THE DEVELOPMENT OF CONTEXT-SPECIFIC BIOFEEDBACK TRAINING
SCREENS: AN APPLICATION TO HOCKEY OFFICIALS

A Thesis
Submitted to the Faculty of Graduate Studies and Research
In Partial Fulfillment of the Requirements
For the Degree of

Master of Science
in
Kinesiology and Health Studies
University of Regina

By
Adam James Chomos

Regina, Saskatchewan
July, 2014

© 2014: A.J. Chomos
Adam James Stephen Chomos, candidate for the degree of Master of Science in Kinesiology & Health Studies, has presented a thesis titled, *The Development of Context-Specific Biofeedback Training Screens – An Application to Hockey Officials*, in an oral examination held on June 13, 2014. The following committee members have found the thesis acceptable in form and content, and that the candidate demonstrated satisfactory knowledge of the subject material.

External Examiner: Dr. Richard MacLennan, Department of Psychology

Supervisor: Dr. Kim D. Dorsch, Faculty of Kinesiology & Health Studies

Committee Member: Dr. Patrick Neary, Faculty of Kinesiology & Health Studies

Committee Member: *Dr. David Paskevich, Adjunct

Chair of Defense: Dr. Laurie Clune, Faculty of Nursing

*via tele-conference
Abstract

The benefits and potential of biofeedback training for enhancing athletic performance has received noticeable consideration in both research and practice. While most biofeedback research applied to sport participants has focused primarily on athletes, one group of participants has been neglected in both research and training. This group is known as sports officials. Ice hockey officials are required to possess various physical, cognitive, and psychological skills, suggesting that biofeedback training to enhance their on-ice performance holds strong utility. Since biofeedback research applied to sport offers very little perspective into the needs and requirements of biofeedback protocols applied to officials of sport, the purpose of this research project is to develop the first context-specific biofeedback training screens applied to hockey officiating. Working in conjunction with and obtaining approval from the Saskatchewan Hockey Association (SHA), participating referees and linesman were outfitted with a Contour 1080p© helmet camera to capture various on-ice experiences from a game-to-game basis. A focus group was held with SHA official representatives (i.e., official supervisors, mentors) to gain a better understanding as to (a) the various physical and cognitive/mental skills and abilities that are necessary to the official while on the ice, (b) the potential utility of biofeedback training for enhancing hockey official’s performance, and (c) how the previously obtained videos could be incorporated into the training experience so as to make the training experience more applied and meaningful. The results of the focus group provided valuable insight as to how the biofeedback training screens and tasks could be developed around the acquired video segments. Once the video segments were identified and validated by contextual experts (participants of the focus group), they were
incorporated and configured into formatted biofeedback training screens using software offered by Thought Technology™. The implications of this research include educating officials on how their psychophysiology can influence their on-ice performance as well how they can utilize biofeedback training methods to restore and improve their performance. As a result, this research project is a critical step for future biofeedback research and training applied to sports officials.
Acknowledgements

First, to my advisor, Dr. Kim Dorsch. When you took me under your wing after realizing (at the very last minute) that the University of Queensland wasn’t going to happen, I was so appreciative. Over the years I learned so much about the research and teaching process from you, and was blessed to be involved as a T.A. in so many of your courses. For the support you provided on all levels, I will always be grateful.

To my other committee members, especially Dr. Patrick Neary. I only had the pleasure of meeting and working with you at the graduate level, but from this short period of time I learned how genuine and passionate a person you are. Your constant willingness to pass on the textbook or paper to help make things more clear will always be remembered. It is because of you, that I will always ask myself “Psychology or Physiology”? (Don’t worry Kim, psychology still holds the slight lead….).

To Dr. Dave Paskevich. I only formally met you the night of my proposal, but am nonetheless appreciative of your involvement with my research project and respect any critique or suggestion you provide. Thank you!

A special thanks to Doug Lawrence, a liaison throughout the entire research process. From coordinating the relationship with the SHA to your involvement in the focus group and guidance throughout the various stages of research, none of this would have been possible without you.
Dedication

To my wife Chelsea, I know that it hasn’t always been easy with all the sacrifices you made and patience you gave. All of the years of “putting up with” is something I will always be grateful for. I will always remember and appreciate your willingness to be there and give me the time and space to get this completed, especially during “crunch time.” I love you Lizzy!!

To my two incredible little angel princesses: Lynlee Lou and Kennedy Grace. You both amaze me every single day and I am the luckiest and proudest dad in the world. I can’t wait for you both to be older and truly understand how much you mean to me and how much I love you. You both shine on me whenever I need a reason to smile and laugh and always put things in perspective whenever I need to be picked up. I love you both ridiculously!!
# Table of Contents

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title Page</td>
<td>i</td>
</tr>
<tr>
<td>Abstract</td>
<td>ii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>iv</td>
</tr>
<tr>
<td>Dedication</td>
<td>v</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>vi</td>
</tr>
<tr>
<td>List of Figures</td>
<td>viii</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Biofeedback for Enhanced Sport Performance</td>
<td>6</td>
</tr>
<tr>
<td>Review of Literature on Biofeedback Applied to Sport</td>
<td>8</td>
</tr>
<tr>
<td>Biofeedback Training and the Role of Learning and Awareness</td>
<td>12</td>
</tr>
<tr>
<td>Learning and Context – Significance to Biofeedback Training</td>
<td>14</td>
</tr>
<tr>
<td>Developing Biofeedback Training Screens</td>
<td>20</td>
</tr>
<tr>
<td>Creating channel sets</td>
<td>21</td>
</tr>
<tr>
<td>Creating screens</td>
<td>22</td>
</tr>
<tr>
<td>Creating scripts</td>
<td>23</td>
</tr>
<tr>
<td>Research Delimitations</td>
<td>25</td>
</tr>
<tr>
<td>Research Objective</td>
<td>25</td>
</tr>
<tr>
<td>METHOD</td>
<td>27</td>
</tr>
<tr>
<td>Video Collection</td>
<td>27</td>
</tr>
<tr>
<td>Video analysis – 1st Stage</td>
<td>30</td>
</tr>
<tr>
<td>Focus Group</td>
<td>30</td>
</tr>
<tr>
<td>Recruitment, location, group size and length</td>
<td>31</td>
</tr>
<tr>
<td>Facilitator and observer</td>
<td>31</td>
</tr>
<tr>
<td>Question design</td>
<td>32</td>
</tr>
<tr>
<td>Informed consent</td>
<td>32</td>
</tr>
<tr>
<td>Data collection</td>
<td>33</td>
</tr>
<tr>
<td>Data transcription, coding, and analysis</td>
<td>33</td>
</tr>
<tr>
<td>Biofeedback Screen Development</td>
<td>36</td>
</tr>
<tr>
<td>Training for developing screens</td>
<td>36</td>
</tr>
<tr>
<td>RESULTS</td>
<td>37</td>
</tr>
<tr>
<td>Development of Biofeedback Training Experience</td>
<td>38</td>
</tr>
<tr>
<td>Application of Biofeedback Training to Enhance</td>
<td>39</td>
</tr>
<tr>
<td>Officiating Performance</td>
<td>39</td>
</tr>
<tr>
<td>Communication and conflict resolution</td>
<td>40</td>
</tr>
<tr>
<td>Judgments and decision-making</td>
<td>40</td>
</tr>
<tr>
<td>Consistency</td>
<td>41</td>
</tr>
<tr>
<td>Effort and work ethic</td>
<td>41</td>
</tr>
<tr>
<td>Video Analysis – 2nd Stage</td>
<td>42</td>
</tr>
<tr>
<td>Confirmation of Video Segments by Contextual Experts</td>
<td>44</td>
</tr>
<tr>
<td>Completed Biofeedback Training Screens</td>
<td>45</td>
</tr>
</tbody>
</table>
Created channel sets, screens, and scripts ......................... 46
Purpose of contextual video and auditory stimuli .................. 46
Created training screens utilizing video clips and sound effects ........................................... 47
Implications of Research .......................................................... 53
Research implications ............................................................... 53
Applied implications ............................................................... 54
Educational Implications ........................................................... 55
Summary and Conclusions .......................................................... 57
REFERENCES .................................................................................. 61

Appendices

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Letter to Saskatchewan Hockey Association</td>
</tr>
<tr>
<td>B</td>
<td>Media Release Form</td>
</tr>
<tr>
<td>C</td>
<td>REB Ethics Approval</td>
</tr>
<tr>
<td>D</td>
<td>Focus Group Consent</td>
</tr>
<tr>
<td>E</td>
<td>Focus Group Summary</td>
</tr>
<tr>
<td>F</td>
<td>Developed Biofeedback Training Screens</td>
</tr>
<tr>
<td>Figure</td>
<td>Title</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Respiration Training Screen with Video Stimulus</td>
</tr>
<tr>
<td>2</td>
<td>EEG Training Screen with Audio Stimulus</td>
</tr>
<tr>
<td>E-1</td>
<td>BVP Training Screen with Video Stimulus</td>
</tr>
<tr>
<td>E-2</td>
<td>Respiration Training Screen with Video Stimulus</td>
</tr>
<tr>
<td>E-3</td>
<td>Temperature Training Screen with Video Stimulus</td>
</tr>
<tr>
<td>E-4</td>
<td>Respiration Training Screen with Video Stimulus</td>
</tr>
<tr>
<td>E-5</td>
<td>Training Multiple Modalities with Video Stimulus</td>
</tr>
<tr>
<td>E-6</td>
<td>Training Multiple Modalities with Video and Audio Stimulus</td>
</tr>
<tr>
<td>E-7</td>
<td>Respiration Training Screen with Audio Stimulus</td>
</tr>
<tr>
<td>E-8</td>
<td>Training Multiple Modalities with Video Stimulus</td>
</tr>
<tr>
<td>E-9</td>
<td>EMG Training Screen with Video Stimulus</td>
</tr>
<tr>
<td>E-10</td>
<td>Temperature Training Screen with Audio Stimulus</td>
</tr>
<tr>
<td>E-11</td>
<td>EEG Training Screen with Audio Stimulus</td>
</tr>
<tr>
<td>E-12</td>
<td>EMG Training Screen with Video Stimulus</td>
</tr>
</tbody>
</table>
For the hockey official, conflict is inevitable. Officials are constantly being scrutinized for the calls they make or fail to make, and are often subjected to both verbal and even physical abuse from players and coaches (Ackery, Tator, & Snider, 2012). While on the ice, the official is given anywhere from a split-second during the play, to 10-15 seconds (Hockey Canada, n.d.a) in between whistles to take in all information and act accordingly by enforcing a rule or simply engaging in a conversation with either or both participating players and coaches.

For years, leading organizations such as Hockey Canada (n.d.b) have tried to implement guidelines to help officials deal with on and off-ice conflict. These guidelines have focused primarily on teaching officials to develop an understanding of and adapt to how the game’s participants think (cognitions) and feel. This focus may suggest then that the official’s psychological and physiological makeup can play a critical role in determining how specific situations and confrontations are approached and responded to. For example, when conflict arises, physiological levels elevate as a result of a distress signal being sent from the amygdala to the part of the brain that communicates with rest of the body, the hypothalamus (Understanding The Stress Response, 2011). When these levels elevate, the body’s autonomic nervous system (ANS), which is responsible for involuntary body functions, takes over (Understanding The Stress Response, 2011). As a result, the heart beats faster, breathing becomes faster and more shallow, muscles become tense, hands begin to sweat and become clammy, and overall body temperature decreases (Everly, n.d.). When this physiological activity occurs, the way the body behaves and the way an individual responds emotionally or cognitively may be less than ideal for maintaining or reaching high levels of performance. However, what few people realize is
that the ability exists to train oneself to respond to these situations in a matter that can
enhance, rather than impede performance (Schwartz & Andrasik, 2003). Only for the last
20 to 30 years has a training tool been available to individuals including participants of
sport that allows them to train these physiological states so they are able to respond
effectively and perform at a maximum potential. This tool is known as biofeedback.

A proper definition of *biofeedback* includes statements both on the practice and
purpose of biofeedback (Schwartz & Andrasik, 2003). To build on Olson’s (1995)
definition, Schwartz and Andrasik (2003) propose additions to incorporate both the
processes involved and the goals of biofeedback. As a result of both ideas, biofeedback
can be comprehensively defined as:

Biofeedback as a process is a group of therapeutic procedures that uses various
instruments to accurately measure, process, and feed back to both the persons and
their therapists, information with educational and reinforcing properties about both
normal and abnormal neuromuscular and autonomic activity in the form of analog or
binary, auditory, and/or visual feedback signals. The objectives of biofeedback are
to help persons develop greater awareness of, confidence in, and voluntary control
over the various physiological processes that are typically outside awareness and
under less voluntary control. By first learning to control the external signal, persons
can learn to use cognitions, sensations, or other cues to prevent, stop, or reduce
symptoms (Schwartz & Andrasik, 2003, pg. 35).

While this definition encompasses biofeedback as simply the process of learning
to become aware of one’s physiological responses, biofeedback can be differentiated
from *biofeedback training*, which goes beyond biofeedback’s informative nature,
suggesting that our physiological responses can be controlled and even changed or
modified, resulting in a more optimal physiological functioning state. The purpose of
biofeedback training then, is to use the physiological information provided by the
biofeedback instrument to learn to gain voluntary control over those normally involuntary psychophysiological processes (Blumenstein, Bar-Eli, & Tenenbaum, 2002).

*Psychophysiology* is defined as the “scientific study of cognitive, emotional, and behavioral phenomena as related to and revealed through physiological principles and events” (Cacioppo & Tassinary, 1990, p. ix). The main idea behind psychophysiology is that every change in physiology is accompanied by a change in emotional and mental state, and vice versa (Blumenstein et al., 2002).

Various types or modalities of biofeedback and biofeedback training exist and are used clinically to treat a wide spectrum of conditions and ailments, as well improve cognitive and psychological functioning. These include:

- **Electromyography (EMG)** also referred to as *muscle feedback*, which is used to measure muscle activity. The electrical activity of a muscle is measured and then displayed to the individual on a screen for the purpose of modifying the EMG signal by relaxing or activating muscles that are tense or possibly injured.

- **Galvanic skin response (GSR) and skin conductance (SCR)** are modalities of biofeedback, also referred to as *electrodermal biofeedback*, that measure electrical activity at various skin sites.

- **Thermal biofeedback** is a biofeedback modality that involves the use of skin temperature of the fingers to measure the sympathetic arousal of the autonomic nervous system (Zaichkowsky & Fuchs, 1989). According to Fischer-Williams, Nigel, and Sovine (1981), the primary belief surrounding the validity of thermal biofeedback suggests that when an
individual becomes stressed or anxious, decreased peripheral blood flow causes a reduction in skin temperature, whereas when one is calm and relaxed, an increase in temperature to the body is detected (as cited in Blumenstein et al., 2002).

- **Heart-Rate variability (HRV) and blood volume pulse (BVP)** are types of cardiovascular biofeedback that measure and provide feedback about heart rate and blood flow (Zaichkowsky & Fuchs, 1989). HRV biofeedback training measures physiological functions including breathing (RR), heart rate (HR), and blood pressure (BP). This biofeedback modality teaches individuals how to regulate these functions through diaphragmatic breathing techniques at a pace to ensure consistency between heart rate and respiration patterns. BVP measures the change in blood volume with each heartbeat with the overall purpose of BVP training to make individuals aware of the factors that increase or decrease their HRV (Peper, Harvey, Lin, Tylova, & Moss, 2007).

- **Electroencephalography (EEG)** is a biofeedback modality and is also referred to as brain wave biofeedback or neurofeedback. Neurofeedback detects and provides information regarding brainwave activity. The purpose of neurofeedback training is to alter one’s brainwave patterns to reflect a more optimal brainwave and cognitive state. While some researchers and practitioners view neurofeedback as being separate from biofeedback, for the purpose of this research project it will be included and regarded as a modality of biofeedback.
The application of biofeedback training in sport is one that has gained popularity from both a research and an applied training perspective. The efficacy of biofeedback as an intervention for a wide-spectrum of conditions and illnesses outside of sport has opened the door to look at the potential benefits to increasing performance among the game’s participants (i.e., athletes, coaches, and officials). As a result, considerable attention has been given towards the psychophysiological benefits that biofeedback has to athletes of both individual and team sports. Specifically, the application of biofeedback training in sport has been documented as enhancing overall performance (Blumenstein & Bar-Eli, 1998), alleviating competition and pre-competition anxiety (Costa, Bonaccorsi, & Scrimil, 1984), treating injuries (Swanik, Lehart, Giraldo, Demont, & Fu, 1999), and increasing flexibility (Cummings, Wilson, & Bird, 1984). However, while biofeedback training has shown a growing utility towards the positive effects on enhancing athletic performance (Blumenstein et al., 2002), one group of sport performers have been neglected in both biofeedback research and practice. This group of individuals are known as officials. Weinberg and Richardson (1990) suggest that top officials of all sports share common characteristics in that they possess consistency, rapport, decisiveness, poise, integrity to the game, judgment, confidence, and all share high amounts of enjoyment and motivation.

The qualities mentioned above suggest that an official requires a specific physical and cognitive skill set to effectively carry out his or her responsibilities. In addition, officials require decision making skills that allow them to properly enforce the various rules of the game (MacMahon, Helsen, Starkes, & Weston, 2007), and interpersonal skills that allow them to effectively communicate with players and coaches throughout
the game (Dorsch & Lawrence, 2011). Surprisingly, performance enhancing literature in
sport psychology has neglected the impact that such skills and abilities have on
officiating performance, instead focusing primarily on those constructs possessed only by
players and coaches. Since competitive sport cannot exist without the official, and since
the official’s presence and decisions can influence the outcome of the game,
understanding the physical and cognitive complexities as it relates to their officiating
performances and on-ice experiences is a warranted addition to existing sport psychology
literature.

**Biofeedback Training for Enhanced Sport Performance**

The means to improving performance through biofeedback training occurs by
achieving desired goals related to specific physiological states thereby influencing
optimal cognitive functioning. From an applied sports perspective, the focus of
biofeedback training reflects improved psychophysiological functioning as it relates to
specific aspects of performance. While it is important to understand, especially from an
education and research point-of-view, specific factors both in the methodology and the
overall process of how desired physiological changes occur from biofeedback training, it
is how those changes directly impact performance that is of most use to sport
participants. For example, one extensive utility of biofeedback training in sport is in the
treatment of performance anxiety (Moran, 1996) since research has indicated that high
amounts of anxiety can be damaging to an individual’s participation in competition,
motor learning, and overall performance.
Muscle performance such as strength, force, endurance, and perceived performance pain is another aspect of athletic performance that has been recognized among research as having the potential to be improved through biofeedback training (Blumenstein et al., 2002). In addition, biofeedback training has also been demonstrated as effective in training muscle performance when the performance outcome was to alleviate tension for muscle relaxation (Schwartz & Andrasik, 2003). Despite the evidence that biofeedback training can be used to enhance muscle performance from a wide spectrum of muscular conditions, the consensus among researchers in the field of biofeedback applied to sport conclude it is typically quite difficult to demonstrate a direct correlation or causation between biofeedback and enhanced muscle performance (as cited in Blumenstein et al., 2002).

Biofeedback training has also demonstrated a positive effect on athletic performance when the training protocols incorporated other mental training techniques such as mental imagery and relaxation training (Crews & Landers, 1993; De Witt, 1980). Imagery is a mental skill that seems to be prominent in a wide variety of sports, especially those that require the performer to maintain control of thoughts and emotions (Schwartz & Andrasik, 2003). From a research perspective, imagery techniques among various athletes in various sports have been studied to better understand the methods and content of what is being imaged as well the outcomes that imaging techniques have on performance (Schwartz & Andrasik). Athletes such as synchronized swimmers (Wenz & Strong, 1980), kayakers (Blumenstein & Bar-Eli, 1998), and golfers (Crews, Martin, Hart, & Piparo, 1991) have all benefited from some form of improved performance when biofeedback training was used in conjunction with imagery, relaxation training, or a
combination of the two. Schwartz and Andrasik have further validated the effectiveness of techniques that work in conjunction with biofeedback to enhance imaging techniques among athletes. Such techniques include immersing individuals in restricted environments such as the restricted environmental stimulation tank (REST) in which the athlete is submersed in a tank of salt-saturated water, or introducing environmental conditions such as loud crowd noise so as to challenge athletes to successfully use imagery under higher pressure situations.

While the application of biofeedback in sport has yet to look at the impact and potential benefits for officials of the game, considerable attention, especially over the last few decades, has been given towards the psychophysiological benefits to athletes of various sports (Blumenstein et al., 2002). The varying modalities of biofeedback have left ample opportunity to investigate the methods and contexts in which biofeedback is used to enhance the performance of athletes. Despite the lack of attention that sports officials have received, it is necessary to look at the various findings within biofeedback research applied to athletes. Since sports officials require physical, cognitive, and psychological skills and abilities to guide their successful officiating experiences, understanding how the various modalities of biofeedback are used to enhance athletic performance is important for the development of biofeedback protocols specific to sports officials.

**Literature Review on Biofeedback Applied to Sport**

Research on biofeedback training in sport has focused on athletes of both individual and team sports, with the methods and modalities of training varying
depending on the desired psychophysiological result and performance enhancing goal. When the result of biofeedback training was to control or reduce the amount of pre-competition stress among competitive synchronized swimmers (Wentz & Strong, 1980), judo athletes (Blumenstein, Bar-Eli, & Tenenbaum, 1997), and speed skaters (Beauchamp, Harvey, & Beauchamp, 2012), EMG, GSR, HRV, SCR, or a combination of these biofeedback training modalities were utilized, in some instances in conjunction with additional relaxation and mental imagery training techniques. Neurofeedback (EEG) has also been used to enhance performance among athletes by teaching athletes how to voluntarily activate specific states of EEG activity (Blumenstein et al., 2002). EEG training is concerned primarily with the four major frequency bands: beta (above 13 Hz), alpha (8-13 Hz), theta (4-7 Hz), and delta (0.5-3.5 Hz). While EEG biofeedback is not used to determine specific brain function, Walter (1963) suggests it is useful to distinguish between more general states of arousal such as deep sleep (delta), daydreaming state (theta), relaxed but aware (alpha), and full awareness/alertness (beta). The rationale of using EEG neurofeedback to improve athletic performance is based on the idea that by identifying associations of cortical activity (i.e., high alpha) and the aspects of behaviour (increased focus and awareness) that are considered optimal, the athlete can be trained to enhance his or her performance by emulating the cortical levels associated with optimal performance (Vernon, 2005). Several studies support this idea, such as Silverman’s (2011) study on treating a baseball player who sought neurofeedback intervention because of a struggle to maintain focus during games. Sessions were conducted with the purpose of training to inhibit theta (3-6 Hz), high beta (22-36 Hz), while rewarding beta (15-18 Hz). By the end of the treatment program, the participant
described an improved ability to focus and concentrate, but also reported positive changes in coordination as well as a negativity he previously carried toward the game. In the sport of archery, Landers et al., (1991) conducted neurofeedback (EEG) training with archers while aiming. Over a 14-week training protocol it was discovered that increases in left temporal lobe power were correlated with improved overall performance among the archers. Since different sports require different demands on the brain, Hammond (2007), notes that while some athletes such as archers and golfers require a quiet mind and require neurofeedback training to reflect that state, some athletes may need to produce a different kind of concentration resulting in a completely different neurofeedback protocol.

Heart rate variability (HRV) is a modality of biofeedback that has extended a utility to enhancing athletic performance as it relates to alleviating competition stress and anxiety, improved reaction time, relaxation, and improved sport-specific tasks. In its simplest description, the purpose of HRV training is to increase the heart rate variability in heart rhythms to reflect a better balance of the sympathetic and parasympathetic influence on the heart. A smooth HRV pattern indicates more balanced autonomic nervous system functioning (Schwartz & Andrasik, 2003). Research on HRV applied to athletic performance has shown various successful results, including Vashillo, Visochin, and Rishe (1999) who applied HRV biofeedback training with resonance frequency breathing to 30 elite Russian wrestlers. Half of the group performed 20 minutes of HRV training twice a day for 10 days, while the other half of wrestlers received no HRV biofeedback training. The training group showed a decreased heart rate, improved HRV, normalized blood pressure, and increased skin temperature compared to the control
group, which showed no such improvements. Further, the group receiving the HRV biofeedback training showed a reduction in reaction time and an increased speed of relaxation of quadriceps muscles, as compared to no change in the control group. Another study by Strack (2003) demonstrated the positive effect of HRV biofeedback on batting performance among high school baseball players. The training group showed improvements of up to 60% in batting performance compared to the control group.

EMG biofeedback also holds strong utility when applied to sport and athletic performance, especially when used to develop and fine tune specific techniques applied to sport (Blumenstein et al., 2002). The positive effects of EMG biofeedback from a rehabilitation and physical therapy standpoint have also been well documented, especially when being used in collaboration with additional physical therapy techniques (ExRx.net, n.d). Further, improvements in muscular performance such as strength and flexibility using EMG biofeedback training have documented in several studies, such as Dorsey (1976) and Goodspeed (1983) who reported improvements in motor control among gymnasts upon completing EMG biofeedback training. Cummings et al. (1984) also produced evidence of superior flexibility gains during a retention period among sprinters, which the authors claim as relevant since flexibility is reported as being related to the incidence of injuries. Ultimately, the purpose of EMG training is that through being provided feedback of the electrical activity of a given muscle, the athlete learns to change the EMG signal by either relaxing tense muscles or activating muscles that are injured (Blumenstein et al., 2002).
Biofeedback Training and the Role of Learning and Awareness

While the various modalities of biofeedback training result in differing physiological outcomes, there are commonalities between the differing modalities and desired outcomes when looking at the role that learning and awareness, (i.e., the ability to feel, perceive, or be conscious of events, objects, or sensory patterns, Dictionary.com,) have on the process of biofeedback training (Dunn, Gillig, Ponsor, & Well, 1986). In most biofeedback training situations, the biofeedback instrument provides a visual representation of what is happening in the body from a physiological standpoint. By observing this phenomenon, the individual learns to become aware of and control and/or change the body’s physiology to reflect a more desired and optimal state. To activate or initiate this change, the individual must learn to develop a response to the activity being presented, or, the feedback being provided. For example, if an individual wanted to improve the utilization of brain activity to reflect a more focused and attentive state, EEG biofeedback training would be performed. The individual, with various sensors placed on the scalp, would receive a visual representation of any brainwave activity representative of his or her current psychophysiological state (i.e., resting or calm while relaxed sitting in a chair). Since focus and attentiveness is associated with the beta brainwave state, the focus of the biofeedback training would be for the individual to first become aware of this activity (as presented to him or her) and through this awareness learn to activate or increase levels of beta brainwave activity. Because biofeedback training follows an operant conditioning framework (Dunn et al.), the presence of a stimulus which also acts as a reward for successful or as a consequence for unsuccessful performance, facilitates the learning process. For example, if increasing beta brainwave activity (to reflect a more
focused state) was the goal of biofeedback training, the task for the individual would be to keep his or her levels of beta activity above a set threshold. In some instances, along with the displayed visual representation of this brain activity, the individual would also be presented with a stimulus such as a video. Whether the video continuously plays depends on the individual’s ability to keep beta brainwave activity above the threshold. If enough beta activity is present, the video will play. However, failing to activate enough beta brainwave activity will cause the video to pause, acting as negative reinforcement for the individual to try and reach the desired goal.

Since biofeedback training is guided by operant learning principles, it would be expected that the individual carry a degree of subjective awareness for learning to occur (Dunn et al., 1986). Therefore, introducing and applying the idea that the context, (i.e., the circumstances that form the setting for an event, circumstance, or idea, Dictionary.com) impacts the overall process of learning and awareness within biofeedback may hold potential significance. From an applied sports perspective, the role that context plays in biofeedback training is one that has the potential to facilitate the overall learning process, since the training experience would occur in conditions that are more relevant and relatable to by the individual or athlete.
Learning and Context – Significance to Biofeedback Training

The broad use of the term *learning* refers to the acquisition of new or modification of existing knowledge, skills, and values through experience and/or practice (Dictionary.com). *Contextual learning* extends this broad term by suggesting that when our experiences and practice takes place within an appropriate and valuable context, the process of learning becomes more effective and meaningful (Westera, 2011). Various pedagogies, (i.e., the methods and practices of teaching), stress the importance of context in learning, and have done so for over a century. The term contextual learning likely originated from John Dewey’s (1938) theory of experiential learning. Dewey believed that for learning to be maximized, having authentic experiences was critical. Further, he believed that learning is contextualized and reflects real-life situations, and stressed the importance of the interrelatedness of concepts, ideas, and all things, rather than the things themselves. Like Dewey’s experiential theory of learning, more recent pedagogies exist that stress the importance of context in learning. *Action-learning* is a learning process that focuses on knowledge acquisition through hands-on practice as opposed to traditional classroom instruction (McGill & Beaty, 1995). *Problem-based learning* is another pedagogy that focuses on knowledge acquisition by developing flexible knowledge, intrinsic motivation, problem-solving skills, and self-directed learning (Hmelo-Silver, 2004). Problem-based learning also focuses on the development of collaboration and communication skills in that learners often work together in a group environment (Hmelo-Silver). *Situated cognition* is another context-based theory of learning that proposes that knowledge cannot be separate from action (Brown, Collins, & Duguid, 1989). That is, all acquired knowledge exists in activity bound to social,
cultural, and physical contexts (Brown et al.). According to this theoretical framework, learning is determined not by the amount of accumulated knowledge, but how that knowledge is put to use across situations. While the theoretical constructs within the various context-based pedagogies may differ, the consistency is that for learning to occur, information or knowledge must have meaning, and meaningfulness will only occur if that knowledge can be applied in relevant experiences. While traditional learning approaches bound the learning and learner, contextual-based approaches function with desire for learning to be mobile, for there to be a purpose, and for that purpose to be achieved through the transferability of knowledge directly to experience (Edwards & Miller, 2007).

The application of context-based pedagogies to optimizing sport performance through biofeedback training is critical for the development of biofeedback protocols. When considering the various technical demands that an athlete performs and the environmental demands that may be encountered, the idea of knowledge transferability from a biofeedback perspective is essential for this special population. Considering the potential for improving psychophysiological functioning and performance among athletes, the unfortunate reality for biofeedback training is that the laboratory setting, while hooked up to various electrodes and sensors, is not an ecologically valid representation of the environment in which the athlete performs. While necessary for the athlete to learn skills and strategies to control and modify their psychophysiology for the purpose of optimizing performance, it may be irrelevant or meaningless for an athlete to learn such skills in a setting that means nothing to them from a performance standpoint.
Over the last decade, advances in technology combined with the development of appropriate software tools have allowed for specific sport populations to experience biofeedback training in the context of their own sport. For example, stationary athletes such as marksmen and archers are able to perform biofeedback training while performing the same tasks as if they were in competition. Similarly, athletes who require great balance, such as gymnasts, can perform various performance tasks while the biofeedback sensors are attached to the gymnast and measuring physiological performance. Athletes who require quick reaction time in their respective sport have also benefited from recent developments in biofeedback software, as biofeedback protocols and training screens for baseball, soccer, and tennis have been developed to help train for better swing averages, penalty kick accuracy, and tennis serve return (Thoughttechnology.com). Despite these advancements, biofeedback training is still overwhelmingly conducted in laboratory settings (Andreassi, 2000), thus making it difficult to replicate the environment that the athlete performs in. Therefore, it is not surprising that biofeedback research in sport has focused primarily on closed skill sports, such as target sports (Collins, 1995). With ecological validity concerns surrounding both the practice and application of biofeedback training for sport populations, exercise-related psychophysiological and biofeedback research is in need of what Nitsch (1997, p. 22) refers to as “a spiral sequence of field and laboratory studies” (as cited in Blumenstein et al., 2002). In order to provide an environment and context that the athlete can relate to while performing biofeedback training, researchers must learn to adapt the typical laboratory environment through the use of simulations, virtual realities, and/or the various technological options that are widely available (Blumenstein et al., 2002). Doing so can provide the athlete with an
“off-field” experience that elicits psychophysiological responses more closely related to those when on the actual playing surface.

One application of technology-driven psychophysiological research comes from the stress management, anxiety management, and stress inoculation training of military personnel using virtual reality (VR) and computer simulation training. Various authors who have contributed to this research area have defined the impact of stress and anxiety as reducing operational effectiveness, information processing, focus of attention, and memory recall and encoding (Bouchard, Guitard, Bernier, & Robillard, 2011) all of which are critical for military operations. Further, stress and anxiety also directly influence one’s physiology and emotion regulation, impeding performance when emotional, cognitive, and behavioral control are required (Bouchard et al.). Therefore, the basis for the research by Bouchard and colleagues was to provide military personnel not only with the strategies and skills to effectively cope with potential stressful situations, but also to immerse them in such situations, through VR, so as to inoculate individuals to existing and future stressors.

The use of VR in stress management training has also been found in research aimed at different populations such as pre-school children and children with Down syndrome (Tarnanas & Manos, 2001), and medical personnel (Wiederhold & Wiederhold, 2004). In the first case, pre-school children and children with Down syndrome were trained using VR to evacuate a classroom in the event of an earthquake. Applied to medical personnel, VR was used to investigate performance differences between groups who received VR as opposed to those who did not, while tending to a wounded virtual person. In these cases, results indicated improved performance among
groups who were immersed in stressful situations through VR as opposed to groups who received non-VR training or no training at all. While this research illustrates the potential for VR and simulations to elicit genuine reactions in virtual stress and anxiety provoking situations, the improved performance that is reported in such studies suggests that providing a context that is meaningful to the individual, whether through VR, simulations or the use of other technologies, can facilitate learning by subjecting the individual to meaningful situations that cause psychophysiological reactions similar to the actual event. And while VR provides a useful means to portraying a valid environmental representation, various technologies can immerse the individual in the virtual environment to a different degree (Bouchard et al., 2011). This includes the use of head-mounted displays, motion tracklers, representations on computer and projector screens, and even the projection of stereoscopic images onto walls and ceilings (Bouchard et al.).

One area where video technology has been applied to enhancing the performance of sports officials comes from literature applied to the various decision-making processes and skills that officials require. Despite a popular belief that referee’s decisions and judgments in general are accurate (Brand, 2013), research actually suggests that a large percentage of referees’ decisions across sports are incorrect (Gilis, Weston, Helsen, Junge, & Dvorak, 2006; Mascarenhas, Button, O’Hare, & Dicks, 2009), especially when having to make decisions in problematic situations or environments (Plessner, Schweizer, Brand, & O’Hare, 2009). Regardless of the sport and context, sports officials rely heavily on the various pieces of information that are available to them at any given moment. This information often acts as a cue, guiding the official to decide whether to make a call versus not make a call, blow a whistle versus let play continue, and enforce
one rule versus another. Further, researchers suggest that the greater the relationship between the available information or cues and the decision-making options that are available to the individual (Brand), the more likely that individual is to make accurate or correct decisions (Goldstein, 2004). This suggestion has lead to the development of video-based training programs that aim at improving the decisions of sports officials, especially in contact situations (Schweizer, Plessner, Kahlert, & Brand, 2011). Further to this, Brand’s study indicated that when comparing to a common standard, video-training programs can teach expert referees to make accurate decisions. Research that has investigated the utility of these training programs requires the official to watch various videos online. Immediately after watching the video, the official is asked to rule on what they watched (i.e., penalty or no penalty) in which immediate feedback is then provided to them based on their decision. Generalized results from such research indicate that this training method is not only able to increase the amount of correct decisions by a sports official, but that referees who participate in this type of training made up to 25% fewer mistakes in a posttest than in the pretest (Brand). Findings from this and similar studies suggest that video-based training programs can teach sports officials to minimize the mistakes they make and instead make accurate decisions in ambiguous incidents (Brand).

Despite the long-standing existence of the utility of contextual learning in general, and the increasing use of virtual realities, simulations, and context-specific videos, little emphasis seems to be placed on context within the biofeedback training literature. Indeed, minimal descriptions of the specific training screens are given in reports of biofeedback training. Consequently, it is felt that incorporating context specific training screens may enhance biofeedback training. The development of such screens is the
Developing Biofeedback Training Screens

Creating a meaningful biofeedback training experience for ice-hockey officials can be formed through the development of contextual and meaningful biofeedback training screens. To develop these screens, Thought Technology™, a Canadian-based company that is a worldwide leader in biofeedback and psychophysiological software and hardware manufacturing, has developed software including the Screen Editor feature. The purpose of the screen editor feature within Thought Technology™ software is to allow clinicians, practitioners, and researchers the ability to either modify existing training screens created by Thought Technology™ or create new screens based on the demands and requirements of the individual or group seeking biofeedback interventions. The existing training screens are typically geared towards specific modalities of biofeedback or biofeedback training with the training stimuli and tasks dependent on the desired psychophysiological outcome. For example, if the goal is to produce positive changes in brainwave patterns associated with high levels of focus and attention, EEG biofeedback training screens are utilized. Feedback about brain activity is then provided on the screen in the form of a graph or line bar for the individual to see. Further, the training screen utilizes either a visual or auditory stimulus such as a video or ring tone. The purpose of the stimulus is to act as a reinforcement indicator for the individual’s success or failure on a given training screen. So, in the case of enhancing cognitive functioning through EEG biofeedback training, the individual’s ability to keep the
necessary brainwave activity at the desired level or threshold will determine whether the stimulus plays or doesn’t play, thus acting as the appropriate reinforcement. While many screens are geared towards one modality of biofeedback, others are developed to focus on training multiple modalities at once. For example, while the stimulus on a given screen may remain the same, the individual can train a combination of biofeedback modalities including EMG, BVP, HRV, SC, and thermal feedback. The more modalities being trained, the more feedback provided back to the individual as it relates to his or her physiological functioning.

**Creating channel sets.** The first step to developing fully functional biofeedback training screens is to create channel sets. A channel set refers to the communication between the biofeedback software and both the physical and virtual channels that exist on the hardware encoder. The physical channels are the actual number of channels displayed on the encoder while the virtual channels are created by running the physical channels through specific algorithms within the software. Virtual channels are responsible for outputting specific data such as the mean, maximum, and minimum rates, and other more complicated data. There are approximately 250 virtual channels available for any developed channel set. For a channel set to be created properly, step-wise calculations are applied to raw signals and are recorded by the given sensor or electrode that the individual is hooked up to (i.e., EEG). The calculations applied to the raw signal allow outputs of relevant numbers such as SMR and theta amplitude means, maximum, and minimum values, or whatever specific data are required that exceeds the capabilities of the raw signals. In terms of how the channel sets are computed and made relevant for the client or patient, there are a number of steps or layers that occur in a specific order.
First, the raw signal (i.e., EEG) is taken. Next, a specific filter is applied to that raw signal in order to narrow the focus as to what piece of data is desired. For example, a filter on the raw EEG signal might be applied to examine only the 4-8Hz range of theta. The way that this filter computation is typically named or identified by the software might be “Theta 4-8” or “Theta IIR.” While this 8-10 Hz filter range is useful to the practitioner or clinician, this number still isn’t considered to be a “relevant” number and thus is not presented to the individual in this form. It would simply look like a waveform in a line graph, moving or jumping above and below the zero-axis on the graph. The next computation or layer that is required is to apply a “peak-to-peak amplitude” so that the specific filtered range (4-8 Hz) can be transformed into a ultraviolet (uV) amplitude number, which is relevant to the individual staring at the screen. For example, the 4-8Hz filter would become the peak-to-peak amplitude, since this amplitude is based on peak-to-peak differences or changes in the waveform. It is this specific calculation that can be displayed in the form of a bar or line graph with thresholds for training, and is also linked to the feedback provided back to the individual. It is anticipated that only after trial training sessions with the officials occur, will decisions about virtual channels and calculations to include and not include be made.

**Creating screens.** Once the channel set has been created and configured, the next step is to create the training screen. The screens refer to what the individual sees while hooked up to the various sensors or electrodes. The screens indicate which data are actually outputted for the individual and in what form. Further, the screens often utilize a stimulus, typically in an auditory or visual form. The stimulus often acts as a reinforcement tool, telling the individual that they are either succeeding or failing at a
given training task or activity. For example, the purpose of a training activity may be to minimize or inhibit theta (4-8Hz) brain wave activity while at the same time maximizing or rewarding SMR (13-15Hz) activity. In this case, the individual might see two bar graphs representing each brainwave state. Within these bar graphs, the practitioner or clinician would set thresholds, so as to give the individual a visual target or goal for keeping brainwave activity above or below the set threshold. In addition to the two bar graphs, the individual might also be provided with an image or short video acting as a visual stimulus. If the individual is able to keep the designated brainwave levels above or below the desired thresholds, the individual will receive positive reinforcement in that the image will remain clear or the video will play. Conversely, if the individual is unable to meet the desired threshold levels, the individual receives negative reinforcement in that the image will become distorted or the video will stop.

As it relates to this research project, the screen creation aspect of the screen building process is considered most critical since it is believed that a large part of implementing contextual relevance into the biofeedback training experience will come from adjusting the visual and auditory stimuli, as well the training tasks and activities wherever possible. More specifically, by adapting the more generic training videos, images, and auditory reinforcement tones into more meaningful ones, as they relate to the hockey official’s on-ice experiences.

**Creating scripts.** Once the channel set and screens have been developed, the last step is to create a script, which refers to a specific set of screens placed in a specific sequence and in a timeline. Scripts are most commonly utilized when the biofeedback practitioner’s protocol is geared towards specific modalities of biofeedback training.
Instead of selecting screens individually, selecting the script will initialize not only specific training screens, but will also place those screens in a specific order to be played for a pre-determined amount of time. The alternative to using scripts is to select the screens individually, through what is referred to as open display mode. Selecting this mode allows practitioners or researchers the ability to select screens individually, however the session settings that can be saved within the script mode are required to be set or changed each time the screens are selected. For example, after progressing through initial training sessions, it may be determined that the official’s training protocol will focus on the EEG biofeedback modality. As a result, several EEG training screens that focus on training different brainwave states might be used to construct the official’s EEG training session. Additionally, within each screen, thresholds and any additional settings are saved from session to session. In contrast, if the official’s EEG training session was created as an open display session, the screens to make up the session would have to be selected individually and the screen duration and thresholds would have to be set for each screen, each time it is utilized. Additional benefits of script versus open display sessions include the ability to access and export various types of data. Script sessions allow for the ability to run specific calculations on a single session or group of saved sessions (i.e., for a patient, athlete, official) and export the data into a Microsoft Excel or Word format. This is particularly beneficial for providing visual reports of progress to the client or using them for research purposes. Similar to the expectations for determining or modifying specific channel sets, it is anticipated that only once officials begin training will the development of scripts become more useful.
Research Delimitations

Sports officials have yet to receive the same attention as athletes when it comes to biofeedback training. As a result, it is necessary for this paper to include information about how biofeedback training methods and previous research has been applied to athletes so as to gain insight as to the potential utility towards improving the on-ice performance of ice-hockey officials. With that in mind, it is also necessary to describe the boundaries that have been set for this research study. The focus of this research project is only to develop the first known context-specific biofeedback training screens applied to hockey officials. It is not a study about the impact of biofeedback training on hockey officials or officiating performance and in no way attempts to measure any psychophysiological changes as a result of biofeedback training. It is believed that the first and necessary step to applying biofeedback training to enhancing officiating performance is to create a context and learning environment that is relevant to the hockey official. As the scope of this thesis, it is anticipated that future research applied to investigating the potential benefits of using biofeedback training on hockey officials will be more suitable by utilizing biofeedback training screens and stimuli that are meaningful to the official.

Research Objective

The purpose of this research is to develop context specific biofeedback training screens for the application to ice-hockey officials. In order to ensure the ecological validity of the final screens, it is imperative to include officials as active agents (Sherif & Sherif, 1969) in their development. As will be described in the next section, this goal was accomplished in two ways. First, on-ice, first person video footage depicting various
real experiences of hockey officials was obtained. Second, officiating supervisors and mentors were consulted as to the best way to use the video. This process culminated in the development of biofeedback training screens for ice hockey officials.
Method

The development of context-specific biofeedback training screens resulted in several procedures falling under three key methodological steps, including: (a) video collection, (b) focus group, and (c) biofeedback screen development. The process of collecting video included all activities relating to acquiring potential video footage to be used within the biofeedback training screens. The focus group was conducted with “experts” of officiating to indicate those types of video clips to look for within the video collection and the purpose for using the clips as they relate to both biofeedback training and enhancing officiating performance. The final step was to create all components of the biofeedback training screens while taking into consideration the analysis of the focus group results and the follow-up discussion with hockey official supervisors and contextual experts.

As part of her larger program of research, this project’s supervisor has been collaborating closely with a contextual expert from the Saskatchewan Hockey Association’s (SHA) Officials Division. This individual has had 12 years of experience as an ice hockey official with 18 years as a supervisor. He has held numerous roles in the SHA Officials Division. All decisions were made through consultation with him and in some instances other members of the SHA and SHA Officials Division.

Video Collection

Working in collaboration with the SHA, permission was granted to involve officials from the Saskatchewan Prairie Junior Hockey League (PJHL) for the purpose of
obtaining on-ice, first person video footage. Prior to approaching the SHA, it was determined that it was necessary to obtain video footage from a level of hockey that included a high intensity on the ice, so as to provide good examples of rule enforcement, communications with both players and coaches, and other examples where decision-making processes are required. The purpose of collecting video footage from a first person perspective was to substitute the somewhat generic video stimuli within existing biofeedback training screens with something more meaningful and relevant to the officials. By subjecting officials to game-like situations that depict their real, on-ice experiences as best as possible, it is believed that the official will have a more positive biofeedback training experience. Ethics review was not required for this portion of the project since all video footage involved naturalistic observation in a public environment where there is no expectation of privacy. It was made explicitly clear that the video was in no way to be used for anything other than screen development.

Upon receiving approval from the PJHL, a letter (see Appendix A) was distributed by the SHA via email to any participating team’s coach to provide a summary of the research project and to indicate why the officials would be wearing a helmet camera. In addition to receiving consent from the PJHL and providing the necessary information to coaches, a media release form (see Appendix B) was created, signed by both representatives from the SHA and PJHL, and distributed to each participating official. By signing this form, each official agreed to (a) wear a helmet camera for the duration of the game, (b) have any potential footage appear in a biofeedback training protocol, and (c) have this video potentially appear in research publications and conferences. Further, the media release form also clearly identified that any of the
acquired video footage would never be used for performance evaluation purposes and specified that while any potential video may be used for developing biofeedback training protocols and for future research, only members of the research team are to view the video footage in any other circumstance. As a compensatory measure, each participating official had his or her own video footage burned to a digital versatile disc (DVD) and distributed to the officials at the end of the video collection period. The DVD’s were dropped off at the SHA head office, to be provided to the officials accordingly.

The method for developing context specific biofeedback training screens applied to hockey officials was through the acquisition of first-person video, portraying the various on-ice experiences of hockey officials. Both referees and linesmen were outfitted with Contour™ 1080p helmet cameras, in an attempt to capture first person, on-ice footage of any factors that contribute to successful officiating performance and experiences. Approximately one hour before the start of each game, the researcher met the participating officials in their locker room to prepare for the on-ice video recordings. This included mounting a camera onto each participant’s helmet, ensuring each camera was fully charged, and any additional testing to ensure the cameras were ready for recording. Each fully-charged battery provided approximately two hours of continuous recording. As a result, during each intermission, recordings stopped in the locker room and the existing batteries within each camera were swapped out with fully-charged ones for the upcoming period. With this starting and stopping process for every period, each official had three separate video files (one for each period) approximately one hour in duration, for each officiated game. In total, 15 hockey games were recorded and approximately 130 hours of on-ice footage was collected.
**Video analysis – first stage.** The purpose of the initial video analysis was to perform a preliminary investigation of the acquired video. With 130 hours of acquired video footage, the intent of the first video analysis was to (a) locate any video files that were to be excluded (i.e., due to bad camera placement, technical difficulties with the camera, blurry video, etc.), (b) to identify video files that exhibited occurrences of made or missed calls (i.e., rule enforcement), and (c) to locate physical and/or verbal altercation between players, coaches, and officials.

**Focus Group**

The purpose of the focus group was to gain insight from professionals in the field of hockey officiating as to how (or if) biofeedback training could be considered a useful tool for the development of hockey officials. In order to achieve this goal, one of the first steps was to gain a clearer understanding of the various skills and abilities, cognitive processes (i.e., decision-making, focus, etc), and any physical, cognitive, psychological, and personality requirements that are considered essential to the hockey official. Before this process was begun, an application was submitted to and approved by the University of Regina’s Research Ethics Board (see Appendix C).

It was anticipated that the information received from the focus group would inform the researcher as to the type of behaviours to be targeted within the video segments. For example, if the analysis of the focus group responses indicated that “having thick skin” is an important quality for a hockey official to possess, the researcher’s focus within the video segments may be to locate examples where the official is engaged in a verbal altercation with players and/or coaches. By including
contextual experts (i.e., experts in hockey officiating) as focus group participants, the researcher was able to perform an objective analysis of potential video segments rather than an analysis based on speculation and assumption as to the various factors that impact officiating performance. It is not sufficient for the researcher to assume any behavioural and cognitive processes (i.e., decision-making, focus, etc.) that are necessary and important to the official’s successful on-ice experiences. The focus group was audio recorded, transcribed, and then analyzed by the researcher.

**Recruitment, location, group size, and length.** Hockey official supervisors and mentors within the SHA were invited to participate in the focus group, held at the University of Regina. Of the ten invitees, four individuals accepted and were open to sharing a variety of viewpoints as they related to both biofeedback training and officiating performance. Considering the open-ended nature of the discussion, the focus group duration lasted approximately two hours. The participants shared a range of officiating roles including officiating at a high level at both provincial and national levels (i.e., Western Hockey League, Saskatchewan Junior Hockey League), and acting as a supervisor or mentor for developing younger, less experienced officials. Further, each participant carried a minimum of ten years officiating experience.

**Facilitator and observer.** The roles of a facilitator and an observer were implemented and shared (between the primary research and researcher’s supervisor) during the focus group. The role of the facilitator was to ensure the discussion remained on task while opposing views and ideas were heard. The role of the observer was to supplement the audio recording of the focus group by taking notes during the discussion,
focusing on any non-verbal cues that offered any assistance in any informative matter (i.e., where agreement existed between participants).

**Question design.** The format for the focus group was of an informal, casual conversational style (Patton, 2002). Very little sequence or form of questioning was involved in hopes of facilitating an opinionated discussion among the participants. Since it was expected that participants would have little to no prior experience with or knowledge of biofeedback and biofeedback training terms or methods, the focus group started with a general discussion about biofeedback and how it is believed to be applicable to hockey officiating performance from an “outsider” perspective. By providing them with this information, participants were better equipped to offer their insight as to not only how biofeedback training could be beneficial to the hockey official, but also to further elaborate on those essential officiating skills, cognitive processes, and psychological requirements that they believed could be enhanced through biofeedback training.

**Informed consent.** Similar to most focus groups and related in-depth interviews, participants were required to share information that if misused, could potentially leave them vulnerable (Fraenkel & Wallen, 2009). Therefore, to protect participants and interviewers from any misunderstandings, all participants were required to give their consent prior to initiating the focus group. Included within the consent form was information about the research purpose, procedures, potential risks and benefits, issues of confidentiality, storage of data, right to withdraw, and follow up measures (see Appendix D).
**Data collection.** The responses from the focus group participants were used to determine those video segments to be used for the development of the biofeedback training screens. For example, if the participants were to indicate that the ability to communicate effectively with players and coaches is a necessary skill for an official to possess, video clips that involve various forms of communication between officials and players or coaches, including any explanation of rule enforcement as well verbal altercations may be pulled from the video collection. It was also anticipated that the focus group discussion would provide valuable information not only to the various officiating skills, abilities, and behaviours that are important to successful officiating performance, but also how those skills, abilities, and behaviours could be improved using biofeedback training.

**Data transcription, coding, and analysis.** The audio recordings were transcribed, coded, and analyzed by the researcher with the intent of identifying key concepts, ideas, and themes relating to hockey officiating performance and biofeedback training. FS-USB Pro Encryption System was used to transcribe the 90-minute audio recording, resulting in a 30-page document. As it was addressed with all participants prior to beginning the focus group, all information documented within the transcription provided full anonymity to each participant by using a pseudonym (i.e., P1 for participant 1, P2 for participant 2, etc.) for each response. The transcription provides a verbatim review of the focus group as it relates to the development of biofeedback training screens and any discussion unrelated to the research project was excluded.

Once the transcription was completed, *content analysis* was used to make sense of the information as well to identify core consistencies, themes, and any meanings (Patton,
related to the research project. With the nature of the discussion and considering there were four participants, recording the frequency of certain responses, themes, or constructs was not essential, instead focusing on the group’s individual and collective beliefs surrounding questions relating to both biofeedback training and its utility for enhancing officiating performance. As a result, when coding the various responses, thematic categories that represented the topic of conversation (i.e., the importance of audio and visual stimuli within training screens; performance areas that could be improved through biofeedback training) were created and any relevant responses were placed within each category (see Appendix E). Further, the analysis provided valuable information as to the types of videos to be relevant within the biofeedback training screens. For example, if it were suggested that officials require “effective communication skills” when dealing with the players and coaches, clips depicting the various communicative processes between officials and players and coaches throughout would be targeted among the video collection. Categories of video segments were created so as to organize specific depictions accordingly. For example, a folder was created containing only video of communicative processes between officials and players and coaches, a separate folder containing video of enforcing rules, a separate folder of video that depicted situations that require quick and accurate decision-making, and so on. The goal of this process was to identify the best representations (based on the analysis of the focus group responses) of those video clips to be used for the development of the biofeedback training screens. Further to identifying potential video segments, using content analysis allowed for identifying additional information beneficial for creating an authentic biofeedback training experience. This included any information pertaining to
the various skills and abilities that participants believe biofeedback training could improve, as well any ideas relating to biofeedback training tasks or exercises, and context-relevant stimuli outside of the previously acquired video.
Biofeedback Screen Development

Training for developing training screens. Considering the technical requirements for developing the biofeedback training screens, a 6-hour intensive training course through Skype and GoToMeeting was provided by Thought Technology’s™ workshops department. The purpose of the training course was to educate members of the research group on the various steps and considerations for developing channel sets, screens, and scripts as they relate to the overall training screen development. To avoid any ethical misconceptions or confusion between the researcher and Thought Technology™, information as to both the overall research project and utilized audio and visual stimuli was kept to a minimum. Prior to beginning the training course, the researcher selected random and non-applicable video clips to be used for training and as a replacement for the actual first-person video clips of the officials. As a result, Thought Technology™ was not required to consign to keeping any aspect of the training course confidential.
Results and Discussion

With very little evidence to support the positive influence of biofeedback training on sports officiating performance, the purpose of the focus group was to gain insight from professionals in the field of hockey officiating as to how biofeedback training could be considered a useful tool for the development of hockey officials. Further, because the application of biofeedback training has been investigated primarily in athletes of the game, focus group participants were able to elaborate on various factors to be considered for the development of a biofeedback protocol, including the various performance areas of hockey officiating that they believed biofeedback training could enhance or improve.

Based on the theoretical foundations provided from contextual learning pedagogies, on-ice, first person video was captured for the purpose of adapting the more generic biofeedback training screens and experience into a more contextually relevant one by incorporating the video into the existing biofeedback software. As a result, participants discussed the types of clips they believed would not only be relevant, but that would also create as authentic a training experience as possible.

The results of the focus group can be categorized as falling under the umbrella of either the development of the biofeedback training experience or the application of biofeedback training to enhancing officiating performance (Appendix D). Following a brief introduction into the role of context in learning, participants acknowledged that the role of context and authentic experience is critical, suggesting the importance of accuracy of the training experience compared to the real game. Further, that when the use of instructional videos are used as a training tool for officials, those that include the build-up
of the play (i.e., big hits, scrambles in the corner, close offsides) rather than just positional video such as skating around or away from the puck, are more relevant and engaging. Participants also indicated that adding in a physical activity component to the biofeedback training protocol (for example, to simulate the fact they are constantly moving on the ice) would further distinguish the authenticity of the training experience. However, participants also suggested that doing so within biofeedback training would likely be more beneficial if added in as a progression to their overall training experience. Meaning, that progressing into a physical activity task would be most beneficial only after spending a sufficient amount of time at more introductory stages of training (i.e., learning how to become aware of and control their physiology).

Development of the Biofeedback Training Experience

The discussion about the development of the biofeedback training experience focused primarily on determining how the earlier obtained video clips could be implemented into the biofeedback training screens, as well other considerations for building the screens such as training activities and tasks. From the discussion, consensus confirmed the earlier stated belief that in order to create a contextually relevant training experience, it is necessary for more “thought-inducing” or “borderline” situations to be presented rather than video of the official following the play with nothing happening. That is, if the purposes of the videos are to induce a physiological reaction, it was considered necessary to include videos that portray areas of officiating that are required to be a successful official (i.e., communication with coaches, accuracy of calls, reaction time). Participants also indicated that the role of an auditory stimulus may be just as
useful and relevant to the overall training experience as the visual stimulus provided by the videos. More specifically, participants suggested that it is often the sounds around them on the ice that put them in the “zone” or a “specific state of mind” and that the “reaction of the crowd, players, and coaches is just as likely to trigger some kind of physiological response.” While participants talked specifically of extreme auditory examples of coaches berating the official for made or missed calls, or specific instances of parents and fans screaming an obscenity, they also emphasized the role of a more generalized noise, that “having a general crowd noise in the background (much like at the rink) would further make the training experience more authentic.”

**Application of Biofeedback Training to Enhancing Officiating Performance**

The remainder of the focus group discussion focused on identifying and understanding how biofeedback training could be applied to improving the on-ice performance of hockey officials. From the discussion, participants identified four key performance areas believed to be not only essential to successful officiating experiences, but also that “differentiate good from not-as-good officials.” The four key performance areas identified were (a) communication and conflict resolution, (b) judgments and decision-making, (c), consistency, and (d) effort and work ethic.

**Communication and conflict resolution.** Participants indicated that communication, as it relates to effectively relaying information to both coaches and players, in particular as a means of conflict resolution, is an important quality for a successful hockey official to possess. When asked to elaborate more on the idea of conflict resolution, participants emphasized the power that communication has to “bring
the intensity level down”, “maintaining composure”, “being up front and direct with (your) message”, “calm things down and relax”, and “talk level-headed.” Participants further discussed the implications and potential of using biofeedback training to improve communication and conflict resolution skills. It was suggested that the first person videos could potentially be useful for inducing reactions that are most commonly experienced while on the ice. For example, the ability to “simulate situations where the official skates up to the bench and the coach steps down to blast the official” would be beneficial as it would “allow the official the opportunity to practice responding in certain situations.” The one drawback to this idea however, is that participants believed that without a live or real scenario, it would be difficult to replicate the emotion and intensity of the given situation. Meaning, if the official isn’t experiencing or being exposed to the emotions of genuine, on-ice situation, it would be difficult to activate those same emotions and cognitions in a different setting. Finally, participants strongly suggested that younger, less-experienced officials would benefit most from communication and conflict resolution training due to the multi-referee system that is most commonly implemented. That is, when two officials are on the ice, it is often the senior, more experienced official who takes the lead and is responsible for all communications with coaches, often leaving the less-experienced official sheltered from any conflict and uncomfortable situations.

**Judgments and decision-making.** Another performance area that participants believed biofeedback training to be useful for hockey officials stems from the various judgments and decision-making processes that are required by the official while on the ice. With the constant pressure to make quick and accurate decisions and enforce the
various rules of the game, participants suggested that including training tasks and activities that require quick and accurate judgments would be beneficial. For example, incorporating an “Is it or isn’t it?” type of training activity where the official is shown a video segment or series of clips and is required to make the correct calls or decisions. When asked about the types of video clips considered relevant for this type of activity, participants suggested to look for situations within the video collection that include “deciding whether to blow the whistle to stop play versus let play continue, close calls at the blue line (offside versus no offside), and situations where the type of penalty being called is not clear (i.e., check from behind versus boarding).”

Consistency. Consistency is a performance factor that participants suggested would be valuable to investigate from a biofeedback training perspective. Participants indicated that one of the largest complaints that coaches and players have with officiating has to do with the inconsistency in how games are officiated from person-to-person. Specifically, that the combination of refereeing styles, demeanors, and personalities all contributed to inconsistency in terms of how certain plays were called and others weren’t called. As a result, participants noted that “looking at consistency both within the official and between officials would be a useful tool.” For example, to understand where differences exist between officials in terms of making accurate decisions or how stress and conflict situations are managed would be exceptionally useful in terms of official development.

Effort and work ethic. Finally, participants indicated effort and work ethic as performance areas that are essential to positive officiating experiences. From a biofeedback training perspective, participants suggested that the potential utility for EEG
biofeedback training, especially if there was any way to relate mental processes and higher brain functioning such as concentration, focus, and preparedness to the official’s work ethic and amount of effort they expend. For example, participants indicated that being able to understand why the official “didn’t skate hard” (into the play) or why the official “skated hard into a zone when he shouldn’t have” as it relates to brain functioning, would be extremely interesting and beneficial for official development.

**Video Analysis – 2nd Stage**

Once the focus group results were analyzed, the video segments/clips from the earlier performed video analysis were further analyzed to determine their relevance and applicability to incorporate within the training screens. As a result, it was during this process that clips were labeled as effective or ineffective, removing those that deemed as ineffective from the video library. Further, the overall video collection was revisited to ensure that no relevant video segments, based on the responses and results of the focus group, were missed. From this analysis, 30 video clips were identified to be examined by contextual experts. The 30 clips ranged anywhere from 90 seconds to approximately five minutes. The selected videos depict a variety of situations that focus group participants identified as important to officials’ successful experiences on the ice. This included instances of increased physical play behind and at the net, fighting, enforcing rules, and calling penalties, and in some cases exchanging words with both players and coaches. Since the average time taken in between a whistle and subsequent puck drop is approximately 10 seconds, the majority of selected video clips encountered a brief stoppage, most typically for an offside, or covered puck by the goaltender after a save. Regardless, the selected video clips depicted more “extreme” situations rather than
instances where the official is simply skating along with the play with very little going on around him or her.

Further to the analysis of the acquired video, the results of the focus group suggest that an official’s on-ice performance is just as heavily influenced by what he or she hears as it is through what he or she sees. That is, that the role of an auditory stimulus may be just as influential on officiating performance when compared to the role of a visual stimulus. Therefore, it was determined that in addition to adapting the visual stimuli within the biofeedback training screens, context-specificity would be further obtained by incorporating relevant auditory stimuli into applicable training screens as well. To accomplish this, a number of sound effects and sound file websites were researched for the purpose of identifying sound effects files that best represent relevant auditory stimuli as indicated in the focus group discussion. As a result, sound effects for general crowd noise or ambience within a hockey rink and effects for crowd responses to bad calls (i.e., booing) were sought after and found on a website named www.sounddogs.com. Within the thousands of sports-related sound effects files, this website contained several excellent examples of general ambience within the crowd as well on the ice. The general noise on the ice includes the sounds of skating, sticks slapping, and muffled communication from players. The sound effect files portraying more intimidating crowd situations include a more rowdy and boisterous crowd presence with distinct “booing” and hostile remarks directed towards the officials. While the selected video clips also include full audio within each clip, the majority of audio recordings are either unclear or contain an ambience-like background that does not fit the description provided by focus group participants, therefore rendering them as irrelevant.
Confirmation of Video Segments by Contextual Experts

Once the 30 video clips were distinguished from the original video collection, face validity was required and provided through the original focus group participants and contextual experts. Prior to using the video segments to create the biofeedback training screens, it was deemed necessary to receive confirmation and approval that the video segments depicted what they intended to depict. As a result, selected video segments were provided to the original group of contextual experts (i.e., supervisors and mentors) to confirm and rate the quality of the video segment as it relates to its intended usage.

Four focus group participants were contacted through email requesting their involvement in this stage of the research, with two of those participants replying and confirming their availability and willingness to participate. Due to scheduling conflicts, two separate individual interviews were held, one at the SHA office and the other through email conversation. Prior to engaging in any discussion, participants were provided with an update as to the progress of the research and a fully detailed report on the results and conclusions drawn from the focus group discussion. Further, both participants were reminded of and provided with a copy of the consent form so as to clearly establish the need for their involvement at this stage of the research project. For the session that was held at the SHA head office, permission was received to audio-record the session in case any new and relevant information pertaining to the research project was provided. After discussing some of the focal points within the results of the focus group, participants were shown or provided selected video clips and given an explanation as to the researcher’s beliefs for what the clip illustrated. Since the majority of the selected video clips exemplify similar occurrences and combinations of hitting, scrums after the whistle,
and end-to-end action, only a few examples of believed to be applicable video clips were revealed to the participants. Participants confirmed that the provided clips did illustrate situations that are important for measuring officiating performance, thus making them relevant to the biofeedback training experience. In addition, while the acquired sound effects were not a part of the follow-up interview, the participant from the SHA session revisited the earlier discussed notion (during the focus group) that what an official hears is just as likely to induce a reaction or response as what he or she sees on the ice. When asked to clarify, the participant indicated that anything from the coach berating the official to the general ambience of the crowd or lack-thereof all have the potential for influencing the way the official carries himself and various aspects of officiating performance. It was this revisited idea that confirmed the necessity for utilizing audio stimuli in conjunction to the video clips within the biofeedback training screens.

**Completed Biofeedback Training Screens**

When creating the training screens, it was understood that with very little support from previous research or previously designed biofeedback protocols, there would be a few components of the training screen development left to be determined. Specifically, there is nothing to indicate those modalities of biofeedback training that are most important or relevant to enhancing the on-ice performance of hockey officials. With an understanding that additional training screens will be created and implemented as training with the official progresses, 12 trial biofeedback training screens were created utilizing the most commonly trained modalities applied to athletes. This includes screens for HRV, Respiration, EEG, EMG, and Temperature modalities of biofeedback. Further, it is
anticipated that valuable information pertaining to both channel sets and scripts will emerge once training with an individual official has commenced. As a result, the created channel sets for the training screens adhere to the standards of existing channel sets that are currently being applied to enhancing the performance of athletes.

**Created channel sets, screens and scripts.** As it was mentioned earlier in this paper, creating the appropriate channel sets and scripts for a biofeedback training protocol applied to hockey officials will likely be done only once a trial period with officials has been completed. With the flexibility for creating and modifying existing channel sets and scripts, a standard and commonly used channel set and script was incorporated into the 12 created training screens. As for creating the screens, the video segments derived from the focus group and confirmed by contextual experts were saved into a file folder within the biofeedback software. Saving the video files within the software allows for their use not only within newly developed training screens, but also to replace the more generic videos and images within the existing biofeedback training screens. As a result, the 30 video files ranging anywhere from 90 seconds to five minutes were saved into the software. In addition, the six sound effect audio files were also saved, allowing them to be interchanged, similar to the videos, within any given training screen.

**Purpose of contextual video and audio stimuli.** The purpose of the selected first person, on-ice video clips and sound effect files was to create a more meaningful and relevant biofeedback training experience for hockey officials. Based on the foundations provided from context-driven learning theories and pedagogies, it is believed that the more meaningful and applicable the learning and training experience is, the more likely
the official is to not only take away from that experience, but to also apply it directly onto the ice. Similar to those more generic training screens, the purpose of the video and auditory stimulus within the training screens remains the same. Following the same positive and negative reinforcement guidelines that apply to the majority of training screens, the videos and sound effects will be used as a prompt to indicate whether the official is succeeding or failing at a given training exercise. In the case of the screens that utilize the video clips, the ability of the official to keep the biofeedback modality threshold at the desired level or not will determine whether the selected video plays (positive reinforcement) or stops/pauses (negative reinforcement). Conversely, if the sound effects files are being used as the stimulus for a given training exercise, the official’s success or failure will determine whether they hear a more generalized crowd noise or ambience as opposed to the remarks of a more hostile crowd, with loud and distinct presence of “booing” and other negative connotations. Since the video clips and sound effects are relevant to the official’s officiating experiences, it is believed that this will ultimately benefit them both within biofeedback training sessions and when dealing with similar situations on the ice.

**Created training screens utilizing video clips and sound effects.** All 12 created training screens are provided in Appendix F. To illustrate and describe both the stimulus and accompanying physiological measures, we can examine the construction of both a video and audio-based training screen. For example, upon closer inspection of Figure 1, we can see that the modality of biofeedback is respiration training, and that the training screen utilizes a video clip as the acting stimulus. To the top right side of the screen is a bar graph that is measuring the individual’s respiration rate, or breaths taken
per minute. The result of this one physiological measure then calculates and displays other information pertaining to the individual’s respiration rate including mean, minimum, maximum, and standard deviation values. Below these four calculations are two line graphs, both which provide similar information but in a different form. The top bar graph displays any fluctuations in respiration rate every three seconds while the bottom graph with a solid orange line is a respiration pacer, which challenges the individual to try and synchronize or “pace” both the inhalation and exhalation of a single breath. What is important to note within this training screen is that the video stimulus is being controlled entirely by the individual’s ability to control his or her respiration rate as displayed in the bar graph. With the threshold set at a specific value, if the individual is able to keep this rate below the threshold, the video will play. Failure to do so however will cause the video to pause, reinforcing the individual that he or she is failing at the given task or activity.
Figure 1. Respiration training screen utilizing on-ice, first person video clip as the stimulus.
Figure 2 provides an example of a training screen that utilizes sound effects as an audio stimulus for EEG biofeedback training. The green and blue bar graphs are the focal point of this training screen, representing theta and alpha brainwave states. Enhanced theta brain activity is associated with a drifting, trance-like, and inattentive state while enhanced alpha brain activity is associated with a more relaxed yet concentrated state. As a result, the purpose of this training activity is to minimize or inhibit theta brain activity while at the same time enhancing alpha activity. The horizontal bar graph directly above the theta/alpha bar graphs indicates the brainwave state that is most dominant throughout the training exercise. The two outer bar graphs for ‘Eye Rolls’ and ‘Muscle Tension’ are EMG related measures and are relevant for identifying when occurrences of tensing muscles, clenching the jaw, or rolling of the eyes causes irregular data or scores. The audio files are directly associated with the two brainwave bar graphs, rewarding the individual’s ability to inhibit theta activity and increase alpha activity. So long as the individual is successful with this task, a general ambience within the crowd or on the ice will play. As soon as one of the thresholds is not met, the sound effect will instantly change to a more hostile atmosphere, with distinct heckling and booing from the crowd or berating from a coach. If the official is able to return to the desired brainwave states, the audio file will again instantly revert to the more general crowd noise.
Figure 2. EEG training screen utilizing sound effects as an auditory stimulus.
While these two examples illustrate differences between stimuli within the training screens, it is important to mention that regardless of the training screen and tasks involved, both the audio and video stimuli are interchangeable within a given screen. For example, if the official performs EEG training using a specific video clip as the stimulus, the next time the official trains the same modality using the same training screen, the video clip can be substituted for another clip. Alternately, if the researcher feels the need to substitute a video clip for a sound effect file, this too is easily performed within the given training screen. In addition, both the audio and video stimuli can be activated at the same time within a training screen. In this case, the official’s success at a given training activity would determine whether the video plays or pauses as well as the type of audio feedback provided. The flexibility of the training screens is a huge benefit to a newly developed biofeedback protocol since it is believed that more video-based and auditory stimuli will be added into the software once a trial training period with the officials ends. Only at this point will researchers gain insight as to whether aspects of the developed training screens need to be improved or modified.
Implications of the Research

The implications of this research warrant acknowledgement from future research, applied, and educational perspectives. Without guidance from previously conducted research that has applied biofeedback training methods to enhancing officiating performance, the first step was to create a training environment or context that could be perceived by the official to be as highly meaningful and relevant as possible. It is believed that developing the software training screens, stimuli, and activities is a small, albeit crucial, component to the overall goal of enhancing the on-ice performance of hockey officials through biofeedback training; however, by creating context specificity as opposed to relying on the more generic training screens that are prominent within existing biofeedback training regimes, the hockey official may be better suited to develop an understanding of his/her psychophysiology as it applies to their officiating experiences. That is, if the biofeedback tasks, exercises, and incorporated visual and auditory stimuli within the biofeedback protocol are specific to the context of hockey officiating.

Research implications. From a research standpoint, developing a meaningful context for the officials is a critical first step to the overall goal of enhancing their on-ice performance. One of concerns or critiques that biofeedback and biofeedback training warrants has to do with the difficulty of transferring what is learned in a laboratory setting directly into real-life situations. In the context of sports officiating, concern then lies with whether and how easily the official can transfer his or her training experiences directly onto the ice. As a result, it is believed that creating the proper context or environment for biofeedback training is necessary to help facilitate this transference
among hockey officials. While this specific research is geared solely towards creating the biofeedback training screens, future research can focus on developing the biofeedback protocol as it relates to determining the number and duration of sessions, and how other sports psychology and mental training techniques can work in conjunction with and be implemented into the biofeedback training protocol. With the lack of support from existing research and literature on biofeedback applications to sports officials, future research and development in this area will require similar methodological considerations guiding this research project. Meaning, the application of biofeedback research and literature towards sports officials needs to utilize both a theoretical framework combined with the continued efforts to keep “experts” in the field of hockey officiating involved, so as to fully understand how biofeedback training can enhance their on-ice performance. Further, the implications of this research on future research will allow for the proposed research question and theoretical framework to be put to test. That is, that context relevance and meaningfulness within the biofeedback training experience is necessary to facilitate the benefits that biofeedback training has to offer. Research can be designed to compare performance increases or decrements both within and between groups of officials, where the treatment group will receive the context relevant training screens and exercises while the non-treatment group will receive the more generic biofeedback training experience.

**Applied implications.** With the development of the training screens, tasks, and activities completed, the next phase of research can commence, in that selected officials can progress through a pilot or trial period where the efficacy of the developed training components can be investigated. Since it is anticipated that very few officials carry any
degree of experience with biofeedback training, working one-on-one in a clinical setting
will be instrumental to further develop biofeedback protocols and programs as they relate
to enhancing the official’s on-ice performance. More specifically, working one-on-one
with the officials will provide valuable insight into:

- Structure of biofeedback training as it relates to number and duration of training
  sessions
- Modalities of biofeedback training that officials find most relevant to their on-ice
  experiences
- Additional mental training and sports psychology tools to be incorporated into
  biofeedback training
- How biofeedback training can be incorporated into the official’s overall training
  regimen (i.e., provided at clinics versus getting a commitment to come into the
  laboratory weekly)
- Developing tools to effectively measure whether biofeedback training leads to
  performance improvements on the ice

**Educational implications.** Focusing on the overall goals of biofeedback training
and the steps required to reach those goals, the educational implications are worth
mentioning even if they are not linked directly to the outcome of developing the
biofeedback training screens. While developing a relevant context for training is
believed to be an essential step, one of the most daunting challenges with biofeedback
interventions has to do with the processes involved including self-regulation and
awareness. Since the officials carry next to no understanding or experience with ideas
and concepts relating to biofeedback, exercise physiology, and psychophysiology,
facilitating knowledge acquisition surrounding these key areas will be essential to their success with biofeedback training. More so, it is believed that providing the appropriate environment and tools for learning how biofeedback and related concepts apply directly to their officiating performance will transfer directly to their training experiences. Since it is anticipated that the “buy-in” and commitment from hockey officials will be determined largely by how applicable they believe biofeedback training to be, diligence will be required towards providing tools, references, and instruction that are not only relevant but that do not lose the official with technical jargon and verbiage. For example, when creating the introduction to biofeedback and psychophysiology discussion at the beginning of the focus group, it was necessary to avoid any terms or explanations relating to biofeedback that could potentially confuse or “lose” the participants. This attention will be required with future biofeedback protocol development and training considerations for the officials.
Summary and Conclusions

The purpose of this research was to create a meaningful biofeedback training experience for hockey officials by creating context-driven training screens. On-ice, first person video footage of hockey officials’ game experiences were captured using helmet cameras, with the intent of finding relevant video clips to replace the more generic and seemingly irrelevant images or videos that exist within current biofeedback training screens and protocols. Since there is very little existing literature or research to suggest how biofeedback training could be applicable for sports officials, it was necessary once the video collection was acquired, to ask experts of hockey officiating to provide insight into the matter. Consequently, a focus group was held with an expert panel of hockey officials, consisting of supervisors, mentors, and elite officials within the SHA.

The purpose of the focus group was to gain an understanding from the officials as to how biofeedback training could be used to enhance their on-ice performance. Further, the discussion provided valuable and necessary information as to the types of video clips that could be implemented into the training screens, as well as other ideas pertaining to making the training experience more meaningful. It was no surprise that the participants carried little to no knowledge of biofeedback and related ideas surrounding psychophysiology. As a result, all participants were in agreement that a huge factor for determining the commitment level for engaging in biofeedback training would be the relevance of the training experience.

Once the focus group discussion was analyzed along with any relevant video clips, the clips were returned back to members of the focus group to confirm that they were strong depictions and were relevant to include within the biofeedback training
screens. In addition to the confirmed video clips, it was strongly suggested that an auditory stimulus was a necessary component to consider as well as the video. Six sample sound effect files were configured into the biofeedback software, consisting of various sounds and ambience that the focus group participants claim officials to be aware of while on the ice. Twelve biofeedback training screens were developed utilizing both video and audio stimuli.

While the boundaries and delimitations of this research study were discussed earlier, it is also necessary to specify potential criticisms as they relate to both the development of contextual biofeedback training screens and the future impact on officiating performance. First, one of the drawbacks to the methodology of creating a contextually-driven biofeedback experience for hockey officials is that research does not clearly identify the importance of context in existing biofeedback training software and protocols. That is, there seems to be a lack of support that applying context into the biofeedback training experience warrants any different training outcomes, as compared to a more generic, non-contextual training experience. However, this lack of support could potentially be reinterpreted as a lack of awareness of the potential for context-specific screens to enhance outcomes of biofeedback training.

When it comes to screen development, there is nothing in the literature to suggest that any aspect of creating channel sets, scripts, or screens is more beneficial over another. For example, there is nothing to suggest how long a video stimulus (i.e., video clip) needs to play within a given training screen and activity or the optimal number of training screens to be utilized for a given training session. Any assumption made with
these processes comes solely from existing training screens and activities within existing biofeedback protocols.

While the focus group participants indicated specific officiating performance areas that they believed biofeedback training could be used to improve or enhance (i.e., communication, conflict resolution, decision-making, effort, work ethic), research on biofeedback training hasn’t clearly demonstrated utility or effectiveness on influencing these areas, other than EEG’s impact on higher brain functioning including decision-making processes. Meaning, that improving on skills such as communication, conflict resolution, effort, and work-ethic have not been demonstrated or investigated in existing biofeedback literature and research. In addition, previous research has failed to identify how the key goal of biofeedback and biofeedback training, self-regulation, applies to any of these performance areas. So while officials themselves have identified performance areas that are essential to becoming a good hockey official, there is nothing to suggest (or refute) that those key areas can be improved using biofeedback training.

While this research is felt to be a critical first step, the implications of this research, as discussed earlier, are likely to be more prominent only after the officials are able to experience training first-hand. Decisions as to the number and length of sessions, additional screen and stimulus creation or modifications, and how other mental and related sport psychology training techniques can work in conjunction with biofeedback techniques are necessary to the success of utilizing biofeedback training to enhance officials’ on-ice performance. As it relates directly to this research, it will be essential to conduct a trial period so as to validate the efficacy of the developed training screens, especially as compared to the more generic biofeedback training screens and experience.
In closing, it is expected that, with the continued technological advances in biofeedback software and hardware tools, biofeedback training will become more meaningful and contextual for the official in the future. Even though it results in accessing and training fewer modalities of biofeedback, utilizing a two-channel wireless encoder will eventually allow officials to use biofeedback training while on the ice. It is anticipated that once the officials have a chance to learn and experience biofeedback training within the laboratory setting that this type of biofeedback training experience and option will be considered and implemented.
References


of anterior cruciate ligament-injured females during functional activities. Journal of
Athletic Training, 34(2), 121-129.

how to cope in crisis: The case of a virtual earthquake. Studies in Health
Technology and Informatics, 81, 495-501.


http://www.exrx.net/Psychology/EMGBiofeedbackStrength.html.

relaxation method. Unpublished correspondence from the Pyotr Lesgaft Academy
of Culture (Russia) and Rutgers Medical School, New Brunswick, NJ.

the evidence with implications for future research. Applied Psychophysiology and
Biofeedback, 30(4), 347-363.


Weiderhold, B. K., & Weiderhold, M. D. (2004). Virtual reality as a tool in early
interventions. Retrieved October 19, 2012 from

Leisure Press.

Wenz, B. J., & Strong, D. J. (1980). An application of biofeedback and self-regulation
procedures with superior athletes. In R. W. Suinn (Ed.), Psychology in sports:
Methods and applications (pp. 328-333). Minneapolis, MN: Burgess.

Appendix A

Letter to SHA and Officials
Dear Officials, Players & Coaches,

The University of Regina, with the complete acknowledgement and support of the Saskatchewan Hockey Association, is conducting a research study that entails understanding how a hockey official’s physiological activity impacts their ability to make decisions, enforce rules appropriately, communicate with coaches, players, and sometimes even fans – in other words, their officiating performance, using a tool known as Biofeedback.

What is Biofeedback?

Biofeedback refers to the idea that through self-regulation, an individual is able to consciously become aware of, and change their physiological responses to perform more effectively. Through the use of various electrodes and sensors, physiological responses such as heart rate, skin temperature, brainwave activity, and respiration, can be displayed on a screen for the individual to see with the overall goal of training themselves to change those responses to a more optimal level. Research has confirmed its usefulness for enhancing sport performance, relieving stress, alleviating pain, improving decision-making processes, increasing relaxation, and maintaining an overall optimal physiological state.

Why Hockey Officials?

While on the ice, the official has just a split second during the play, and often only 10-15 seconds in between whistles to take in all information and act accordingly by enforcing a rule or simply engaging in a conversation with both players and coaches. As a result, the physiological makeup plays a vital role in determining how certain situations and confrontations are approached and responded to. For example, when a conflict situation occurs, physiological arousal (such as stress) elevates. When these levels elevate, breathing becomes heavier and shallower, the heart beats faster, muscles become tenser, temperature decreases, and our hands become clammy and sweaty. When these things occur, the way we often respond is less than ideal. Biofeedback training allows for not only a concrete understanding and confirmation that specific physiological levels are associated with certain arousal, but is a way to train our physiological makeup to respond more optimally when those situations occur in the future.

Developing a biofeedback protocol specific to hockey officials has yet been done and has important implications from both a research and training standpoint. Most research in the
area of sport psychology focuses primarily on the athletes and coaches, neglecting officials as a participant of the game whose actions sometimes play as crucial a role as those of the players and coaches. This research study is the first of its kind that we know of (applying biofeedback to hockey referees) and is necessary for future research that will further investigate this application. Ultimately, this research hopes to create a foundation that will educate hockey officials to adapt the way they respond to on-ice situations in a way that enhances their performance and the game for all participants.

**What does the study involve?**

As biofeedback training becomes an increasingly popular training method for athletes, sport-specific training protocols are being developed in an attempt to bridge the gap between what is learned in a laboratory setting and how it is put to use on the playing surface. For example, biofeedback golf protocols have been developed that incorporate training screens that have the trainee watch critical putts with specific crowd noise playing in the background. It is believed that making the training screens relevant to the athlete is important since learning is often better achieved in situations that are close to as real as possible.

The purpose of this research study is to gather first-person video footage of common situations encountered by officials (referees and linesmen). Such examples include enforcing rules, calling penalties and goals, and the various communications and confrontations with players and coaches. Obtaining the appropriate footage will be achieved using helmet cameras, which will be provided and attached to the helmets of both referees and linesmen of the same game. The video footage will then be incorporated into existing biofeedback software to create a training atmosphere that better represents the experiences of the officials when on the ice.

The total number of games needed to obtain sufficient video footage has not yet been determined, with the first slate of games in which helmet cameras will be incorporated scheduled for the week beginning July 18, 2011.

We want you to know that we will only use clips from the video footage in the development of the training tool. We will not share any of the footage with the SHA the SHA’s Referee Division, the media, or anyone else without your consent. We are not interested in analyzing or evaluating your performance or any behaviors of the officials, coaches, players, or spectators.

If you have any questions about this project, please feel free to contact Adam Chomos at adam_chomos@hotmail.com or Dr. Kim Dorsch at Kim.Dorsch@uregina.ca.

We thank you for your participation and cooperation in this part of the project.
Appendix B

Media Release Form
MEDIA RELEASE FORM

Thank you for your participation in this research project. The purpose of wearing the Contour 1080p helmet cameras is to capture first person footage of your typical officiating experiences, with hopes of obtaining authentic accounts of enforcing rules, engaging in various communication with players and coaches, and any other examples of your typical game experiences. This captured footage has the potential of appearing within a biofeedback training protocol as designed by members of this research project. By participating in this study, you agree to:

- Wear a helmet camera for the duration of your game
- Have any potential camera footage appear in a biofeedback training protocol
- Have this video potentially appear in research publications and conferences

By agreeing to participate, you also understand that:

- Any of the acquired footage will never be used for performance evaluation purposes
- Outside of the above-mentioned intended usage, only members of the research team are to view the acquired footage in any other circumstance

Upon commencement of the video collection period, you will be provided with a DVD including all of your own personal video footage. Thank you for your participation

Name of Participant ___________________________ Signature of Participant ___________________________ Date ___________________________
Appendix C

REB Ethics Approval
DATE: May 13, 2013

TO: Dr. Kim Dorsch
  Kinesiology and Health Studies

FROM: Dr. Larena Hoeber
  Chair, Research Ethics Board

Re: Developing Biofeedback Training Tools and Protocols to Enhance Officiating Performance (File # 109R1213)

Please be advised that the University of Regina Research Ethics Board has reviewed your proposal and found it to be:

☐ 1. APPROVED AS SUBMITTED. Only applicants with this designation have ethical approval to proceed with their research as described in their applications. For research lasting more than one year (Section 1F), ETHICAL APPROVAL MUST BE RENEWED BY SUBMITTING A BRIEF STATUS REPORT EVERY TWELVE MONTHS. Approval will be revoked unless a satisfactory status report is received. Any substantive changes in methodology or instrumentation must also be approved prior to their implementation.

☐ 2. ACCEPTABLE SUBJECT TO MINOR CHANGES AND PRECAUTIONS (SEE ATTACHED). Changes must be submitted to the REB and approved prior to beginning research. Please submit a supplementary memo addressing the concerns to the Chair of the REB. **Do not submit a new application. Once changes are deemed acceptable, ethical approval will be granted.

☐ 3. ACCEPTABLE SUBJECT TO CHANGES AND PRECAUTIONS (SEE ATTACHED). Changes must be submitted to the REB and approved prior to beginning research. Please submit a supplementary memo addressing the concerns to the Chair of the REB. **Do not submit a new application. Once changes are deemed acceptable, ethical approval will be granted.

☐ 4. UNACCEPTABLE AS SUBMITTED. The proposal requires substantial additions or redesign. Please contact the Chair of the REB for advice on how the project proposal might be revised.

Dr. Larena Hoeber

**supplementary memo should be forwarded to the Chair of the Research Ethics Board at the Office for Research, Innovation and Partnership (Research and Innovation Centre, Room 109) or by e-mail to research.ethics@uregina.ca

Phone (306) 585-4775
Fax (306) 585-4853
www.uregina.ca/research
Appendix D

Focus Group Consent Form
Participant Consent Form

Project Title: Developing biofeedback training tools and protocols to enhance officiating performance

Researcher(s):

Kim Dorsch, Ph.D., Professor, Faculty of Kinesiology and Health Studies, Kim.Dorsch@uregina.ca, 306-585-4742

Patrick Neary, Ph.D., Professor, Faculty of Kinesiology and Health Studies, Patrick.Neary@uregina.ca, 306-585-4844

Adam Chomos, M.Sc. student, Faculty of Kinesiology and Health Studies, chomos2a@uregina.ca

Doug Lawrence, SHA Referee’s Division Research Liaison, Doug.Lawrence@talentc.ca

Purpose(s) and Objective(s) of the Research:

• Officiating involves many physical, cognitive, and psychological skills. Some researchers suggest that officiating sports is more demanding and complex than playing. Yet attempts to understand officiating performance are neglected in the sport psychology literature. One way of enhancing the performance of athletes that is just recently receiving attention is the area of biofeedback training. Biofeedback training is a method of using a display of an individual’s physiological reactions as a means to identify and train self-regulation in order to enhance performance.

• The purpose of this focus group is to gain information from expert ice hockey supervisors and officials to develop biofeedback training tools and protocols for ice hockey officials

Procedures:

• You have been asked to attend a focus group discussion which will last approximately 90 to 120 minutes

• After providing you with a brief description of what biofeedback is and a demonstration of current biofeedback technology, we will ask you to engage in a discussion relating to biofeedback training and ice hockey officiating.

• We will be audio and video recording this session. The video tape will only be used as a secondary means of identification for when we transcribe the audio tape. It will not be shown or used in any other way.

• Please feel free to ask any questions regarding the procedures and goals of the study or your role.

Funded by:

• This project was funded by the Social Sciences and Humanities Research Council of Canada
Potential Risks:
• In order to demonstrate the biofeedback equipment, we will be asking for a volunteer. There may be a possibility that someone may be allergic to the electrode paste or the electrodes themselves. We ask that if have a known allergy, that you not volunteer for this portion of the focus group.
• Other than this minimal physical risk, there are no other known or anticipated risks to you by participating in this research

Potential Benefits:
• It is anticipated that empirical and methodological advances in biofeedback training will be obtained through the successful completion of this project.
• Wider social benefits are also expected in that enhanced self-regulation skills not only directly impact the officials' game performance and their lives in general, but also may impact the negative behaviours that are exhibited by the other sport participants. While the often abusive verbal and physical behaviours directed at the official are in no way condoned, if the official can learn to regulate their responses to these encounters, it is possible the occurrence of such acts may be diminished.

Confidentiality:
• We will make every attempt to keep your input into the focus group discussion confidential. We will use a pseudonym for you when transcribing the data and you will not be linked to any quotes.
• However, due to your position within the Saskatchewan Hockey Association Referee’s Division, some people may know that you participated in this study
• Given the nature of the focus group method, we can only ask that each focus group participant respect the privacy and confidentiality of each focus group member once the session is completed.

Storage of Data:
  o The video- and audio-taped data will be stored in the Motivation for Active Living Laboratory in a password-protected computer in a secure facility under the supervision of Dr. Kim Dorsch.
  o The audiotapes and any electronic transcriptions will be kept indefinitely in a secure site, separate from the consent form or any other identifying information you provide to us.
  o Once we have completed the analysis of the focus group, the video tape will be erased and disposed of securely.

Right to Withdraw:
• Your participation is voluntary and you can answer only those questions that you are comfortable with. You may withdraw from the research project for any reason, at any time without explanation or penalty of any sort.
• Whether you choose to participate or not will have no repercussions on your relationship with the researcher, the university, nor your hockey association
• Please understand that your input in the focus group may influence the direction of the discussion and other members’ responses. For this reason, once the focus group is completed it will be impossible for us to withdraw your responses
Follow up:
• As has been our practice in the past, we will be willing to provide an update to the membership of the SHA or WHL Referee’s Division, if you wish.
• We will contact each organization once the biofeedback training tool has been developed.

Questions or Concerns:
• Contact the researcher(s) using the information at the top of page 1;
• This project has been approved on ethical grounds by the UofR Research Ethics Board on (insert date). Any questions regarding your rights as a participant may be addressed to the committee at (585-4775 or research.ethics@uregina.ca). Out of town participants may call collect.

Consent

Your signature below indicates that you have read and understand the description provided. You have had an opportunity to ask questions and your questions have been answered. You, hereby consent to participate in the research project. A copy of this Consent Form has been given to you for your records.

______________________________      _______________________
Name of Participant          Signature

______________________________      _______________________
Researcher’s Signature          Date

A copy of this consent will be left with you, and a copy will be taken by the researcher.
Appendix E

Focus Group Executive Summary
### Focus Group Executive Summary

#### Focus Group Objectives
- Determine whether biofeedback training has the potential for improving hockey official's performance
- Discuss the relevance of context in the biofeedback training experience for hockey officials
- Determine how earlier obtained on-ice, 1st person videos of officials could be used in the development of biofeedback training screens
- Discuss other factors related to the biofeedback training experience for hockey officials (i.e., other training activities not including 1st person videos)

#### Participants
- 4 male participants recruited from the Saskatchewan Hockey Association (SHA)
- Three (3) SHA hockey officials and one (1) SHA liaison
- All three officials with 20+ years of officiating experience
- All three officials currently assuming supervisor roles within the SHA
- One official current manager of officials for SHA

#### Methodology
- 120-minute focus group held at the University of Regina
- Informal/conversational style format to discussion
- Informed consent obtained ensuring anonymity and confidentiality of participant responses

#### Focus Group Results
- After an introduction to biofeedback followed by a discussion of its application in sport, officials were asked to discuss the importance of context and authenticity in a training and clinical environment. Participants reported the importance of:
  - Accuracy of training experience to real life/game
  - When the use of instructional/training videos are used, showing more than just typical skating around with and without the puck
  - Videos that include the “build up” of the play (i.e., big hits, scrambles in the corner, close offsides)

- When asked about the importance of adding Physical Activity to create an authentic experience, participants reported:
  - That in a real game, focus is on both physical and mental aspects
  - The physical aspects happen more subconsciously and automatically
  - That with biofeedback training, it might be more of a progression, starting in a laboratory setting and working up to adding in a physical activity component

- Throughout the duration of the focus group, themes emerged as most relevant and important to creating the authentic and contextual experience necessary for the application of biofeedback training to hockey officiating performance. Those themes can be categorized as falling under the umbrella of 1. The development of the Biofeedback training experience, and 2. The application of Biofeedback to improving officiating performance:
Development of Biofeedback Training Experience

After being shown examples of “typical” biofeedback training screens and captured first-person video clips, participants engaged in a discussion about how they thought the video clips could be incorporated into the biofeedback training experience and any other ideas to make their training experience more relevant and contextual to their experiences as a hockey official. From their discussion, responses focused on:

1. 1st person video clips
2. Audio/Sound

1st PERSON VIDEO CLIPS

As discussed in the earlier stages of the focus group, the use of first-person video of on-ice experiences of the official will be used to make the biofeedback training experience more applicable and contextual. When asked about the kinds of clips they would like to see included within biofeedback training screens, participants reported:

- Liking the idea of a camera moving around with the play
- But just simply following the play with nothing happening wouldn’t be beneficial
- The need for “borderline, extreme” circumstances such as penalty situations, hard hits/crashes into the boards, scrambles at the net
- To include more “thought-inducing” situations
- To include video clips that focus on aspects of officiating that are necessary to be a successful official such as communication, accuracy of calls, and reaction time

AUDIO/SOUND

When discussing the potential role for the acquired videos in the development of a biofeedback protocol, participants suggested that an audio/sound stimulus may be as equally important as the video or visual stimulus, reporting:

- That the “sounds” while on the ice put (the official) in that state of mind or zone
- That the reaction of the crowd or players/coaches equally as important for triggering a response
- That an audio stimulus could be used with video or by itself (i.e., listening to a coach screaming)
- That having a general crowd noise in the background (much like at the rink) would make the training experience more authentic

Application of Biofeedback to Improving Officiating Performance

After discussing how the use of video and auditory stimuli (to replace the more generic training screens and activities) could be applicable and beneficial to the biofeedback training experiences among hockey officials, participants engaged in a further discussion, identifying key performance factors that are necessary to successful officiating experiences, and how they believed biofeedback training and the use of the video and audio stimuli could improve their on-ice performances. From this discussion, emerged themes included:

1. Communication and Conflict Resolution
2. Judgments/Decision-Making
3. Effort and Work Ethic
4. Consistency
**COMMUNICATION & CONFLICT RESOLUTION**

Participants indicated that communication skills, as they relate to conflict resolution with players and coaches, are important qualities for a successful official. When asked how they defined conflict resolution, participants reported (the ability to):

- Bring intensity level down
- Maintaining composure
- Being up front and direct with your message
- Calm things down and relax
- Talk level-headed

Participants discussed the potential application of biofeedback training to improving communication skills, since being in conflict situations can often cause a less than ideal physiological state. As it relates to the on-ice 1st person videos, participants reported that useful training and teaching tools would include:

- Simulated situation where the official skates up to the bench and the coach comes down to “blast” the official
- Allow the official to practice responding to certain situations
- However, without an actual live scenario, will be difficult to replicate the same emotion and intensity of that situation

The application of biofeedback training to communication and conflict management was indicated as being most applicable to “younger” and “less experienced” officials who work in a 2-referee system, as it is typically the senior official who takes the lead in these situations.

**JUDGMENTS/DECISION-MAKING**

Participants indicated that another way to make the biofeedback training experience relevant to hockey officials is to include training tasks that require quick and accurate judgments/decisions. Responses included:

- Close calls
- The necessity to train for accuracy or correct calls versus speed of making the call
- “Is it or isn’t it?”

When asked about those kinds of video clips that could be used to simulate situations that require quick and accurate judgments/decisions, participants included:

- Situations that force the official to decide whether play should go on, or the whistle blown
- Situations where the type of penalty being called is not clear (i.e., check from behind vs. boarding)
- Close calls at the line (offsides)

**CONSISTENCY**

One of the supporting themes that emerged when discussing the impact that biofeedback could have on the various requirements (skills and abilities) of a successful official included consistency. Participants indicated that one of the biggest complaints from coaches, players, and teams includes the inconsistency between officials on a game-to-game basis.

- Consistency from official to official vs. consistency within the official

**EFFORT AND WORK ETHIC**

One aspect of “performance” that participants believed would be interesting to look at from a biofeedback training standpoint, was the areas of effort and work ethic.

Specifically with neurofeedback, the ability to tie in and train mental processes such as focus, preparedness, and concentration and how they relate to the effort expended and work ethic of the official

- (i.e., why didn’t official A skate hard into the play or why did official B skate hard when there was no reason to?)
Appendix F

Developed Biofeedback Training Screens
Figure E – 1. BVP Training Utilizing Video Stimulus
Figure E – 2. Respiration Training Utilizing Video Stimulus
Figure E.3. Temperature Training Utilizing Video Stimulus
Figure E – 4. Respiration Training Utilizing Video Stimulus
Figure E – 5. Training Multiple Modalities Utilizing Video Stimulus
Figure E – 6. Training Multiple Modalities Utilizing Video and Audio Stimuli
Figure E – 7. Respiration Training Utilizing Audio Stimulus
Figure E – 8. Training Multiple Modalities utilizing Video Stimulus
Figure E-9. EMG Training Screen Utilizing Video Stimulus
Figure E - 10. Temperature Training Utilizing Audio Stimulus
Figure E – 11. EEG (Theta/Alpha) Training Screen Utilizing Audio
Figure E – 12. EMG (Stress/Muscle Tension) Training Screen Utilizing Video