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A Preliminary Investigation On Sports-Based VR Technology With The Influence Of Psychological Skill Training

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Abstract: Virtual Reality is a new-age technology that is used across multiple domains. Apart from entertainment and gaming, VR is now also being implied in training sectors such as Medical Surgeries, Training simulations, and Physical Sports training. Imagery Assisted Virtual Reality tends to improve psychological skill development and mental skills and increase gaming strategy. Imagery-based VR Training is a non-conventional methodology for training athletes through VR technology. This paper focuses on the psychological aspects involved in training athletes mentally and the use of Imagery Assisted Virtual Reality Training program as well as the outcomes of the program.

Index Terms **– VR, Imagery Assisted Virtual Reality, Sports Imagery Ability Questionnaire, Test of Performance Strategies**

Introduction

Virtual Reality is a branch of modern computer science where the technology is used to create a simulated environment that can be experienced in 360º immersive view. VR places the user in the virtual CG (Computer Generated) environment whereas the traditional interfaces allow the user just to interact through a virtual screen. The use case of VR is limitless. However, Virtual Reality tends to change one's psychological traits for those who use it for a long time. It aids in adherence, motivation, and involvement in physical activity Singh et al [1]. VR can be used to create a riveting experience with stereoscopic conditions. Apart from training simulations (medical field, construction, emergency response, scientific research, educational content) and games, VR is used to create manipulation which is a tougher task to perform in a real-world setting.

In recent times, Virtual Reality has extended its contributions to the medical field including; increasing occupational therapy compliance [2], accelerating physical rehabilitation [3], speeding up the stroke rehabilitation process [4], reducing symptoms of Parkinson's disease [5], distracting from pain [6], and is used as exposure therapy for Post-Traumatic Stress Disorder (PTSD) [7]. While VR is being used across a vast number of fields, we will consider the usage of VR in the sports area for this paper. Different types of VR technologies are used from training simulations to the actual game itself. Researchers have documented the use of VR to positively affect decision-making in rugby [8], and soccer skills [9], and decrease goalie reaction time in handball [10]. The athletes have also used VR to experience going down a bobsledding track [11] and swimming without really performing the task (swimming in the water) [12]. All the documented studies resulted in positive outcomes. To assess why VR training may be successful for athletes' physical and psychological skill development, it is important to keenly observe the research in the field of imagery as both allow a person to experience the self by completing a task without actually performing it. Imagery is generally asserted as imagining a movement that leads to the same neural activations as an actual movement. There are several hypotheses as to consider why imagery is effective, with a keen focus on the assertion [13] that imagining a movement leads to the same neural activations as an actual movement. To bring out the best from the athletes by using Imagery Training through Virtual Reality, Holmes et al [14] alongside several of his colleagues over the past 15 years, have built a successful on the idea of functional equivalency with the development of the PETTLEP approach on how imagery training should be focused on athletes. The PETTLEP model is the acronym for Physical, Environment, Task, Timing, Learning, Emotion, and Perspective. Imagery is considered functionally equivalent if it addresses the seven areas. The physical nature of the task is evidenced by athlete imaging in a way that attempts to replicate the physical nature of the task. The Environment includes all the stimuli senses along with the task the athlete imagines. The cumulative time of the imagery should be equal to or close to the same as the actual task. Considering the imagery learning that takes place as one develops their skill, as well as the emotion of the task, is important to consider for the equivalency. In the end, it is pertinent that the athlete should use their self (internal) perspective to have their imagery for skill and external if desired.

Even though VR technology is constantly developing, there are still components of the sports experience that are difficult to replicate via virtual reality. VR only focuses on the stimulus (e.g., seeing yourself climbing over a cliff), while imagery allows for specific stimulus and response propositions (e.g., feeling confident and self-esteem while climbing the cliff) to be included in the experience. Imagery is considered one of the most recommended psychological tools within the sports psychology literature helping athletes develop imagery is of utmost importance. Considering all the pros and cons of the long-term usage of VR-based Imagery Training this paper presents the cognitive psychology behind imagery training via usage of Virtual Reality Training.

Imagery Training using Virtual Reality

For the following research, 27 participants of one NCAA Division I baseball team were taken in. Among 27 players, seventeen were hitters and the remaining ten were pitchers. They ranged from 18-23 (m=19.8) with 14 years of gameplay and 1.65 years on the current team. [15]. Sports Imagery Ability Questionnaire by Jennifer Cumming, Sarah [16] will be used as a screening tool to explore whether or not higher imagination ability results in larger effectiveness of a subsequent imagination intervention. to boot, mistreatment a lot of knowledge base techniques like brain imaging and vessel reactivity will be used with the SIAQ to research doable mechanisms and responses are reflective of higher and poorer imagers.

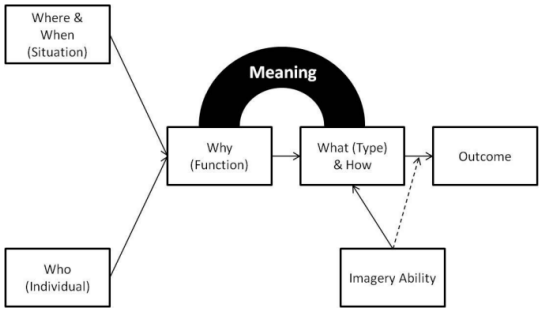

Figure reproduced with permission from Cumming & Williams (2013)

Figure 1 SIAQ Model

This questionnaire consists of 15 questions each of which is rated on a 1 (very hard to image) to 7 (very easy to image) Likert scale. The questions represent five subscales; skill imagery ability (e.g., refining a particular skill), strategy imagery ability (e.g., making up new plans/strategies in mind), goal imagery ability (e.g., players imagining themselves winning the medal), affect imagery ability (e.g., the positive emotions players feel while doing the sport) and mastery imagery ability (e.g., staying positive after the setback). This questionnaire is both valid and reliable [17, 18]. Test of Performance Strategies (TOPS) is designed to assess the athletes' use of psychological skills and strategies in both practice and competition through the use of 64 questions answered on a 1 (never use) – 5 (always use) Likert type scale. There are eight subscales accessing skills and strategies at practice and eight for competition.

In relation to my sport, how easy is it for me to image…	Very hard to image	Hard to image	Somewhat hard to image	Neutral (not easy or hard)	Somewhat easy to image	Easy to image	Very easy to image
1. Making up new plans/strategies in my head	1	2	3	4	5	6	7
2. Giving 100% effort even when things are not going well	1	2	3	4	5	6	7
3. Refining a particular skill	1	2	3	4	5	6	7
4. The positive emotions I feel while doing my sport	1	2	3	4	5	6	7
5. Myself winning a medal	1	2	3	4	5	6	7
6. Alternative plans/strategies	1	2	3	4	5	6	7
7. The anticipation and excitement associated with my sport	1	2	3	4	5	6	7
8. Improving a particular skill	1	2	3	4	5	6	7
9. Being interviewed as a champion	1	2	3	4	5	6	7
10. Staying positive after a setback.	1	2	3	4	5	6	7
11. The excitement associated with performing	1	2	3	4	5	6	7
12. Making corrections to physical skills	1	2	3	4	5	6	7
13. Creating a new event/game plan	1	2	3	4	5	6	7
14. Myself winning	1	2	3	4	5	6	7
15. Remaining confident in a difficult situation	1	2	3	4	5	6	7

Figure 2 SIAQ Likert Type Scale

For both practice and competition, TOPS assesses the use of self-talk, goal setting, imagery, emotional control, automaticity, relaxation, and activation. For practice, attentional control is assessed, while negative thinking is assessed for competition. TOPS is a well-established and validated tool [19].

IAVR Training Procedure

The psychological skills program was intensive in program design. For this research, Monoscopic filming was used to create a single image presented to both eyes through the VR goggles or Head Mounted Display. The stereoscopic video presents separate images to each eye from slightly different angles to create a three-dimensional (3D) effect. Stereoscopic 2D video requires two separate videos to be made which cuts the resolution in half. This, along with the difficulty filming with a larger stereoscopic setup consistent with the vast majority of 360-degree videos currently available online. In this phase, it was decided that first-person film,

traditionally done for virtual reality training, as well as third-person film for those who preferred to watch themselves from an external perspective, would be used. Regardless of perspective, all films would be watched through VR Headset for an immersive 3D experience.

Imagery has been delineated as "Expertise that mimics real expertise. We can be aware of 'seeing' an image, feeling movements as an image, or experiencing an image of smell, tastes or sounds without actually experiencing the real thing" [20]. Imagery is the most used psychological technique in the field of sports psychology and has been proven to be effective for both physical and psychological development in the sport [21, 22]. In recent times, a study conducted by researchers indicated that video-assisted imagery is an effective way to teach imagery, develop confidence and enhance performance [23, 24]. During the discussion on the implementation of the VR program, it was decided that film could be supplemented by having blank spaces where the athletes imaged (imagined) an experience. This would do three things: (1) allow the VR to work as an aid in imagery development; (2) allow for some of the player's experience to be imagined instead of filmed (3) allow for the addition of response propositions in the athlete's experience. This led to the development of the imagery-assisted virtual reality (IAVR) used with the team.

Each imagery script was written with the intent to allow the athlete to see themselves be successful during their on-deck swings/pre-inning pitches, as well as to help each other athlete solidify a pre-swing/pitch routine that allowed them to control any psychological skills they wanted to achieve/maintains. For each player, the imagery scripts were written based on the guidelines of William et al [25] on imagery script development and the PETTLEP approach.

All players were filmed doing their skills (hitting/pitching). Each pitcher threw his three pitches, which allowed all pitchers to have video of all three pitches, and hitters to have video hitting off all pitches. Hitters who asked were able to get the film off more than one pitcher. Specifically, all players wore the camera (for a first-person perspective) walking out of the locker room, putting on their gloves, and then walking out to the batter's box during their walk-up song. Players reported that watching these moments encouraged confidence while also helping them feel prepared. The first-person perspective video added a component in which athletes could feel the emotional experience of preparing to compete, through IAVR. Unlike a dynamic sport like football or soccer in which the camera could be left on a player throughout a drill or scrimmage, baseball is much more static. For this reason, it was not possible to simply put a camera on a player and leave it on throughout a scrimmage or through an entire drill. Instead, we had two filming days, one to get all the skill footage necessary and one to get film for psychological development purposes.

The players were asked for their opinions on the clips. Their feedback led to using 360-degree footage for motivational filming, and a combination of first and third-person GoPro film for skill shots. Although initially surprising that the players did not want 360º film for the skill clips, players consistently indicated that they felt that having the 360º film was not beneficial as they do not look around when performing the skills being filmed, and liked the higher resolution film of the GoPro more for skill development. The clips chosen by a player were then made into one video sequence that the player could play from start to finish. Each player also met with the sports psychology consultant and discussed what the player wanted to image during the imagery spots on their video sequence. For hitters, the first opportunity to image occurred when they were two people away from hitting, something they are encouraged to do in actual games. Having them image at the same time during the VR training allowed for functional equivalency to be increased. The second time that the video went blank for imagery was when they were to image themselves on deck, helping them solidify this pre-performance routine. For pitchers, they imagined their warm-up routine. Example sequence for hitters: (1) VR of walking out of the locker room and seeing their team in the dugout (first-person 360º film). (2) Blank space in the video for participant imaging. In this case, the hitter's image hits off the opposing team pitcher. If chosen, audio of guided imagery script was playing. (3) VR of putting on their gloves (if applicable), grabbing their bat, and walking to the edge of the dugout, (first-person, 360º film). (4) Blank space for imaging being on deck. If chosen, audio of the guided imagery script playing. (5) VR of walking up to the batter's box, walk-up music playing (first-person, 360º film). (6) VR of themselves taking good at-bats. This could be making a good read for a walk or making a good hit. The film always ended on its best swing. This film was a combination of first-person film taken via the hitter wearing the camera, and third-person film has worn either by the catcher or pitcher.

Players were asked to watch the film one-two time a day, in their proper stance. In the beginning, one VR session was done at practice as a group to help players get in the habit of using the technique. In total, this was a time requirement of 12-15 minutes a day.

Discussion from IAVR Training

The inferential statistical analysis shed some light on the effectiveness of an IAVR protocol, however, these results should be seen as a jumping-off point for more research instead of conclusive findings. The results indicated that imagery ability was improved for three of the five subscales. This is a promising finding that indicates that IAVR could help athletes improve their imagery ability and therefore their likelihood of using imagery effectively. Future research should assess whether an IAVR program can affect all five subscales of imagery ability if it specifically targets all areas. For this intervention, each athlete had their areas targeted (i.e., one person may have had responses related to affect, another to mastery).

Table 1 Descriptive Statistics and alpha levels for TOPS and Sport Imagery Ability Questionnaire.

Dependent variable	Baseline		Time 2		*P*
	Mean	*SD*	*Mean*	*SD*	
SIAQ					
Skill	**5.62**	**0.86**	**5.97**	**0.74**	**0.04**
Strategy	5.24	0.99	5.65	0.79	0.07
Goals	**5.77**	**1.00**	**6.20**	**0.67**	**0.00**
Affect	6.02	0.94	6.38	0.76	0.16
Mastery	**5.14**	**1.20**	**5.72**	**0.69**	**0.01**
Practice					
Goal Setting	3.43	1.01	3.67	0.77	0.26
Emotional Control	3.55	0.60	3.65	0.64	0.46
Automaticity	**3.51**	**0.64**	**3.84**	**0.48**	**0.04**
Relaxation	**2.71**	**0.96**	**3.65**	**0.93**	**0.00**
Self-Talk	**3.48**	**0.75**	**3.93**	**0.02**	**0.01**
Imagery	**3.36**	**0.90**	**3.82**	**0.73**	**0.04**
Attentional Control	3.47	0.60	3.71	0.43	0.18
Activation	3.44	0.60	3.65	0.65	0.16
Competition					
Goal Setting	3.58	0.93	3.99	0.58	0.06
Emotional Control	3.43	0.28	3.40	0.44	0.18
Automaticity	**2.91**	**0.83**	**3.43**	**0.81**	**0.01**
Relaxation	3.48	0.83	3.79	0.69	0.06
Self-Talk	**3.51**	**0.92**	**3.95**	**0.71**	**0.04**
Imagery	**3.50**	**0.77**	**4.02**	**0.58**	**0.02**
Negative Thinking	**3.74**	**0.71**	**4.01**	**0.66**	**0.05**
Activation	**3.43**	**0.69**	**3.79**	**0.62**	**0.04**

Note: Bolded variables were significant.

Although preliminary these results are very promising, especially considering the importance of imagery ability for an athlete to achieve the many benefits of imagery use. The TOPS analysis indicated several psychological skills and strategies were used more after the IAVR protocol was completed than at baseline. Imagery use was increased which is expected as it was a component of the study, and with imagery, ability increases come imagery use increases [26].

Along with the increase in imagery, use increased in positive self-talk, and automaticity in both practice and competition. Each athlete also had a component of their script in which it would refer to a cue word that the athlete used to calm down (self-talk strategy), therefore both of these strategies were a focus of the intervention and it, therefore, makes sense that they both increased in practice and competition. Negative thinking during the competition was decreased (indicated by a higher mean due to reverse coding of the subscale), indicating that the protocol had a positive impact on how a person thinks about the good and the bad of competition.

Existing Intervention Studies using VR

Virtual Reality (VR) can be used to create realistic training with standardized, controllable, and stereoscopic conditions. With the implementation of virtual reality, fake influences (manipulation) can be made which are either difficult to perform or not possible in real-world settings. Furthermore, standalone training can be made. Thus, there would be no complete dependence on training partners, coaches, or gyms [27,28]. VR can be used to perform stress training by the implementation of several stressors, such as hard opponents or loud auditory [29]. Virtual Environments can be tuned to prepare for competition to learn how to deal with stress or opponents can be created who act similar to real future opponents. In addition to this, psychological training can be made to decrease stress and increase self-confidence by the template of Marshall et al. [30].

Conclusion

With the constant changes in VR technology, it is expected that this technology will become easier and easier to use, making this a potentially viable and important tool for sports psychology consultants to consider when working with athletes. Like other technological tools, it should only be used when it adds to the athletes' experiences, and by people who truly understand how to develop the program and utilize it for maximum gain. VR is used for tactical training, as VR is a useful tool for visualization. It is further possible to use VR in addition to the conventional training to teach some aspects. E.g. endurance training can be made by the use of an ergometer placed in VR so that athletes have the feeling to perform their sports on real (future) running, cycling, or rowing tracks and thus, can prepare for the next competitions. Each VR training produces data that on the one hand could be used for oneself, but also for other athletes to improve performance. Therefore, a native web-responsive app can be created with which athletes can watch self-reliantly correct movement executions from highly skilled athletes. They can change the speed and the perspectives and can get further information concerning the movement executions. Overall, this applied work indicates that Virtual Reality for Physical training may be an effective, novel, and affordable tool for sports psychology consultants to use with their athletes.

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