Chapter 15
Physical Skills and Digital Gaming: The Relationship between Basketball and an Augmented Reality Adaption

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15.1 Introduction

In the first instance "Gamification" and "Game-based-learning" or "Serious Games" are indicating different things. Gamification "is different to other concepts, such as 'serious games', which is concerned with the incorporation of non-entertainment elements into game-environments (Liu et al., 2011) where a task is incorporated into the game so that the task is accomplished (Oja and Riekki 2012, p. 138)" (Wood & Reiners, 2012, p. 102). In the sense of Gamification game principals and game elements were particularly used for motivational reasons. They should support the engagement within tasks or should support the coping of tasks on a preferably high level of activity while the target group hasn't any or not enough intrinsic motivation to do so. Application designers are taking"the motivational properties of games and layers them on top of other learning activities, integrating the human desire to communicate and share accomplishment with goal-setting to direct the attention of learners and motivate" (Landers & Callan, 2011, p. 421).

Thereby the work on learning objects is just one application option. Other options are focusing on administration- or management challenges, sporty workout or typical tasks within the framework of business like the work on an assembly line, data processing and so on.

But if learning should be conveyed through the use of game elements, beyond motivation psychology (see Hebbel-Seeger, 2012, 2013) it has to by clarified which other factors are effective. Especially questions about transfer and the transfer conditional variables are meaningful if digital applications are used.

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15.2 Transferability between real and digital worlds

> "At first players always learn something about the game they play. Next to explicit and implicit rules, they aquire specific game skills. By playing regularly you just get better (Juul, 2005). But apart from these learning moments, computer and videogames are overstepping the framework of the game itself and can overspill into other areas of life" (Breuer, 2010, p. 13).

A connection in-between digital games and motor-driven abilities is usually explored in scientific studies of neurophysiology. Walter et al. (2001) examined neural activities of probands in a driving-simulator while Whright & jackson (2007) explored the neural activities and the learning success of test persons who needed to react on video projections of tennis rackets.

Rosenberg, Landsittel, and Averch (2005) and Rosser et al. (2007) showed that the use of digital games is connected to efficiency and quality in the context of endoscopic interventions by surgeons. The authors trace back this fact to the additional release of dopamine in the area of the striatum and the frontal cortex during game: both are areas which are connected to eye-hand coordination. By playing games of certain ability Rosser et al. state the possibility that nerve tracts can develop in a way which enhances eye-hand coordination and visual depth imagination to later on improve minimal invasive skills such as described in the example of learning skills by surgeons for surgical interventions.

Influences of digital games on sport motor-driven skills were reviewed for the first time by Fery and Ponserre (2001) using the example of golf. They observed a positive transfer shift from the digital game to the real golf drive movement caused and enhanced by the pre-given visualization in the digital form which prepared the test person by imaging the movement before its execution. This thesis is also represented by Witting (2010) who sums up different studies in following results: "Even if so many schemes of action which are presented in video games, are not consciously practiced by gamers, they can still be observed and absorbed as available action schemes" (Witting, 2010, p. 11).

Cassavaugh and Kramer (2009) prove a connection to the training of a digital driver's simulation and the driving performance of a car in the real world, while Dörrfuß et al. (2008) state a significant influence of training with the game "Wii-Sports Bowling" regarding the performance of novices in the context of real world bowling. The effect of the game is interpreted via the sensomotoric layer caused by the game-interface with focus on the event of full bodily control: "The fact that the Wii allows for the player to use a style of control which enables them to carry out a motion much like in the real bowling game put us in the position to employ it as a means of coordinative training" (Dörrfuß et al., 2008, S. 3).

The Same result is described by Sohnsmeyer (2011) using the example of table tennis. He also choose the game console "Wii" for his studies and observes, " that the engagement with digital table-tennis is leading to better reaction time. This result underscores the assumption of possible potential in digital games on subareas of anticipation skills" (Sohnsmeyer, 2011, p. 218).

Apart from the proof of transferability on the sensomotoric layer, Sohnsmeyer also detects a highly significant cognitive impact in terms of table tennis specific instructional knowledge and takes it as evidence for the plausibility of Fritz's (2011) model of transferability (comp. Sohnsmeyer, 2011, p. 218). This result match to the meta-analysis from Vogel et al. (2006) which reports a general advantage of games and interactive simulations for cognitive gain outcomes.

Also Miller, Tsui, Dearden, Wolthuis, and Stanley (2010) discover references for a transfer from digital gameplay to real world performance by the example of bowling in real world and on the "Wii" console. They not only compare a Wii-treatment-group with a control-group but also look on a real-world-Bowling-treatment-group asking for the role of efficiency and situation-dependency in digital learning. They came to the result, "the Wii group outperformed the regular group in terms of their bowling scores within their own medium, but when tested in regular bowling the Wii group underperformed the group trained in regular bowling" (Miller et al., 2010, S. 3).

Wiemeyer and Schneider (2012) also observe training effects in a study with experienced basketball players in the context of a real pitching training and virtual training with Nintendo's "Wii" console and the game "Sports Resort". In analogy to the results of Miller et al. Wiemeyer and Schneider confirm a specific domain related superiority in performance by the virtual training group vis-à-vis the real training group but the performance evens out in the real training situation: "The results show that there is on the one hand a general effect of virtual and real training on both real and virtual throwing performance. Furthermore, the VT [Virtual Training] group showed specific improvements in the VTT [Virtual Throwing Test], whereas the RT [Real Training] just caught up with the VT in the RTT [Real Throwing Test]" (Wiemeyer & Schneider, 2012, p. 68).

The authors, however, point out the fact caused by the lack of a control group that cannot be excluded and the observed effect is simply based on the repetition of the test and does not result from treatment. On the other hand, the results can be interpreted in such a way that the specific pre-experiences of all probands—all experienced basketball players—show that digital adaption is more effective in comparison to a short-term treatment of 5 weeks with 10 training units.

Apart from the perspective on transferability of digital games to real world perception and coordination skills, a lot of studies are exploring the sanitary constitution and influences on players. Gamberini, Barresi, Majer, and Scarpetta (2008) results on the base of a meta-analysis of relevant studies that there are two general effects in the context of "Healthcare" and digital games: "First they are entertaining. In contexts where health rehabilitation or health support processes can be painful or boring, computer games act as motivators. Secondly, computer games provide alternative worlds, which can be shaped on the target's needs, facilitating the development of adequate behaviors transferable in to the real world" (Gamberini et al., 2008, S. 139).

Wiemeyer (2010) notices in a meta-analysis: "Also the therapy of cancer, diabetes, asthma, burn-ups, cerebral injuries profit from Serious Games" (Wiemeyer, 2010, p. 252), even if he expresses his concerns that "the given studies rarely meet scientific quality criteria. Besides a lot of questions are open: Dose-Reaction-Relation, sustainability and useful setting" (ibid).

15.3 Transfer effects, transfer layers and forms of transfer

While most part of empirical studies in context of digital games explore the interdependency of virtual application to the real world, Araújo, Davids, and Serpa (2005) invert this perspective. The authors investigate in their study the relation between proficiency level of sailors and their decision making in a computer simulated sailing regatta. They observe a connection between the sailing skills and the proficiency level of the probands and the performance in the computer based sailing regatta, i.e. the ranking and time needed. Experienced sailors, so the result, use the given information about wind and competitors more successfully than unexperienced probands.

In reverse the authors assume that the future use of computer simulations in the field of professional sailing can bring a lot of advantages. An exemplary application is named by Araújo et al. in the field of talent recruitment and promotion because in the course of the investigation the novices who started to concentrate earlier on relevant sources of information where those who at the end became more successful than those who didn't.

According to the authors perspective, computer simulations can in addition be used to provide training in a safe environment and to avoid possible problems and restrictions of a natural environment while exploring the dynamics of decision processes. Furthermore, they assume an effect in specific and situated training situations and, by manipulating a training situation, an effect of setting the learners focus on the important source of information.

My own studies of sailing and the influence of cognitive exercise and practical decision taking (comp. Hebbel-Seeger, 2008) back up this supposition: It has been shown that the confrontation with a sailing simulation where the theoretical methods and approaches have been adapted to practical education for novices (comp. Hebbel-Seeger, 2006) have led to more successful performance in real-world sailing experience.

On the one hand those results correspond with Wiemeyer (2009) assumption "… that effects of transfer in sports primarily are to be expected on two layers:

- Sensomotoric or rather the perceptive layer (elementary performance)
- Cognitive layer (knowledge, decision and strategy)" (Wiemeyer, 2009, S. 123).

The basic action in the sensomotoric performance of sailing a boot can be considered to be elementary even though a coordination of elementary partial movement requires a) the positioning of body weight by sitting on the edge of the boat, b) the necessary impact on the tiller for guidance and direction and 3) influencing the position of the canvas so as to tighten and/or loosen the sheet. The simulation mediates the knowledge as to how those partial movements are to be harmonized such as orientation to the wind in a complex human-boat-environment relationship, applied to a strategic layer.

On the other hand, the results of the sailing study also can be interpreted in the way of Fritz's (1997) postulated transferability model making a differentiation of five transfer layers and ten possible forms of transfer. According to this, a transfer can basically take part on every five layers:

- Aspects of the real world are represented in the sailing simulation on the "fact-layer", where users can exemplary derives information about the setup of a sailing dinghy, given elements of navigation and right of way on the water.
- On the "script-layer" the user gains specific practical sailing knowledge with complex attributes which e.g., describes the interplay of the three basic steering elements on a sailing boat—comparably influencing driving, velocity and the upright of the boat and the direct and indirect piloting of a target.
- The difference of the "print-layer" compared to the "script-layer" is defined by "a restricted action depth and a short contextual anchoring" (Fritz, 1997, p. 234). It is about simple action patterns which support holding the upright position of the boat or performing basic maneuvers like turns and jibes (turning the boats across and with the wind).
- "While transfers on the script-layer are relatively based on precise schemes of actions, the metaphoric transfer is allocated on a more abstract layer. Scripts connected to direct experience were not directly transferred from the real world. They were used in a way of "as if" by a structural compliance.
- On the "dynamic-layer" the "direct impulse of action" is traced back to its "core": based on a basic orientation of action with validation in the real world just as much as in the virtual world because the basic patterns in its function, forms of action according human basic needs are autonomy, relatedness and competence" (Fritz, 1997, p. 237). In sports like sailing, where complex and situational variables are especially at the beginning constantly contributing to excessive demands to the learning process, a "safe" environment/space in a digital adaption can have a positive effect on the feeling of gained competences and autonomy in practical doing.

In regard of possible forms of transfer in the meaning of Fritz's (1997) model, the sailing simulation at first is laid out on "problem solving transfer" where the basic functions and interdependencies of the three elements of control (steering elements) in sailing sport—tiller, sheet and bodyweight—are not given but tasks to be worked out. Problems in the virtual world and corresponding developed solving pattern like piloting towards an aim in direction of the wind could be transferred to the practical sailing performance as mentioned in the study above.

An "Emotional transfer" might emerge if joy over the task in the virtual world is transferred to practical sailing. There are no valid results concerning this study at the moment. An "instrumental action orientated transfer" exists in the transfer of (symbolic) procedures from the virtual world to motoric movement in the practical sailing experience, e.g. in context of basic sailing maneuvers and "if—then" references.

While an "ethic-moral transfer"in general shouldn't be part of sport simulations, unless topics like fairness or tolerance in sport are affected by rules, an "associative transfer" happens when "perception in the virtual world converges with the perception of the real world" (Fritz, 1997, p. 238).

In this particular sailing simulation a "reality structured transfer" is targeted by transferring functional coherence like the use of specific control elements and the behavior of the boat explored in the virtual world and adapted to the practical sailing practice. The successful acting of the probands who experienced the treatment by the sailing simulation compared to the control group, is to be stated as proof. The same thing counts for the "informational transfer", e.g. by transferring knowledge, the naming and functions of equipment in the virtual world of the sailing simulation to the real world experience.

After all, the problem solving and "informational transfer" represent cognitive transfer performances. Nevertheless Fritz (1997, p. 238) introduces an additional layer to all the mentioned forms of transfer with the "cognitive transfer" which mainly addresses the aspects of memory and sustainability.

With "time-transfer" Fritz describes the shift of time-experiences e.g. based on a time pressure based urge to act from a virtual world to a real setting using the example of sailing sport which probably causes a relief in the practical experience if expected handicaps are already known.

The tenth and last form of transfer which is named by Fritz (1997) describes the "fantasy-related transfer". "Impressions in the game (elements, storyline, roles, actions and processes) are post-imagined in the own world of minds" (Fritz, 1997, p. 238). In the significance of a "Serious Game", the creative preoccupation with the learning asset, in particular if the imagination provides more "freedom", can be understood as a contribution to a wider perspective and can create new solutions, providing meaning to the real world.

Processes of transfer are not self-dynamic. "It's important for a player on the one hand to show willingness for transfer and on the other hand to accept it." (Sohnsmeyer, 2011, p. 61). "The Key driver" for successful transfer is based on the attention of a player in facing the event in a virtual world (Fritz, 1997): "The virtual world should catch my attention and trigger the impulse to "step inside"… The more this world captures my attention, the more this world catches my attention, … so much better is my readiness for a transfer (Fritz, 1997, p. 241f.).

The stimulative nature, casted by a virtual world, is determined by the own personal character whose individual and motivational disposition is addressed (comp. e.g. Hebbel-Seeger, 2012). Sohnsmeyer concretizes this example based on the genre of a digital game by stating it a prior-ranking role for the willingness of transfer (comp. Sohnsmeyer, 2011, p. 61). On the other hand the realization of a game, the realistic representation, the game mechanics (comp. Jantke, 2007) and the user-interface (comp. Limperos, Schmierbach, Kegerise, & Dardis, 2011) are crucial for providing the incentives for transferability and acceptance.

15.4 Theories of schemes as explanatory models for (sport motoric) transfers

> Cognitive schemes provide a basic aspect to the model of transferability. Schemes organize our sensual impressions, experiences and adventures so they can contribute to stable schemes of perception and action, based on reasonable experiences. Schemes therefore are cognitive structures summing up typical coherences in an area (Sohnsmeyer, 2011, p. 49).

In sport science the works of Schmidt (comp. Schmidt, 1975, 1994) were -in general - still on the leading edge. He solved the problems of capacity and variability with the model of generalized motor programs, that actions can't be analogically memorized (1:1) because of the amount of information, and observed variances during the act of performing stable movement skills which do not question the control of movement of a mental representation. In line with his scheme-oriented modeling Schmidt assumes processes of abstraction in which the identification of rule observance is based on and summed up in similar movement categories: "A Scheme is the characteristic of a population of objects which consists of a set of rules, which are applied as briefing for serving the creation of a prototype for this population." (Schmidt, 1994, p. 24).

A motoric memory stores what is needed to be done to achieve desired results under special preconditions. Here, the motoric memory is divided according to Schmidt (1994) into two units: The "Recognition scheme" contains the program (such as running, throwing, etc.) with the selection and combiantion of involved muscle bundles while the "Recall scheme" incorporates its parameters (which provides the necessary force). "Schmidt takes over these two states of memory from the psychology of memory by making a distinction between the active recall (recall) and the passive recognition (recognition)" (Künzell, 2002, p. 21.f).

Motorized sport skills require corresponding learning processes in which a human comes into contact with the environment and gets information from which he generates the necessary skills, knowledge of movement and the ability to perform. The knowledge about the "performance of movement … is only one aspect of the movement knowledge. Knowledge about the task, the setting, context and individual requirements represents other elements of the movement knowledge" (Munzert, 1992, p. 352). Only in this specification, which overcomes the postulated separation between perception and action, a connection capability regarding to the assumption of schemes in sports and a transfer-related modification of the same through a cognitive occupation within virtual realities, is possible, because "the cognition of certain environmental events and upcoming wishes and plans … 'automatically' [evoke] suggestions and plans, how a realization can be achieved "(Roth, 2001, p. 412.) this means there isn't a fully disconnected scheme for cognition and action, but in principle a continuity and compatibility in between both areas" (Fritz, 2011, p. 99).

Following the understanding of the term of information as Leist (1993) suggests in the context of movement and sports, information isn't only formed of small knowledge particles which "only" need to be absorbed by different channels of cognition. "Information" is much better described as "what a competent receiver" can understand from a message; or: … what can be understood and itself again can generate information" (Leist, 1993, p. 135). Hereby another analogy in the field of educational sciences can be drafted postulating Piaget's perspective: "While thinking is adapting to the given things, it is structuring itself and while doing so, it also organizes and structures the things" (Piaget, 1976, p.18).

According to Fritz (2011) this process needs an effort of abstraction beforehand: 'The specific situation with its abundance of details and peculiarities has to be tranformed to its patterns and structures which can be "weaved" in the neural net of the human brain. In other words: the stimulus effect will only be added, as he adjusts to what is already configured as a structure in the brain' (Fritz, 2011, p. 94).

Piaget hereby says that the shaping and adaption of action driven structures (schemes) is irrelevant whether based on physical or mental construction: "Any typed behavior—regardless of external action or internalized action—means and depicts for us an adaption or re-adaption" (Piaget, 1976, p. 6). Based on this, the modification of real world relevant schemes of cognition and schemes of action in context of virtual realities and the transferability between different worlds appears to be plausible.

15.5 Transfer and transformation

In this contribution Fritz's model of transfer (1997, 2011) in general represents more the heuristic model but a universally valid theory of transfer (comp. also Sohnsmeyer, 2011, p. 60). Hence, this approach seems to be suitable in describing and explaining the "diversity and complexity of the phenomenon "transfer" in conjunction to virtual gaming worlds" (Witting, 2010, p. 56) and as a sample for interpretation of interdependencies between reality and virtual worlds.

The starting point of a possible transfer according to Fritz (1997, 2011) is his expectation of different living environments in which humans act; next to the real world there exists the "dream world", the "gaming or playing world", the "mental world" the "media world" and the "virtual world" whereas over layering e.g. between "gaming world" and the "virtual world" is possible. Experiences and knowledge or therefrom abstracted schemes can also be transferred within and between the worlds. In context of motion and sport "Transference… can be described as positive interrelation between acquired action patterns and the application of those patterns in new contexts of motions and situations" (Hebbel-Seeger, Lietdke, & Lüssow, 2003, S.8).

Fritz speaks of "intramondial transfer" if a scheme transfer happens within a living environment:

> "If a human learned to develop schemes in the real world for specific situations which are helpful for acting, those schemes are amplified when similar situations appear more often. If a human is more often exposed to similar impulses, then he develops the tendency to act according the perceived scheme" (Fritz, 2011, p. 93).

Fritz describes the use of schemes beyond the limitation of singular living environments as "intermondial Transfer": 'Schemes which own validity and meaning for a specific world (e.g. the real world), [are] applied to another world (e.g. the virtual world)" (ibid). Such a transfer in general doesn't "only" happen from one to another instance but also owns the characteristics of interdependency. In particular users of digital games in the context of sport already own domain specific knowledge (e.g. rules) and context relevant schemes of cognition (e.g. interpretation of tactics) which can be used for virtual gameplay. At same time, the experiences in the virtual world are shaping modifications of previous imported schemes, which are modified and retroact into the real context: „The player of a videogame already owns a specific stock of knowledge from the common sense world before he enters a virtual world and which can be helpful during the videogame. During his stay in the virtual world, he will be enriched with canned knowledge (the player gets knowledge from the virtual world, e.g. strategy of acting, factual knowledge, use of input devices etc.). Occurences of transfer happens' (Wesener, 2006, p. 3f.).

Since the fundamental context of the intra- and the intermondial transfer differ from the setting the kind of circumstances a scheme originally has been acquired, the transferred entity needs to be modified to gain meaning in the other world when applied to a new (transfer) situation" (Kempter, 2009, p. 16); "For transferring, transformation is needed—especially in schemes of specific cases with characteristics, which are able to provide abstract structures to offer space for similarities. Only by such transformation a transfer between the worlds is possible because impulses from the one world to the other world are charged with meaning" (Fritz, 2011, p. 94).

Witting (2010) explores transferability of digital games via a questionnaire of the target group. She notices a huge intermondial potential of transferability caused by the high degree of interaction, while the players themselves are mostly aware of an intramondial transfer. "Upfront players reported about the transfer within the virtual gaming world between games of similar types: Virtual gaming worlds require a genre specific pattern of acting so one can successful act in the game" (Witting, 2010, p. 10). "The players express that they are developing specific cognitive schemes for a specific type of genre, helping them to set focus on the elementary aspects and the course of the game" (Witting, 2010, p. 13).

According to Fritz (2011) the depth of transfer for intramondial transfer is not as large in comparison to a transfer from one living environment to the other because the contextual similarities are larger. Accordingly the "adjustment of the transfer content to the equivalent shape of reality …, to harness knowledge and thus actions" (Wesener, 2006, p. 4) in the transfer process can turn out less. To this Witting's finding matches that player mainly verbalize the "more simple" intramondial transfer. A structural adaption "via transformation in the process of transfer happens as long as it evens out on a similar level" (specific level) fitting specific schemes (Fritz, 2011, p. 94). Fritz draws the conclusion that an "intermondial transfer in general only can succeed on a general abstract degree" (ibid). At the same time Fritz doesn't exclude a transfer on a higher level and sums up further transvariables with an open mindset: "Which transfers in which form can be realized in the process of the game is dependent on the game (and its scheme offer) and on the player, his structure, motivations, the rang and the differentiation of his schemes" (Fritz, 2010, p. 101).

Variables of a transfer in a virtual world can be seen as "moments of alikeness between virtual and real world" (Witting, 2010, p. 14). Those moments of similarity don't urgently need to emerge from a realistic visualization; nevertheless such visualization is potentially very helpful for guidance and orientation.

In fact those moments of alikeness can be created by specific interface designs e.g. improved motion controls in sport games (like game consoles Wii©, XboxKinect© or PS3 Move©), the adaption of real world control devices in the shape of steering wheels, joysticks, foot pedals for driving and flight simulations in analogy to the real world and like metaphors of space to "identify" and "assign" the choices of "acting "and "orientation" (comp. Hebbel-Seeger, 2011, p. 333). Nacke and Lindsey (2009) did an electroencephalographic measurement with gamers using a movement sensitive interface. They show that such an interface aided the feeling of action.

The embedment of virtual gaming elements in a real world setting as augmented reality application becomes relevant when both realities merge to new hybrid world. Moments of alikeness from a real world used in a virtual setting create a cognitive relief for the user because they create continuity and transport the internalized function of real world based objects enabling the player to get much better "immersed" into the setting in combination with interaction creating a sense of telepresence (comp. Slater & Wilbur, 1997; Pietschmann, 2009, p. 68ff.). "Telepresence therefore is described as profoundly positive feeling of immersion with a medium" (Huber, Hamprecht, & Heise, 2012, p. 43): "The player … gets into what is for him a very pleasant state quite quickly. He merges with the game and is completely absorbed by it" (Fritz & Fehr, 1997, p. 37).

> "That experience was "flow", first identified by Mihaly Csikszentmihalyi in die 1970s. Flow theory describes a very focused, energized, an effective mental state that takes place when a person is fully involved in an activity" (Edery & Mollick, 2008, p. 158).

Even if time, space and the moments of alikeness step into background during the state of "flow" the users are usually able to make the difference between the worlds they are located in and their matching action patterns. This ability of differentiation is called "framing competency" (comp. Fritz, 1997, 2004, 2011; Schmitt, 2011, p. 33). Gamers describe in interviews that framing competency potentially owns a repressive impact (comp. Witting, 2010, p. 16). Nevertheless Witting comes to the result that "the framing competency listed by users … doesn't basically prevent transfers but … [empowers] the player to create awareness for the clear distinction of the different worlds" (Witting, 2010, p. 16).

This assessment is congruent with Fritz's assumptions who assigns users of virtual worlds a "stable framing competency". "This doesn't exclude that transfers (more or less conscious) do happen" (Fritz, 2011, p. 158). "The detailed sequence of a transfer process and in particular the factors which suspend the controlling of transfer and the framing competency are yet not clarified" (Schenk, 2007, p. 237).

15.6 Intermondial transfer by the example of basketball

The question of intermondial transfer in the context of motion and sport is explored in a study using the example of basketball. The question which accompanied our experiment was to find out and prove the interdependencies between a specific performance in basketball, operationalized via the success of "penalty shots" and the performance in a digital adaption.

The digital adaption is designed as an augmented reality application ("AR Basktball" by Simiotica"[1] vers. 1.2.0) for iOS mobile devices.

[1] http://itunes.apple.com/de/app/arbasketball/id393333529?mt=8.

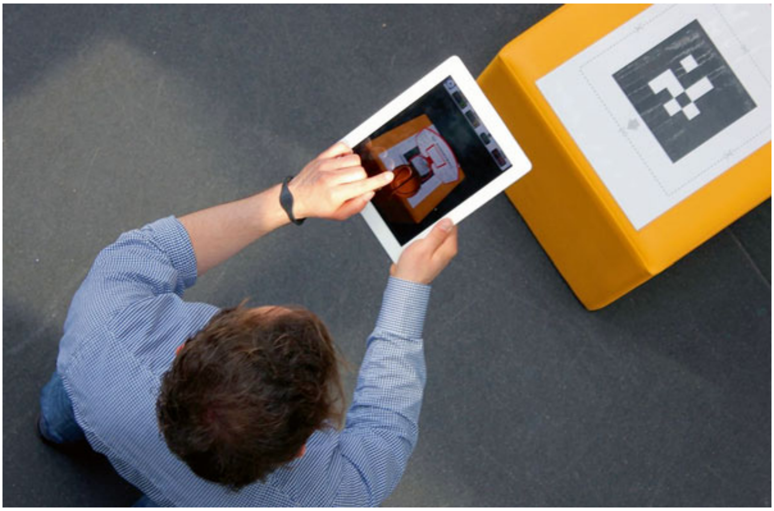

Fig. 15.1 "AR Basketball"—2D-marker and visualized basket on iPad

A basketball basket is displayed on the screen of the device by interpreting the external 2D-markers via integrated camera (see Fig. 15.1). The digital game adopts the game principle of the real world (aiming and shooting) and visualizes it adequately (especially colors and textures of the basketball and the appearance of the basket).

The motion of shooting is performed by a wiping gesture with the finger and serves only as symbolic reference to motion of the real world. The AR adaption of the basketball game provides a dynamic augmented virtual setting where the variables of distance, angle and velocity is always different according to the location of the player, determined by the 2D-marker. Those interdependencies are calculated into a physics-model which provides the simulation of a reality-close flying behavior of the basketball. The physics-model also calculates the proportions and rendering of the basketball and basket.

The aim of the study is the exploration of intermondial transferability of (throwing)schemes from the real to the virtual world. With the specific interface design, a user experience by the probands of nearly zero in combination with a relatively new technology device (iPad) and the AR adaption as new form of virtualization, the application "AR Basketball" were very well suited to this experiment. A possible intramondial transfer, means transfer of genre specific cognitive schemes (comp. Witting, 2010), therefore could be excluded from the study as far as possible.

In combination with real and virtual elements, interaction in real time and the registration of action in three-dimensional space, the application fulfills the three main criteria for augmented reality (comp. Azuma, 1997; Azuma et al., 2001). Within this augmented reality the game "AR Basketball" offers three different modes of game: "Training", "Classic" and "Action".

In the “Training Modus” the system counts all successful strikes in a period of 5 min. Distance and position to the marker is freely selectable. A display informs about the current score, a previously made high score and the running countdown. The training modus starts with the first throw of a basketball. The counting of score is only interrupted if the signal of the 2D marker is lost during the gameplay and it immediately restarts once the recognition of the marker is back again.

Compared to the “Training Modus” different throwing positions are predetermined in the „Classic Modus”. In addition the playground is divided into six zones corresponding to the position of the device and the 2D marker. A map at the bottom of the screen provides information about the current position and gives visual feedback when the correct location is reached. The task in classic modus is to perform three successful shots from each of the six zones. A time limit is not given but points are subtracted when performing a mission shot.

Also in the “Action Modus” different throwing position are predetermined. While the focus is set to pressure accuracy in “Classic Modus” (comp. Roth, 1993, p. 88) the performance in the “Action Modus” is defined by time pressure: The player can throw as many basketballs as possible within a timeframe of 20 s. The aim in “Action Mode” is to reach the highest score in summation of all hits in the six zones.

The Object of the study is the exploration of transferability of sport- and motion based skills and its digital adaption. We decided to use a complex full body gesture as the object of exploration which is tagged by a highly situational constancy; the penalty shot in basketball. The distance to the basket, the size (radius), the height of the basket,[2] as well as color, texture and size of the basketball[3] is predetermined (comp. FIBA 2012).

Oriented to the conjunction and situational conditions of a real world penalty shot, we decided to use the “Training Mode” in the digital adaption of the game “AR Basketball” and modified the time variable by the amount of ten (10) possible attempts for shots. The horizontal distance from proband to marker was 90 cm and the height over the ground level was 105 cm (in analogy to the predefined parameters of penalty shots in the real world but with other dimensions). The named specifications represent and guarantee a stable and functional setting for marker recognition and interpretation and to ensure the most a flat angle to the basketball basket.

The application offers two modes of “throwing motions”: Either the wipe mode, where motion of the finger determines velocity, direction and distance of the shot affecting the impulse and angle of the basketball. The second option was the use of

[2] The horizontal distance from the penalty line to the center of the basket measures 4,225 m. The basket itself is a diameter of 45 cm and is mounted to a height of 3,05 m over ground level.

[3] The texture of the basketball is divided into 8 panels giving the ball its characteristics layout. While the International Basketball Association (FIBA) doesn’t demand a standard for the color, the worldwide largest association, the National Basketball Association (NBA), predetermines the “typical” color of the ball in orange with black lines. Women are playing according the guidelines of the international regulations with basketballs of the size 6 with a range of 724-737 mm and a weight of 510–567 g while men play with a basketball in size of 7, a range of 749–780 mm and a weight of 567–650 g.

a slider on the right side of the screen, also controlled by using a finger to define the impulse of the basketball. If the slider is used, then the device is used to set the direction of the flying line corresponding to the localization of the marker. By choosing the wipe mode more variance is possible (e.g. influence on the direction the basketball should fly to). Another reason for choosing the wipe mode was to avoid the memorization of a certain state of the slider and an expected transformation of the throwing scheme by the probands. This is why we decided performing for this study should happen via the wipe mode.

Despite the very mere symbolic adaption of the real-world-alike throwing motion we anticipated an instrumental-action oriented transfer in the context of the challenge to be solved (Fritz, 2011, p. 130) by expecting the probands to be able to transfer the moments of similarity of virtual and real world schemes, here the flying behavior of the basketball; but also habituated experiences made with (basket) balls made in a virtual or real world context. The specific realization of the augmented reality application also pays into this thesis because it allows the convergence and softening of both worlds which for us is seen as key-element for making processes of transfer possible: "Events of similarity are described as transfer beneficial, which appear to be obvious and traceable as intersubjective. Those usually stay in context of simulation games or refer to aspects of virtual worlds which are strongly oriented to the real world" (Witting, 2010, p.16).

The characteristic of a flying ball in the penalty shot of basketball is the motion of a parabola (comp. Wick, 2005, p. 36) where the ball hits the target in a sinking and forward going movement. The parabola is deviated from the position of the player and the location of the target which is allocated in a horizontal line and a in a higher position as the player. The variables determining the flying line are the height, angle and velocity by the moment of dropping (ibid). In best case, the player is able to hit the target without touching the ring of the basketball basket.

By the size of ring and ball and in perspective of bio-mechanics calculations, the ball needs to enter an angle of at least 31° to hit the target without touching an border of the basket (comp. Zumerchi, 1997, p. 70). The larger the entrance angle is, the higher the effect on fault tolerance can be expected regarding the deviance of the ball reaching the center of the basket. Deductive reason therefore is: to reach the closeness to an entrance angle of 90°, which physically never can be achieved in this experiment.

Between the real world "original" and the digital adaption of the game "AR Basketball" exists one substantial difference. While in the real world, the dropping point of the ball is located beneath the target, the dropping point in the augmented reality application is located above the target. This depicted dropping-height basically doesn't have an impact on the flying line which in both cases is a parabola caused by a lopsided throw. However, an influence on the perception of a situation similarity, and therefore on a central variable for the occurrence of a transfer process, cannot be excluded. The visualization of the cue ball, the game objective and the game task (goal throw) are establishing a relationship to the real world. However, a significant difference between the real world and the virtual world result from the perspective, the view to respectively down to the basket: In the real world, the player looks up to the basket from beneath. In the digital adaptation in the game "AR Basketball" the player looks from above to the basket.

According to Fritz's model of transfer (2011), a throwing scheme from the real world to the virtual world like this should be able to integrate such change of parameters when identified by the probands as situationally "appropriate". Under biomechanical consideration of the different initial positions of a penalty shot in the real world and the augmented reality adaption in the game "AR Basketball" it can be shown that the dropping point of the ball above the target is easier in comparison to the dropping point of the real world setting which potentially offers the possibility of reaching a higher mathematical entrance angle of 90° which as mentioned before increases the fault tolerance of deviating the ball from the center of the basket and therefore for a successful hit on target.

15.6.1 Experimental Setup

At the beginning of the study, the probands were briefed about the task: they should try out to reach the highest score within a certain amount of penalty shots in the real world as well as in the digital adaption. The probands got 1 min to get familiar with the use of the "AR Basketball" application without recording the score. After a short break of one more minute, the probands were asked to perform ten (10) penalty shots in rotation into the real world basketball basket and the digital adaption on the iPad. All in all, the ball had been thrown in 3 rounds with 10 attempts in the digital adaption and 2 rounds with 10 attempts under "real" penalty shot conditions (comp. Table 15.1). No countdown had been set. Nevertheless the time had been recorded next to the amount of hits.

The basis of this methodical setting is the assumption that probands show awareness for transferability in moments of alikeness between the real and digital world. Apart from the adaptions of real world basketball game which we have already described in the digital application "AR Basketball" such as the principles of aiming and taking over external design elements like color of the ball, the shape and positioning of the target

Table 15.1 Experimental phases

Sequence	Phase	Content/task
1	Briefing	Explanation of examination procedure and task
2	Familiarization	Try out the application "AR Basketball" on the iPad for the duration of 1 min without results recording
3	AR Basketball 1	Ten "throws" within the application "AR Basketball" on the iPad without time limit
4	Real Basketball 1	Ten "real" Penalty shots without time limit
5	AR Basketball 2	Ten "throws" within the application "AR Basketball" on the iPad without time limit
6	Real Basketball 2	Ten "real" Penalty shots without time limit
7	AR Basketball 3	Ten "throws" within the application "AR Basketball" on the iPad without time limit

(basketball basket). It is also the setting of the game in a real sports hall which generates a moment of similarity and in which the experiment takes place.

Besides the multiple changes between the performance in the real and virtual world and the record of success, we also wanted to rate the stability of the throwing action; intramondial via several attempts in the same (real) world as well as intermondial a) in context of sensitivity to the real performance for interferences via virtualized action with comparable throw scheme but other parameters and b) in context of possible customization (learning effect) in the virtual world along several attempts in the real world and the transferred throwing scheme.

The aim of our study is the exploration of transferability of schemes from the real world into a virtual world. The forming of schemes is based on many extensive situational and task specific experiences, so the "strength of a scheme [is described] as a positive function of the amount of experience within the same category of motion" (comp. Wulf, 1994, p. 23). Accordingly we operationalized the probands due general qualification in terms of the question and the period of activities in basketball.

In this way, we were able to recruit 52 probands of both genders (f = 14; m = 38) aged between 15 and 34 years who at the time of the exploration were all active players in clubs with a playing experience of at least 3 years with a minimum of 2 training units a week. All through we didn't make any differentiation in terms of how intensive they played (popular and professional sports) nor an affiliation to any league or class. Rather, we saw the action guidance in the success rate, result consistency of the performance (basketball penalty shot) in phase 4 and 6, the stability and the task specific characteristic as relevant to deduce from (throw-) schemes in the real world.

For settling we conducted a hit ratio for both penalty shots with a hit ration of at least 50 % (aspect of success) in the real world and a deviation in the amount of max. 1 hit (aspect of stability). The group of probands who were successful and identified with a stable throwing scheme were compared in the analysis with the group of probands, who in the real world performed less in accuracy and stability (less than 50 % hit ratio in one or both attempts).

15.6.2 Results

In view of the penalty shot success ratio in the real world 32 of 52 probands (62 %) were able to reach five or more hits. 25 of the 32 probands showed a deviation in the amount of hits by ≤1, which corresponded to percentage of 48 % of all probands.

This result is congruent to our expectations that experienced basketball players showed in context of our study and the identified factors of range, length, actuality of sport specific experiences an quasi automated performance of motion (comp. Hebbel-Seeger & Lippens, 1995) which resulted in a comparatively large hit ratio and performance constancy. This is compliant to current results in sciences of motor-activity (comp. e.g. Wiemeyer, 2005).

Table 15.2 Proband classification into groups based on the free-throw performance in the real world

Group	Description	Amount probands	Average amount of successful hit per round	Percentage to the main unit (%)
1	At least 5 successful hits in both rounds	32	6,97	62
1b	At least 5 successful hits in both rounds by a deviation in amount of hits ≤1	25	6,92	48
2	At least once 5 or more successful hits in both rounds	11	4,73	21
3	In both rounds less than 5 successful hits	9	2,94	17

Only 9 of 52 probands (17 %) were not able to perform in both rounds with five or more hits. The average hit ratio of those 9 probands was at 2,94, hits per rounds compared to 4,64 successful hits of the probands (n = 11), who at least could make in one of two rounds in the real world a score of four or more.

The success ratio of the probands who performed in both rounds in each case five or more successful hits (n = 32) was comparatively at 6,97. No important differences could be made to the part group (n = 25), which not only performed five or even more hits but also showed a high result consistency in terms of the amount of hits (difference ≤1 compared to both rounds) (comp. Table 15.2).

As a start we interpret this result as proof for the heuristic scheme theory assumptions for action guidance where successful schemes of motion in a high performance (in sports) are depicted as in a high result constancy (comp. e.g. Reiser, Müller, & Daugs, 1997): The performance constancy of the probands during the penalty shots in the real world (above a certain performance range) correlates with the performance level.

If an intermondial transfer between real and virtual worlds is successful, this means that the probands are able to transform their (throwing) scheme from the real to the virtual world, thus the probands who are also more successful should be better compared to the other ones. In a first observation we noticed that hardly one proband was able to act as successfully in the virtual world as he was in the real world. Only 5 of 52 probands (10 %) were able to reach a slight higher hit ratio in the virtual world on the iPad (average, 0,2, 0,3, 0,8, 1,7 and 2,3 more successful hits per round) compared to the penalty shots on the “real” basket.

Those were probands whose performance under “real” conditions was settled at the lower range with correspondingly low hit ratios (3 probands from group 3, 2 probands from group 2). All other probands were not able to reach a similar performance from the real setting to the virtual world: The differences in the performance between the hit ratio in the real world and the virtual world in group 1, including the part group 1b, and group 2 is significant; not tough in group 3 (we used the Q-Q test for group 1 and the part group 1b but the non-parametric Wilcoxon Signed Ranks

Table 15.3 Explorative observation of penalty shooting performance in the real world by groups

Group sorting by penalty shooting performance	Amount of probands	Average hit ratio per round	Group internal variance of absolute hits over all three rounds	Average execution time per round (s)	Group internal variance of absolute execution time over all three rounds (s)
1	32	6,97	10–18	78,23	50–140
1b	25	6,92	10–19	77,36	50–110
2	11	4,73	7–12	77,18	53–122
3	9	2,94	3–8	74,72	45–116

Table 15.4 Explorative observation of penalty shooting performance on iPad by groups

Group sorting by penalty shooting performance	Amount of probands	Average hit ratio per round	Group internal variance of absolute hits over all three rounds	Average execution time per round (s)	Group internal variance of absolute execution time over all three rounds (s)
1	32	2,09	1–16	34,39	81–170
1b	25	2,12	1–16	34,32	81–170
2	11	2,12	0–20	34,27	72–130
3	9	2,19	0–13	34,81	73–128

Test for groups 2 and 3, because the data wasn't distributed normally and the sample size was rather small[4]).

Accordingly, nothing points to a positive transfer. On the contrary, at first it seemed to result in a negative transfer (interference) by scheme transfer of external similarities which doesn't adapt to the virtual world and therefore doesn't show such a good performances (comp. Hebbel-Seeger et al., 2003).

An explorative data analysis can't back up this thesis. In fact the differences of the penalty shooting observed in the real world and on the iPad between the groups even out the hit ratio and the time needed for the attempts (comp. Tables 15.3 and 15.4.). While the differences concerning the hit ratio of the penalty shots are significant in the real world between groups 1 and 2 and 1 and 3 and also between the groups 2 and 3, no differences can be observed in the virtual world

[4] Group 1: The p-value associated with this test is 0.00 and since this is smaller than alpha (0,05.), we can confidently reject the null hypothesis (there is no difference between the means) and say that there is a significant difference between the average number of baskets made in the real world and the virtual world (.635).

Group 1b: There is also a significant difference in the mean number of real world and virtual world baskets made. The associated p-value for this test is 0.00 which is less than alpha, therefore the null hypothesis can be rejected with confidence (.761).

Group 2: We still got a low p-value (.010), which makes us confident that the means are in fact different.Group 3: We got a p-value of 0.235, which is larger than alpha. Therefore we can not reject the null hypothesis: There is not enough evidence to support the claim that the means are different.

Table 15.5 Explorative observation of execution times per round in the virtual and real world by groups

Group sorting by penalty shooting performance	Amount of probands	Average execution time iPad 1 (s)	Average execution time iPad 2 (s)	Average execution time iPad 3 (s)	Average execution time "Real 1" (s)	Average execution time "Real 2"(s)
1	32	34,56	34,78	33,18	81,44	75,03
1b	25	34,12	34,96	33,88	79.8	74,92
2	11	37,73	32,64	32,45	83,82	70,55
3	9	35,89	35,22	33,33	81,33	68,11

Table 15.6 Explorative observation hit ratio per round in the virtual and the real world by groups

Group sorting by penalty shooting performance	Amount of probands	Average hit ratio iPad 1	Average hit ratio iPad 2	Average hit ratio iPad 3	Average hit ratio "Real" 1	Average hit ratio "Real" 2
1	32	1,56	2,16	2,52	7	6,94
1b	25	1,64	2,2	2,52	6,92	6,92
2	11	1,64	2,72	2,45	4,64	4,82
3	9	2,33	1,78	2,44	2,67	3,22

(we used the non-parametric Mann–Whitney Test[5]). Same is true for the execution time which has been observed in between the groups 1 and 3 and shows a difference (but below a statistic significance) which is missing in the virtual world.

Focussing on the change of the execution times and hit ratios between the singular rounds, the probands showed following comparable development: The execution time shortened across all groups from the first to the second penalty round in the real world without showing a connection to the average reached hit ratio. In contrast, the execution time on the iPad showed only small variances (even if across all groups a shortened execution time is visible), while the performance in group 1 und 2 was increasing on low level. No improvement could be seen in group 3 (comp. Tables 15.5 and 15.6).

The observation of the development or rather change of the hit ratio on the iPad along the three rounds indicates group specific characteristics which can be interpreted as the processes of transfer: While the probands of the 3rd group, in face of the low performance in the real world, no elaborated (throwing) scheme is assumed, no improvements within the three rounds is shown in context of the hit ratio—in all other groups (1 and 2) an improvement of successful attempts is recorded. According to Fritz's model of transfers, we can read this as a sign for processes of transfer and an improved adaption of the acquired (throwing) scheme from the real world to the new context of the virtual world.

[5] The p-values are in all cases 0.00, which means there is a significant difference (reject the null hypothesis: there is no difference between the means) in the performance between the groups.

The situation is different in terms of “body height”. In paragraph 5 the dropping height of the basketball on the iPad is listed as abstractional simplification. This simplification didn’t result at all in better scores during the experiment. In a more differentiated view we can notice that probands with a height of ≥185 cm (n = 25) performed across all three rounds on the iPad with higher hit ratios compared to probands with a height of <185 cm (n = 27). The differences increase in all three rounds and are even significant (0,001) in the third round. Yet all predefined groups (comp. Table 15.2) were equally distributed with view on the variable of body height.

Since body height in basketball plays a decisive role and provides an advantage, one could use the argument that those taller probands were the “better” players within the study whose advantage is also mapped into the virtual world. Other than in the virtual world no statistic relevant differences could be seen in context of performance and the dependency on the variable of body height.

The dependency on anthropometric attribute (body height) and hit ratio during the penalty shooting on the iPad challenges the reliability of the experiment-setup by assuming that the comparatively short distances (comp. paragraph 5) between the defined “throwing line”, the marker and the iPad, as well as the height of the marker—could create an advantage for taller probands: The potentially simple abstraction in the game “AR Basketball” and the higher dropping height within the game could be exploited by taller probands by leaning over. The distance between player and basket crucially could be reduced by still keeping an adequate dropping height; compared to the distance of the basket in the real world.

15.7 Summary and Outlook

Virtual worlds have in different contexts at least a potential in context of transferring emotional, affective, cognitive and even motoric schemes to the real world. The assumption of such an—intermondial—transfer implicates that a transfer in contra-direction from the real into the virtual world must be possible. Sure enough, hints of a transfer are found when players of digital games for example adapt and project known rules of games from the real world into the virtual world.

Nevertheless, most studies in context of motion and sports have set the focus on the transferability from direction virtual world to real world. There is apparently a demand for systematic exploration, scientific interest and evaluation of the matter in the scientific landscape and this specific domain.

Actually possible hints to processes of transfer from the virtual to the real world are found in the studies. Cause by the variety of methodically approaches and different qualities of the studies a transfer is subjected to (motivation, cognition, affect, treatment etc.), valid generalizations can be deviated.

This study only aimed so far to see if and how an expertise acquired in the real world finds equivalence in the virtual world. The foundation of reasoning for potential processes of transfer is based on Fritz’s model of transfer (1997, 2011), which besides the differentiation of forms of transfer, layer of transfers and the process of transfer itself works as scheme for transformation.

In difference to Wiemeyer and Schneider (2012), who also conducted a study using basketball and came to the result that “the real training seems to transfer to the virtual test” (Wiemeyer & Schneider, 2012, p. 69), our results revealed major differences in the performance of experienced basketball players during penalty shooting in a real and virtual setting which in first view seems to controvert a transfer. Nevertheless changes in performance across time on processes of transformation in the meaning of Fritz can be noticed and negotiated with a possible transfer between the real and the virtual world.

Since those results are of explorative character and our study is missing a control group, generalizations are interdicted. Our setting shows in addition sensitivity to the disruptive factor of body height, shown by the identified correlation between linear growth and success rate of the task on the iPad. With this study, we think that we can contribute an initial point of analysis towards further research of transfer-effects between virtual and real worlds and vice versa.

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