

[2] E. Gibbons, Feedback in the Dance Studio, Journal of Physical Education, Recreation & Dance, 75(7), 38-43 (2013). doi:10.1080/07303084.2004.10607273.

[3] M. Geisen, S. Klatt, Real-time feedback using extended reality: A current overview and a further integration into sports, International Journal of Sports Science & Coaching, 17(5), (2021). doi:10.1177/17479541211051006.

[4] R. Kirby, Development of a real-time performance measurement and feedback system for alpine skiers, Sports Technology, 2(1-2), 43-52 (2009). doi:10.1080/19346182.2009.96484 98.

[5] M. Davaris, S. Wijewickrema, Y. Zhou, P. Piromchai, J. Bailey, G. Kennedy, S. O'Leary, The importance of automated real-time performance feedback in virtual reality temporal bone surgery training. in: S. Isotani, E. Millán, A. Ogan, P. Hastings, B. McLaren, R. Luckin. (Eds.), Artificial Intelligence in Education. Lecture Notes in Computer Science, 11625, Springer, 2019. doi:10.1007/978-3-030-23204-7_9.

[6] L. Katz, J. Parker, H. Treyman, G. Kopp, R. Levy, E. Chang, Virtual reality in sport and wellness: Promise and reality, International Journal of Computer Science in Sport, 4, 4-16 (2006).

[7] H. Kelley, R. G. Miltenberger, Using video feedback to improve horseback-riding skills, Journal of Applied Behavior Analysis, 49(1), 138-147 (2015). doi:10.1002/jaba.272.

[8] S. Sadeghi-Esfahlani, V. Izsof, S. Minter, A. Kordzadeh, H., Shirvani, K. S. Esfahlani, Development of an interactive virtual reality for medical skills training supervised by artificial neural network. in: Bi, Y., Bhatia, R., Kapoor, S. (Eds.), Intelligent Systems and Applications. Advances in Intelligent Systems and Computing, 1038, Springer, 2019. doi:10.1007/978-3-030-29513-4_34.
[9] P. Dias, R. Silva, P. Amorim, J. Lains, E. Roque, I. S. F. Pereira, F. Pereira, B. S., Santos, M. Potel, Using virtual reality to increase motivation in poststroke rehabilitation, IEEE Computer Graphics and Applications 39(1), 64-70 (2019). doi:10.1109/MCG.2018.2875630.
[10] I. M. Butaslac, Y. Fujimoto, T. Sawabe, M. Kanbara, H. Kato, Systematic Review of Augmented Reality Training Systems, IEEE Transactions on Visualization and Computer Graphics, 2022. https://doi.org/10.1109/TVCG.2022.3201120
[11] T. N. Hoang, M. Reinoso, F. Vetere, E. Tanin, Onebody: Remote posture guidance system using first person view in virtual environment, Proceedings of the 9th Nordic Conference on Human-Computer Interaction (NordiCHI '16), Association for Computing Machinery, New York, NY, USA, 2016. https://doi.org/10.1145/2971485.2971521
[12] A. Ikeda, D. H. Hwang, H. Koike, AR based self-sports learning system using decayed dynamic time warping algorithm, International Conference on Artificial Reality and Telexistence Eurographics Symposium on Virtual Environments, 2018.
[13] F. Hülsmann, J. P. Göpfert, B. Hammer, S. Kopp, M. Botsch, Classification of motor errors to provide real-time feedback for sports coaching in virtual reality - A case study in squats and Tai Chi pushes, Computers & Graphics, 76, 47-59 (2018). doi: 10.1016/j.cag.2018.08.003.
[14] M. Geisen, K. A. Mat Sanusi, T. Baumgartner, S. Klatt, S, XR Golf Putt Trainer: User opinions on an innovative real-time feedback tool, Seventeenth European Conference on Technology Enhanced Learning, Proceedings of the Second International Workshop on Multimodal Immersive Learning Systems, Toulouse, France, 3247, 2022.
[15] M. Geisen, T. Baumgartner, N. Riedl, S. Klatt, Real-time visual feedback on sports performance in an immersive training environment: Presentation of a study concept, Sixteenth European Conference on Technology Enhanced Learning, Proceedings of the First International Workshop on Multimodal Immersive Learning Systems, Bozen-Bolzano, Italy, 2979, 2021.
[16] TAF-Germany.de, TAF GERMANY e.V. REGLEMENT VERSION2023, 2023, URL: https://taf-germany.de/assets/downloads/downloads-dateien-2023/TAF%20Reglement%202023%20mit%20Deckblatt%2020230222_final.pdf