ERROR PERCEPTION IN GYMNASTICS: TWO CONSECUTIVE INTERVENTIONS

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Abstract

The coach's perception of movement errors is crucial for the feedback. Two consecutive studies investigated exploratory the influence of transfer of knowledge (study 1; S1) and the influence of motor experience (study 2; S2) on error perception rate of the gymnastics element handstand with a roll. Participants of S1 (n = 18) and S2 (n = 21) are distributed to either a control or an intervention condition. The error perception rate of a video test was used as the dependent variable. Interventions consisted of 180 minutes transfer of knowledge sessions (S1) and 90 executions of handstand with a roll (S2). The mental structure (S1) and an execution protocol with subjective performance are used for monitoring. The error perception rate increased significantly for all conditions. An influence of transfer of knowledge and motor experience was not found. A systematic change in the mental structure on the descriptive level and a subjective improvement of the handstand performance was found. The overall increase of the error perception rate is seen as a learning effect. It remains unclear whether there are long term effects on error perception and to what extent changes of mental structure and subjective performance can be used for the feedback.

Keywords: *augmented feedback, movement errors, perception, coaching.*

INTRODUCTION

It is well known that augmented feedback, such as in form of a video feedback or a coach's feedback has an impact on the learning process of movements (Guadagnoli, Holcomb, & Davis, 2002; Magill & Anderson, 2012). Thus, the way in which the feedback is communicated as well as the content of the feedback is correlated with or determining the movement performance (Hodges & Franks, 2002; Veit, Jeraj, & Lobinger, accepted). This is transferable to simple movements, such as one dimensional arm movements (Armstrong, 1970) as well as to more complex movements, such as sport techniques (Kernodlea & Carlton, 1992). Especially in technical compositional sports as in gymnastics, this performance is associated with its degree of perfectionism during demonstration (Robin, 2014). The ultimate goal is an error free demonstration of the athlete's performance (Arkaev & Suchilin, 2009). Taking into account the goal of a perfect demonstration and the usual way to reach this goal by the coach's feedback, the importance of an optimal feedback based on the error perception of the coach is obvious (Jeraj, Hennig, &

Heinen, 2015; Marković, Krističević, & Aleksić-Veljković, 2015). The aims of the two consecutive studies were to exploratory investigate the influences of two factors on error perception of the coach as a function of the error correction process.

The error perception is one of the fundamental steps of an error correction process because it builds the crucial cue on which the decision for the feedback is based on (Jeraj, Hennig, & Heinen, 2015). During the observation of the movement, the coach needs to detect and perceive *relevant* information in order to be able to give appropriate feedback to their athlete. It is still unclear whether and when those observations is a more top-down or bottom-up influenced process (Brewer & Loschky, 2005). Nevertheless there is general agreement for differences found in gaze behavior comparing experts and laypeople (Gegenfurtner, Lethinen, & Säljö, 2011). According to a meta-analysis of Mann, Williams, Ward, and Janelle (2007), experts are better in the perception of visual tasks because of different gaze behavior. On the other hand, it is either possible that the same gaze behavior of experts and laypeople leads to different results, as one study showed in the accuracy measurement of foul-/no-foul decisions during the observation of videotaped material (Hancock & Ste-Marie, 2013). This makes clear that there is not yet enough evidence to state how such relevant information is perceived in detail. The error perception rate in both consecutive conducted studies at hand is used as a measurement of the coach's ability to have perceived the relevant information which would be needed for an appropriate feedback.

Taking into account several recently published work (Heinen, Vinken, & Velentzas, 2012; Pizzera, 2012, 2015), there is support that a specific motor experience helps the observer to identify and use relevant information to form judgments. Thus the motor experience is chosen to be a crucial factor that is used in the consecutive study design here as an independent variable. In addition, one can assume that the knowledge of the coach is also a crucial factor (Jeraj, Veit, Heinen, & Raab, 2015). This becomes plausible arguing with the steps of the error correction process where (a) the perception of relevant information happens before the judgment of the observed movement and (b) assuming that different knowledge leads to a different perception. One study (Iserbyt, Ward, & Martens, 2015) who used the term content knowledge showed the relation between the latter and the performance of the learners. This study focused on the learner and not on a coach or teacher, but the finding is transferable to the two consecutive studies here as it gives a hint that there is a link between knowledge and error perception. This assumption is strengthened when referring to the general view on feedback and its quality (Hattie, 2008; Hattie & Timperley, 2007). Therefor the knowledge is used in the consecutive study design here as an independent variable.

According to the Cognitive Action Architecture-Approach (Schack & Ritter, 2009), learned motor actions are represented stable in the long-term memory system and are built by several so called basic action concepts (BAC) through their execution and practice (Schack, 2012). A recently conducted study shows that the mental structure of a learnt motor action is most elaborate when using a combination of mental and physical training (Frank, Land, & Schack, 2016). This effect was shown after already three practice sessions of 10 executions and 10 imaginations each in comparison to one physical practice only group and one control group. First, one can argue that the execution and imagination of movements lead to a different mental structure whereas the change in error perception rate is questionable. Second, the mentioned studies give also a hint that knowledge from a more global perspective could lead to a change in mental structures because more knowledge about a movement should be go along with a clearer imagination of the movement. Consecutively, one would assume that either a different knowledge level or a different motor experience level lead to a different error perception rate or at least to a different mental structure.

The main aims of the two studies were to show the influence of knowledge and motor experience on the error perception rate whereas the methodical approach of study 2 was driven by the results of study 1. It is hypothesized in study 1 that a higher knowledge level leads to a more structured mental representation, and that in turn a higher knowledge level leads to a higher error perception rate. The hypothesis of study 2 was that a higher motor experience level leads to a higher error perception rate.

One additional aspect which has to be considered in error perception tasks, is the fact that the perception of angles between body segments during judgment tasks is influenced by the visual perspective of the observer (Dallas, Mavidis, & Chairopoulou, 2011; Plessner & Schallies, 2005). This effect was shown for pictures of gymnastics elements taken from different perspectives. Thus one can assume that the perception of errors of a gymnastics movement in a video clip is also influenced by the perspective the video was captured. The additional assumption of the first study was that one of the two perspectives leads to a higher perception rate.

The two following studies were conducted separately whereas the first study (for a timeline see Figure 1) led to the second study (for a timeline see Figure 2). Before the start of the studies, the local university's ethic committee approved both study designs, following the requirements of the Declaration of Helsinki.

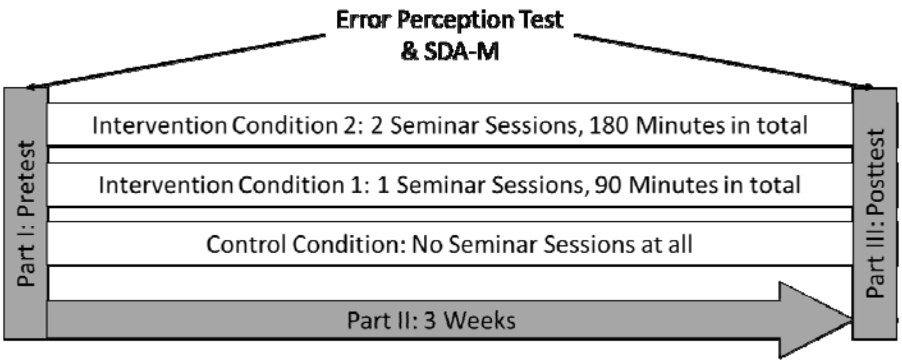


Figure 1. Illustration of the first conducted study with its two time of measurements (pretest and posttest) whereas the error perception test as well as the SDA-M were conducted. Participants were assigned to one of the three different conditions for the three weeks of part II.

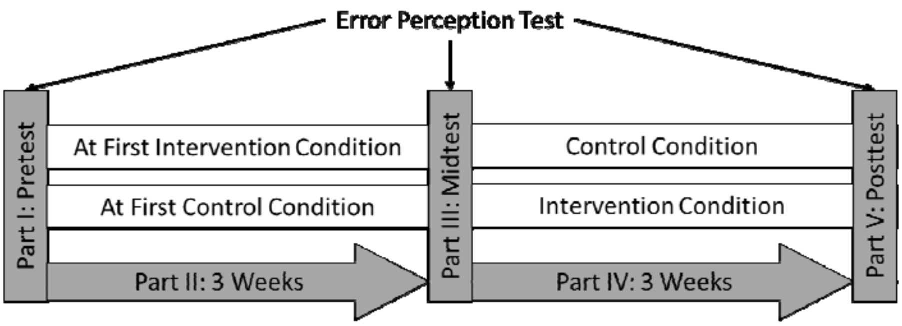


Figure 2. Illustration of the second conducted study with its three time of measurements (pretest, midtest and posttest) whereas the error perception test was conducted each time. Participants started either in the practicing or control condition after conducting at the pretest and changed their condition after conducting at the midtest.

METHODS OF STUDY 1

In total, n = 18 students of physical education participated in this study (M_{age} = 24.5 ± 1.34 years; 13 female and 5 male students). Self-reported none of the participants worked as a gymnastics coach and none of the participants were former or active gymnasts. All participants had completed a gymnastics course at the university and signed an informed consent before participating. Taking into account a participant dropout, the distribution was not equal anymore and the random condition assignment was as follows: Control (n_0 = 7); Intervention 1 (n_1 = 6); Intervention 2 (n_2 = 5).

The *handstand with a roll forward* was the gymnastics element chosen to be explored for the following reasons: First, this element is part of the university's gymnastics education course and it can, therefore, be assumed that all participants have at least a slight or similar knowledge and motor experience with regard to this element. Second, this element can be divided into three phases (Bartlett, 2007) which allows a clear assignment to (a) different error images (1 image per movement phase, resulting in 3 error images); (b) different methodical images (1 image per movement phase, resulting in 3 methodical images); (c) different movement images (2 images per movement phase, resulting in 6 movement images); and (d) different error type videos (2 per movement phase, resulting in 6 error type videos). In addition, this element is easy to teach in a school and training settings and thus, it is interesting for future PE teachers as well as for gymnastics coaches. That is, gymnastics and the chosen element allows for operationalizing error perception because the goal of gymnastics is an error free execution.

Video material was created by asking five gymnasts to demonstrate, one at a time, one specific error type out of the six most frequent error types for the handstand with a roll forward (Bessi, 2005; Gerling, 2009). They were also asked to demonstrate a handstand with a roll forward without any errors. During the execution they were filmed by two cameras, one placed at a distance of 5 meters and at a height of 1.5 meters, orthogonal to the movement plane. The second was placed at a distance of 5 meters and at a height of 1.5 meters, diagonal to the movement plane. The recorded videos were positively evaluated by four independent experts (all had a second highest coaching level license and all were part of the national education team) to ensure that the demonstrated error type and non-error demonstration is perceivable. In total, the video clip pool consisted of 70 different videos (i.e. 7 different executions, from 5 gymnasts, from 2 perspectives).

For the pretest, videos from 3 randomly chosen gymnasts were taken and were shown to the participants (Cloes, Hilbert, & Piéron, 1995; Cloes, Premuzak, & Piéron, 1995). This resulted in 42 videos which was an appropriate amount balancing test practicability and requirements. For the posttest, also videos from 3 gymnasts were selected, but only one gymnast and thus the video clips as well were the same as during pretest (see Table 1). This approach was chosen to avoid learning or memorization effects.

Each participant had to decide if they perceived an error or not. Using a paper sheet, the participant had to mark the preferred option from a 7-point option list. On these 7-point option list, the option "no error perceived" was given in each case and six additional options representing 6 different error types were selectable. Only one option was defined as the correct answer based on the aforementioned expert evaluation. All options except of the "no error perceived" option were presented randomly to reduce the chance to mark the correct option unintentionally.

The Structure Dimensional Analysis-Motoric (SDA-M; Schack, 2004) was used to monitor changes in mental structure between pretest and posttest, according to the point of view that laypeople have a less structured mental representation of a movement than experts (i.e., Schack &

Hackfort, 2007). Besides the most popular form of using terms, it is also possible to use movement videos or images (Stöckel, Hughes, & Schack, 2012). The used paper-pencil version of SDA-M consisted of 12 different images representing 6 movement images, 3 error images and 3 methodical images. The 6 movement images were generated from a videotaped error free demonstration of the handstand with a roll forward where respectively 2 images were taken from the 3 different movement phases as mentioned in the element description. The 3 error images represented 3 different error types, and the 3 methodical images represented 3 different methodical steps where 1 image respectively was taken from the 3 different movement phases. These 12 items were chosen to have a full picture of movement, possible errors and their possible solution which should be considered during error-correction processes. With the paper-pencil version, the participants had to decide for each of the possible 12 x 11 compares resulting in 132 decisions, if the two images belong together or not (for one example see Figure 3), without any further restrictions or hints (Schack, 2012).

Table 1
Illustration of the video clips used for the error perception test from the five different gymnasts for the two times of measurements (pretest and posttest) in study 1, resulted in 42 video clips each.

Used in Pretest		Used in Pretest & Posttest	Used in Posttest	
Gymnast 1	**Gymnast 2**	**Gymnast 3**	**Gymnast 4**	**Gymnast 5**
6 Error Types Demonstrations & 1 Correct Demonstration filmed from 2 perspectives resulting in 42 videos per test				

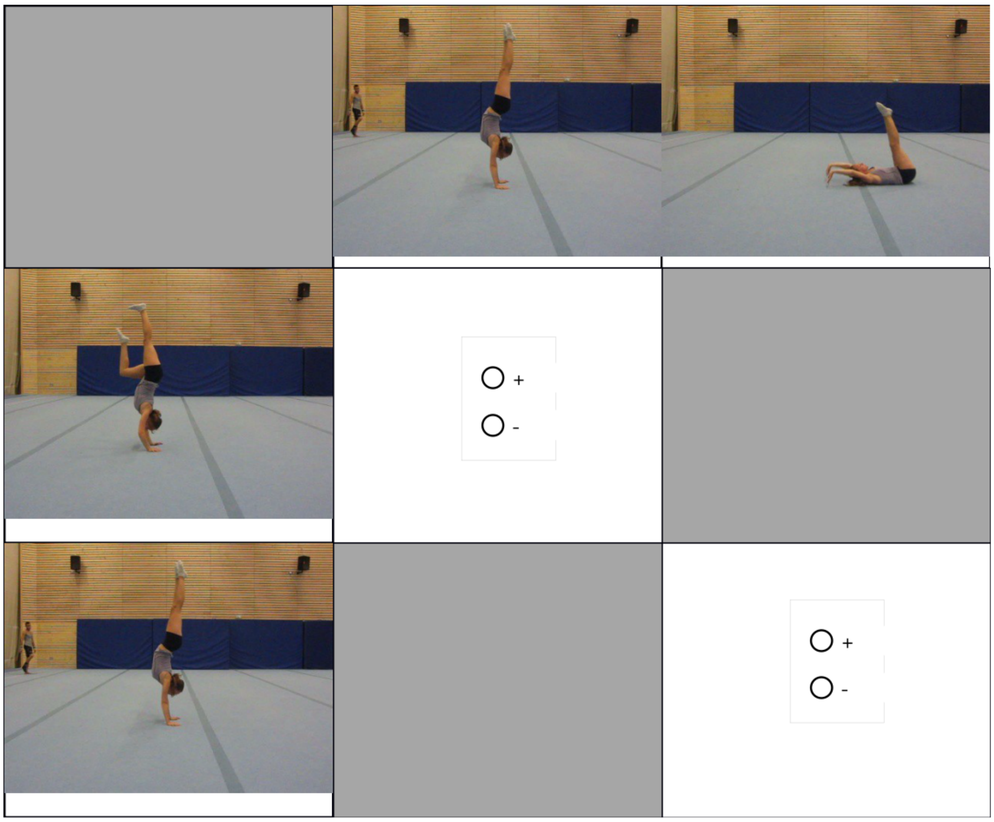


Figure 3. One example of the paper pencil version whereas the participant had to decide whether the two presented pictures belong together (+) or not (-). Afterwards, the decisions of the participant were analyzed according to the SDA-M procedure (for details see Schack, 2012).

In addition, four independent experts filled out this paper-pencil version. The mean mental structure of those experts acted as a reference structure for the further analyses because one assumes that expert's mental structure is well established (Schack & Hackfort, 2007; Velentzas, Heinen, Tenenbaum, & Schack, 2010).

The intervention consisted of two seminar sessions of 90 minutes each where content of biomechanical and methodical knowledge in gymnastics was taught to the students (Bessi, 2005; Deutscher Turner Bund, 2011). Intervention group 1 received one session (90 minutes in total), intervention group 2 received two sessions (180 minutes in total). The amount and the material was taken from the education program for gymnastics coaches and the sessions were conducted by a full educated and licensed gymnastics expert of the national teaching team. Within these seminar sessions, there was explicitly neither a link nor examples of handstand and rolls to avoid that the participants are able to remember aspects in regard to error perception of the videos.

Study 1 consisted of three parts (see Figure 1): In part I, the participants were welcomed in the seminar room where they received information about the study and that the voluntary participation could be canceled at any time without consequences, followed by their informed consent. All collected data used a coding system to ensure anonymity over the whole investigated time. The participants filled out a demographic data sheet, followed by the developed paper-pencil version of the SDA-M. The instructions were written on the sheet to ensure that all participants receive the same information and the same instructions. Before taking part at the error perception test, the selectable options were explained to ensure that all participants know what is meant by the several options. In addition, one video was shown that showed a handstand with a roll forward in an error free demonstration to act as a reference for the participants. This video was not part of the investigated videos later. Then the first video was presented. After the participants' decision, the next video was presented until all videos were shown once, using a random order. After completion of both instruments, the participants were randomly assigned to one of the two intervention groups or to the control group. In total, the whole first part (pretest) lasts 45 minutes.

In part II, Intervention group 1 received one seminar session of 90 minutes, in which knowledge about methodical and biomechanical aspects in gymnastics was taught. Intervention group 2 received two seminar sessions of each 90 minutes with the same content as Intervention group 1. The control group did not receive any information or tasks during the second phase.

In part III, both instruments used in part I were conducted again. The only difference to the pretest was in the selection of videos (see above). Afterwards, the participants were debriefed and given candy too, part III (posttest) was finished after 40 minutes.

A significance criterion of $\alpha = 5\%$ was defined a priori for all results reported. In addition, effect sizes were calculated for all following ANOVA analyses, resulting in partial eta-squared η_p^2.

In order to analyze the SDA-M and their individual changes, several steps were necessary starting with a split procedure for each case which resulted in the calculation of a Z-matrix (for details, see Schack, 2012). *All following distance calculations of the SDA-M used the mean mental structure of four experts as a reference structure (Figure 4)*: (1) The Adjusted Rand Index (ARI) as a measure of similarity (Rand, 1971; Santos & Embrechts, 2009) which resulted in an index between -1 (not similar) and 1 (same). (2) The λ-value as a measure of invariance whereas the critical value resulted in $d_{\text{crit}} = 3.444$ (Lander, 2002; Schack, 2012). Here, the calculated range of the λ-value was between 0 and 1 whereas two compares were seen as invariant for $\lambda \geq .683$ and variant for $\lambda < .683$ (Lander &

Huth, 1999). (3) Based on the former calculated Z-matrices, the Pearson correlation coefficient *r was calculated for each case* (Field, 2013). *Here, data is independent from specific aspects of the aforementioned two analyses (such as handling of single items or defining the critical value). Then, these correlation values were Fisher z-transformed to an arithmetic mean for each of the conditions and time of measurements* (Silver & Dunlap, 1987). *Finally, a descriptive analysis was chosen for this correlation values to report mental structure of the groups.*

For the error perception, all correct answers were summarized and resulted in a relative error perception rate as an independent variable. Afterwards, an analysis of variance (ANOVA) with repeated measures (pretest vs. posttest) was calculated with group assignment (intervention 1, intervention 2 and control condition) as a between-subject factor to detect changes in the three SDA-M values and in error perception as the dependent variables. Finally, paired t-tests were used to calculate differences in mean between the two visual perspectives used (once for pretest and once for posttest) as well as the corresponding effect sizes using Cohen's *d*.

RESULTS OF STUDY 1

No correlation between ARI and λ-values was found, all calculations (pretest and posttest) resulted in $p > .05$. Thus, Pearson correlation coefficient r was calculated for each case and the Fisher z-transformed arithmetic means of Pearson correlation coefficient r for the three groups (intervention 1, intervention 2, control group) and the two times of measurement whereas the analysis revealed the following values (see Table 2):

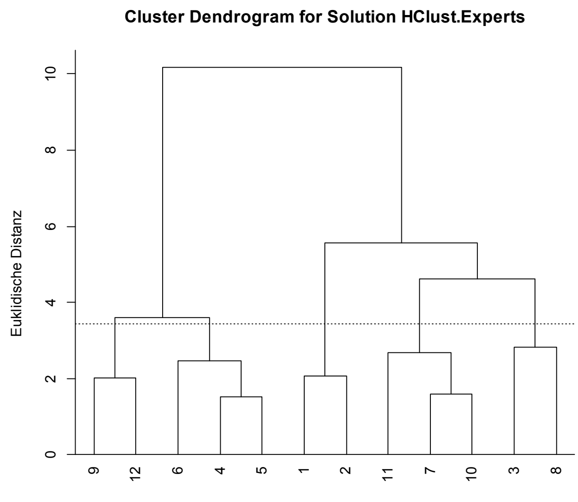
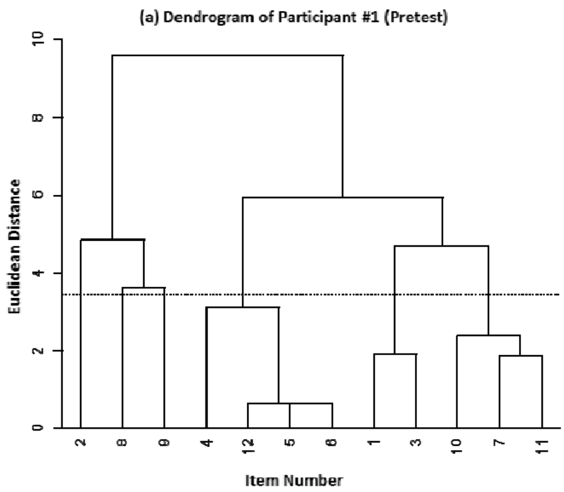


Figure 4. The expert's dendrogram acting as the reference structure. The experts structure the methodical step (9) and the error image (12) of the last phase together, as well as the imageof the mid phase (3) and the methodical step of the mid phase (8). One can also see that experts use a chronological structure for some of the movement images (1, 2; and 4, 5, 6). The images of a methodical step (7) is seen together with two error images of two phases (10, 11). *Note: The dotted line represents the critical* d *value of 3.444 defined by the SDA-M calculation*

Table 2
The Arithmetic Means of Fisher Z-values (Silver & Dunlap, 1987) based on the Pearson's Correlation Coefficients r for the Two Time of Measurements and the Three Different Conditions. None of the Calculations between Pretest and Posttest Value Revealed a Significant Result.

	Arithmetic Means of Fisher's z-transformation		
	Control condition	Intervention 1	Intervention 2
Pretest	0.559	0.872	0.719
Posttest	0.559	0.946	0.820



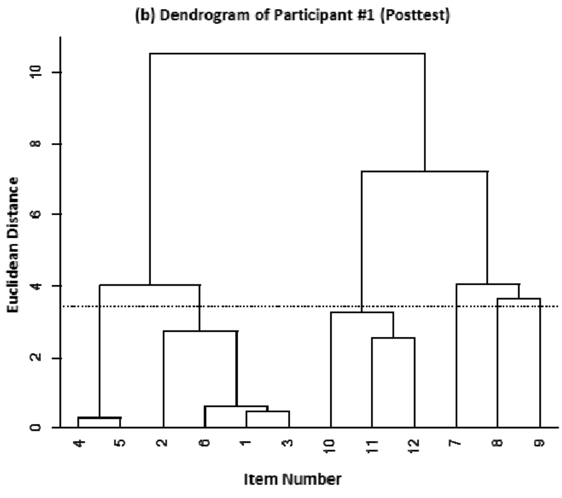


Figure 5. One laypeople's dendrogram of the (a) pretest and (b) posttest measurement who was part of the intervention group. (a) With the pretest measurement, the participant grouped the second part of the movement images (4 - 6) together with the last error image (12). In addition to that there is no systematic way recognizable how the rest of the images are grouped together or not. (b) After the intervention, the participant structures all movement images together (1 – 6). All methodical images (7 – 9) were seen as one group and all error images (10 – 12) were seen as single items. *Note: The dotted line represents the critical* d *value of 3.444 defined by the SDA-M calculation.*

But although the Fisher z-transformed arithmetic means seem to differ in a systematic way, no statistical significance was found according to the calculated analyses, neither for ARI: $F(2, 13) = 0.323$, $p = .730$, $\eta_p^2 = .047$; nor for λ-values: $F(2, 13) = 2.614$, $p = .111$, $\eta_p^2 = .287$; and for Fisher z-transformed arithmetic means: $F(2, 13) = 0.487$, $p = .625$, $\eta_p^2 = .070$. But although, as one exemplary single result, two dendrograms of the SDA-Ms are displayed (see Figure 5). This participant was part of the intervention group and the dendrograms derived from the pretest and posttest measurement. In the first dendrogram (Figure 5a, pretest), one can recognize that the participant has a relative unstructured representation of the movement and their relations to errors and methodical steps, the most items seem to be grouped unsystematically (please see Figure 4 for the experts' reference structure). After the participant's intervention phase, it is remarkable that he or she now structures all movement images together (1 – 6), all methodical images (7 – 9) were seen as one group and all error images (10 – 12) were seen as single items.

It was expected that those participants who were part of the intervention groups show a higher error perception rate than the control group, but there was an increase of 15 % in error perception rate for all groups, $F(2, 15) = 38.781$, $p < .001$, $\eta_p^2 = .721$, and no influence of the intervention on error perception rate was found, $F(2, 15) = 0.036$, $p = .965$, $\eta_p^2 = .005$.

There was no influence of the visual perspective on error perception, neither for the pretest data, $t(17) = 0.768$, $p = .453$, $d = -0.208$, nor for the posttest data, $t(17) = 0.195$, $p = .848$, $d = -0.045$. As a note, the same null results were found for additional calculated analyses in order to check for possible influences, using repeated measures ANOVA, ANCOVA and MANOVA.

The goal of this first study was to show the influence of knowledge on the error perception rate. It was expected at first that a higher knowledge level leads to a more structured mental representation, and at second that a higher knowledge level leads to a higher error perception rate. Additionally, it was expected that one of the two visual perspectives leads to a higher error perception rate.

The results revealed that there is no verifiable influence of knowledge on the mental structure on a statistical level although the structure on the descriptive level follows a systematic way resulting in an improvement of the mental structure for the two intervention groups. This is on the one hand a nice support that the knowledge level is indeed changed caused by the transfer of knowledge. On the other hand it is surprising that the change is not statistically significant because compared to the study of Frank, Land, and Schack (2016), while an intervention amount of already 30 executions and 30 imaginations of a movement lead to a different mental structure. One explanation besides the relative small sample size could be the complexity of the investigated motor tasks used in the study of Frank, Land, and Schack (2016) and in the study here. The movement of an arm swing resulting in hitting a golf ball is less complex comparing this to the whole body movement with different actions during the execution of the handstand with a roll forward. Thus, the assumption is that an imagination of the golfing task is easier transferable and lead to a faster change in the mental structure.

Regarding the result of the increased overall error perception rate independent of the condition was not expected and can be explained by the increase of visual experience caused by the observation of the videos. This result is in line with a previous published study where the task to judge a gymnastics element addressed a slightly different judgement just because of their visual experience in comparison to a group with motor experience instead of the visual experience (Heinen, Vinken, & Velentzas, 2012). The effect here is seen therefor as a learning effect whereas the whole error perception process is not influenced by the interventions. This is interesting because taking into account the aforementioned structural mental change on the descriptive level does not seem to be enough to change as well the error perception as a performance output measure. Thus, it stays unclear if the underlying process is a more top-down or bottom-up influenced process (Brewer & Loschky, 2005).

The additional result of the indifferent error perception rate for the two visual perspectives gives a hint that providing two perspectives for the whole gymnastics element is not enough. Although it was shown that there is an optimal perspective to perceive a specific angle of static elements (Dallas, Mavidis, & Chairopoulou, 2011; Plessner & Schallies, 2005), this optimal perspective is not as easy transferable to complex movements as in this case the handstand with a roll forward. During the observation of the movement execution, it is possible that the optimal perspective changes all the time because the specific and relevant angles or body positions which has to be considered for an error correction changes as well.

As a consequence of the mentioned results, the following study did not use an instrument to monitor changes in mental structure and did not differentiate between two visual perspectives. The influence of the second explorative factor motor experience was used while the hypothesis of study 2 was that a higher motor experience level leads to a higher error perception rate.

METHODS OF STUDY 2

In total, n = 21 students of physical education participated in this study (M_{age} = 21.4 ± 2.1 years; 10 female and 11 male students). One person gave the information that he or she worked as a gymnastics coach and he or she was as well as three participants former or active gymnasts. All participants just started a gymnastics course at the university and signed an informed consent before participating.

The investigated gymnastics element was the *handstand with a roll forward* as before.

The error perception test was similar as before with one difference: All available videos from the orthogonal visual perspective were shown, resulting in 35 videos (each of the five gymnasts demonstrated 6 error types and 1 error free execution) because there were not found differences of the error perception rate based on the perspectives.

The documentation sheet consisted of an instruction part and a predefined table where the participants had to fill out the amount of executions of handstand with a roll forward for the duration of the intervention phase. During the time of measurements, the participants answered one question about the subjective rating of their own performance of the handstand with a roll forward on a 10 point scale between “no execution possible” and “perfect execution possible”.

The intervention consisted of 90 executions of handstand with a roll forward which has to be performed autonomously by the participants using the documentation sheet as a monitoring tool. The handstands had to be performed three times a week, ten times per date resulting in 90 executions within three weeks. The amount of 90 executions were based on a study of Maleki, Nia, Zarghami, and Neisi (2010), in which the completion of 90 motor executions significantly enhanced the handstand performance of gymnastics beginners.

Study 2 consisted of five parts (see Figure 2) and used a cross-over study design: In part I, the participants were welcomed at the seminar room where they received information about the aims of the study and that the voluntary participation could be canceled at any time without consequences, followed by their informed consent. All collected data used a coding system to ensure anonymity over the whole intervention time. The participants filled out a demographic data sheet. Before taking part at the error perception test, the selectable options were explained to ensure that all participants know what is meant by the several options. In addition, one video was shown that showed a handstand with a roll forward in an error free demonstration to act as a reference for the participants. This video was not part of the investigated videos later. Then, the first video was presented. After the participants' decision, the next video was presented until all videos were shown once, using a random order. After completion of the test, the participants were randomly assigned to one of the two groups (either *at first practicing condition* or *at first control condition*). In total, part I (pretest) lasts 30 minutes.

In part II, within the following three weeks, participants of the *at first practicing condition* were asked to perform three times per week ten handstands with a roll forward by themselves, using the documentation sheet as a monitoring device. Participants of the *at first control condition* were instructed *not* to perform handstands with a roll forward for the next three weeks.

In part III, the data collection was conducted exactly three weeks later where the procedure from part I was used again, thus the error perception test was performed again. The documentation sheets were collected from the *at first practicing condition's* participants. In total, part III (midtest) lasted 25 minutes.

In part IV, afterwards the participants changed their condition, meaning that those who were part of the *at first control condition* now received the task to perform the 90 handstands with a roll forward within the next three weeks using the documentation sheet. And vice versa, those who were part of the *at first practicing condition* now were instructed *not* to perform handstands with a roll forward within the next three weeks.

In part V, the data collection was conducted exactly three weeks later whereas the procedure from part I and III was used again. Thus, the error perception test was performed again. The documentation sheets were collected from the practical condition's participants. In addition, participants were debriefed and given candy too. Part V (posttest) was finished after 25 minutes.

A significance criterion of $\alpha = 5\%$ was defined a priori for all results reported. For the monitoring tool, the subjective rating of the handstand with a roll forward was analyzed by using a Wilcoxon Signed Rank test. For the error perception test, all correct answers were summarized and resulted in a relative error perception rate. Afterwards, an analyses of variance (ANOVA) with repeated measures (pretest vs. midtest vs. posttest) was calculated with group assignment (at first practicing condition and at first control condition) as a between-subject factor to detect changes in error perception as the dependent variable. In addition, effect size was calculated, resulting in partial eta-squared in ANOVA η_p^2.

RESULTS OF STUDY 2

The participants have executed in mean 89.8 handstands with a roll forward whereas the subjective rating increased from pretest to posttest measure, $Z = -3.397$, $p = 0.001$.

It was expected that those participants who were part of the intervention groups show a higher error perception rate than the control group for the appropriate time of measurement, but there was an increase of round about 7 % in error perception rate for both groups. $F(2, 38) = 8.065$, $p < .001$; $\eta p^2 = .301$; and no influence of the condition on error perception rate was found, $F(2, 38) = 0.290$, $p = .750$, $\eta_p^2 = .015$.

The goal of this second study was to show the influence of motor experience on the error perception rate. It was expected that a higher motor experience level leads to a higher error perception rate.

Although an overall increase in the error perception rate for all groups of round about 7 % is found, there is neither an influence of the condition on the error perception rate nor a systematic pattern of the error perception rate. The increase of the motor experience of 90 executions did not lead to an increase of the error perception rate. According to the subjective rating there is an improvement in the handstand with a roll forward performance. This subjective improvement is comparable to the objective improvement of the performance shown by a study for all investigated conditions where the students had to execute a handstand 90 times (Maleki, Nia, Zarghami, & Neisi, 2010). The finding is supported here by the subjective rating of the own handstand with a roll forward which increased significant from pretest to posttest measure. Thus, it seems that the change in motor experience is not enough to change the error perception but show slightly changes in the monitoring measurement.

Taken together, there was found a general pattern in both consecutive studies. It seems that a change of one feedback factor of the heuristic concept (Jeraj, Hennig, & Heinen, 2015), goes along with a change in the monitoring parameter (mental structure & subjective handstand performance) but did not change the outcome parameter (error perception rate). The explanations of such a pattern are manifold. One meaningful argumentation is related to the underlying process. It is possible that either the error perception rate as an outcome parameter was not appropriate enough or that the process is less top-down orientated as assumed. One can speculate that for a better error perception, and thus the processing of the relevant information, it is needed to change in addition to the top-down oriented process as well the bottom-up oriented process as it is shown by previous published work whereas single visual training did not lead to improvements on outcome performances (Abernethy & Wood, 2001). A further probable explanation is related to the used interventions. The content and the amount of the knowledge intervention was oriented on national coach education regularities (Deutscher Turner Bund, 2011) but it could be that the duration of the intervention was too short resulting in changes of the error perception rate. Considering that such new content was learned probably but the knowledge of this content was never applied before the posttest measurement would explain changes in the mental structure and the absence of the increase of the transferred performance. Regarding the motor execution manipulation, a similar argumentation leads to the point that a simple increase of the motor experience in the investigated study design does not increase the transfer performance. That could be the case because when persons become experts they can use their own motor experience (Pizzera, 2012) but for the here used times of measurements, persons were not yet familiar to use their increased experiences in the applied field, such as detecting errors by other performers. It would be interesting to investigate possible retention test effects of the two studies here to answer this line of thoughts.

Considering the limitations of the two studies, one aspect should be highlighted here. Although a positive aspect of the material is the used error perception test material that was videotaped from a near real training session. Nevertheless the complexity of the material could be too high for a performance measure of the participant's perception because compared to previous studies only static positions were used to investigate the judgment of the material (Dallas, Mavidis, & Chairopoulou, 2011; Plessner & Schallies, 2005).

CONCLUSIONS

Based on the results, one should focus on differentiating whether and when motor experience or transfer of knowledge leads to a higher error perception because this part of the feedback process on the learning of a gymnastics skill is crucial (Jeraj, Hennig, & Heinen, 2015; Marković, Krističević, & Aleksić-Veljković, 2015). It is necessary to detect the mechanism that lead to the usage of increased knowledge or increased motor experience to develop training and education programs. This could be done for example by investigating coach's gaze behavior during movement observation or by a training of a combination of knowledge and observational tasks to find out when the application is at most effective. Additionally, a gaze behavior analysis combined with a think aloud analysis or comparable approaches might have a decisive contribution to understand and control the highly rapid error correction process.

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