

**THOUGHTS BECOME THINGS: A GROUNDED COGNITION
APPROACH TO IMAGERY USE IN THE POWER CLEAN**

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ABSTRACT

While it is widely argued that personalised imagery scripts are beneficial to performers, theory and data to support this contention is sparse. The current study aims to address these issues by investigating: Firstly, what differences in content and description arise from the use of generic and personalised scripts aimed at improving performance in the Power Clean (PC). Secondly, if any differences are reflected in relevant kinematic measures. Sixteen resistance trained individuals were randomly allocated to one of two conditions: personalised imagery (PI), or generic imagery (GI). During baseline testing, participants performed a 1 repetition maximum (1RM) PC along with a recall test which consisted of giving a personal description of the power clean. Personal descriptions of the PC were used to construct imagery scripts for the PI group. Scripts for the GI group were derived from a standard description of the PC obtained from an international level Olympic-Weightlifting coach and current literature on PC technique. Participants completed three PC training sessions per week and listened to an audio-recorded version of their given imagery scripts five times per week. At the end of the training period descriptions of the PC were compared along with kinematic and performance variables including; peak power (PP), peak force (PF), peak velocity (PV) at 80, 90 and 100% of the participants' 1RM and horizontal bar displacement. There was a significant difference between post-test adjectives used between groups ($ES=1.37\pm 1.27$). The PI group showed a meaningful increase (23.4 ± 7.8 to 31.1 ± 18.1) compared to a decrease in the GI group (14.6 ± 8.7 to 13.6 ± 7.8). At 100% testing load the PI group experienced changes to $Dx2$ and DxT which saw the bar caught closer to the participants' centre of mass in post-testing. The PI group showed small to moderate improvements in PF (80 and 90%) and PV (100%). Findings suggest that PI scripts result in different descriptions of movements and that these differences are of benefit to performance.

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ATTESTATION OF AUTHORSHIP

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

A rectangular box containing a handwritten signature in black ink. The signature is stylized and appears to be a cursive 'R' followed by a horizontal line.

Signed

Date 12/04/17

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ETHICAL APPROVAL

Ethical approval for this research was granted by the Auckland University of Technology Ethics Committee (AUTEC; #16/64) originally on 21 March 2016, with minor amendments approved on 19 April 2016 (see Appendix 1).

LIST OF COMMON ABBREVIATIONS

1RM	One repetition maximum
Dx2	Start position to second pull
DxV	Second pull to the forward most position
DxT	Start to catch position
DxL	Catch to forward most position
PF	Peak force
PP	Peak power
PV	Peak velocity
MBI	Magnitude based inferences
ES	Cohens effect size

CHAPTER 1

INTRODUCTION AND RATIONALE

Background

Imagery has become a widely-adopted practice in the sporting arena, with extensive research proving its benefit over a variety of sporting disciplines. Imagery research has made significant progress since early investigations, namely Mahoney and Avener (1977), who found that successful Olympic level gymnasts made greater use of imagery than their less effective counterparts. Recent experimental research has highlighted the value of imagery for skill acquisition, controlling emotions (e.g. pre-game anxiety), mental toughness, learning and carrying out sport specific strategies (Martin, Moritz, & Hall, 1999). Furthermore, the effects of imagery are influenced by certain key factors: imagery perspective used (i.e. First person versus Third person) (White & Hardy, 1998), imagery ability (Robin et al., 2007) and image modality (i.e. is the image experienced visually, kinaesthetically, auditory, olfactory, and gustatory) (Toussaint & Blandin, 2010). Despite the increase in knowledge and improvements in experimental methodologies, the role of language in the construction of imagery scripts has been poorly researched. Thus, the objective of the current study was to investigate the effects of including a participant's own descriptions of a designated skill on the effectiveness of skill based imagery scripts.

Imagery research to date suggests that using participant-generated scripts will yield better results (Callow & Waters, 2005; Calmels, Holmes, Berthoumieux, & Singer, 2004; Mellalieu, Hanton, & Thomas, 2009; Pain, Harwood, & Anderson, 2011; Smith & Holmes, 2004; Smith, Holmes, Whitemore, Collins, & Devonport, 2001; Wilson, Smith, Burden, & Holmes, 2010). However, only one study has investigated the efficacy of participant generated scripts in comparison to generic scripts (Wilson et al., 2010). Wilson et al. (2010) compared differences in muscle activity (determined via electromyography) (EMG) between participants using either, participant generated scripts and experimenter derived scripts. Findings, showed that those who were using participant generated scripts recorded higher imagery ability ratings, and greater muscle activity compared to participants who used experimenter derived scripts. In the first part, it is unclear what mechanisms contributed to the reporting of greater imagery

ability. The present study aims to address this by examining changes in self-reported descriptions of an athletic movement. In the second part, changes in muscle activity cannot necessarily be interpreted as beneficial to the performer. Thus, the present study will examine both kinematic and outcome data for an Olympic lift to determine any effects, beneficial or otherwise.

Athlete perception is a key factor in successful imagery interventions. Nordin and Cumming (2008) found that athletes would perceive imagery types (CS, CG, MG-A, MG-M, MS) to serve multiple functions:

- Cognitive General (CG): Imagery in relation to strategies of a competitive event, for example up and out defensive pressure in rugby.
- Cognitive Specific (CS): This is imagery of specific skills such as the power clean in weightlifting.
- Motivational General-Arousal (MG-A): Imagery that is associated with feelings of stress, arousal, relaxation and anxiety in relation to competitive sport environment.
- Motivational General-Mastery (MG-M): This is imagery that is aimed at coping and mastering difficult situations, such as being confident and mentally strong during a sports event.
- Motivational Specific (MS): This function of imagery is related to goals and goal-oriented behaviours, for example seeing yourself receiving a medal (Hall, Mack, Paivio, & Hausenblas, 1998).

These findings suggest that imagery type and function do not have a causally direct relationship that can be easily manipulated. The function imagery has and its' outcome comes down to athlete perception and understanding of an imagery script.

Consequently, what an athlete perceives to be the function of an image is pivotal to the effectiveness of the imagery intervention. For example, an athlete may be asked to imagine flicking the wrists when shooting a basketball as this is a technical aspect of the shot. The athlete however, may perceive this in a way that lowers anxiety, thus serving a more motivational function instead of cognitive. For imagery scripts to be most effective, they need to align with an athletes' perception of the task at hand. If the athlete cannot perceive an imagery script in a way they understand, and that is readily applicable to their mental construct of that imaged task this can negatively effective performance outcomes (Robin et al., 2007). CS imagery is particularly vulnerable in this

respect given the distinction that may be drawn between *describing a movement* and *describing how to perform a movement*. This highlights the importance of personalising imagery interventions to make imagery content more appropriate for each individual athlete. As suggested above, the development of an imagery script should not see skill oversimplified into an explicit set of instructions that are followed to achieve the desired response. Rather a more complex process is required to bring interacting systems (e.g. perceptual, environment, situation, and body) together for the benefit of performance (Davids & Araújo, 2010).

Traditional theories of cognition have looked to explain the process of imagery using an information processing approach for example, bio-informational theory (Lang, 1979). The idea behind information processing theory is that the mind is an information processor/computer. According to this theory, the brain receives information from multiple sensory inputs, information is then stored and processed, and this leads to the appropriate behavioural response. From an information-processing point of view, language comprehension is a simple process whereby meaning is extracted from words and text and stored in memory. When the appropriate stimulus is present the meaning is drawn from memory to elicit the desired behavioural response. To date, bio-informational theory continues to be the preferred choice for researchers and practitioners looking to personalize imagery scripts; whether it is through the use of all three propositions (Mellalieu et al., 2009) or just stimulus and response (Smith, Wright, Allsopp, & Westhead, 2007). Regardless, what can be extracted is the underlying goal of these interventions, to develop scripts that have meaning for the user.

In trying to understand how personalised scripts can be of benefit to the practice of athletic skills it becomes clear that the origin, and role, of symbols (propositions) in the formulation or shaping of movements matters. Further consideration finds it nonsensical to argue that symbols or propositions directly represent any detailed part of a given movement (Davids & Araújo, 2010). Grounded cognition provides an alternative to traditional information processing theories of cognition and to some extent addresses this issue. It looks to delve deeper into the interaction between perception, action, the body, the environment and the situation (Barsalou, 2008). Situated cognition is a sub theory that comes under the umbrella of grounded cognition and is a useful theoretical framework for unpacking the relationship between personal language and the related meaning that emerges for the individual. Situated cognition theory views language as not only being subject to storage and retrieval processes, but involved in preparing

individuals for situated action (Glenberg, Meyer, & Lindem, 1987). The input to language comprehension is far more complex than initially thought, with perception of situations, the body and environment all playing a role in language comprehension. Due to the complexities in the input, storage and output of language meaning, there is a need to re-think the way that imagery scripts are being interpreted by participants in imagery interventions. Instead of archival memory being the primary process, comprehension can be viewed as a priming process that prepares individuals for situated action (Barsalou, 1999).

Situated action focuses on the emergent, dependent nature of activity. The words used within imagery scripts act to shape or constrain an individuals' cognition, and to a certain extent are a result of what memory generates when specific words are used. (Barsalou, 2008) explains that situated cognition falls into line with dynamic systems theory, where it is theorized that fixed representations of information are not present within the mind. Instead, past concepts in memory are further developed from the interaction between memory, consciousness, the environment, the body and situation (Barsalou, 2008). From a dynamic systems perspective, individual preference towards particular words represents processes or attractor states that arise from successful dynamic solutions of movement problems (Barsalou, 2010). A criticism of information-processing based models, is an assumption that information retrieval is context-neutral, with statements representing propositional networks that are absent of situation/context (Barsalou, 1999). The notion of context neutrality is problematic when trying to understand the benefits of personalised imagery scripts.

A number of studies have investigated the effects of imagery on strength based tasks (Bakker, Boschker, & Chung, 1996; Cupal & Brewer, 2001; De Ruiter et al., 2012; Lebon, Collet, & Guillot, 2010; Newsom, Knight, & Balnave, 2003; Ranganathan, Siemionow, Liu, Sahgal, & Yue, 2004; Wilson et al., 2010; Yue & Cole, 1992; Zijdewind, Toering, Bessem, van der Laan, & Diercks, 2003). However, it is important to note that none of these studies investigated movements that required a high degree of skill or co-ordination (i.e. bicep curl and leg press). Indeed, most of studies have looked at simplified tasks or inferential measures this is interesting as much of the original justification for the use of imagery comes for skilled performers. Therefore, we are left with the following question, "What effect does imagery have on strength based tasks that require high levels of skill and co-ordination". This question justifies further investigation into Olympic based movements due to the skill and co-ordination

requirements these movements demand. The skill based components of certain sports have also been shown to be positively influenced by imagery, with Robin et al. (2007) reporting significant improvements in service return accuracy in experienced tennis players who utilized imagery. These studies provide evidence that supports the use of imagery as a strategy to cope with the various mental requirements of sport and to improve skill based movements. Based on the demands of Olympic weightlifting movements, imagery could be a useful skill to implement due to the evident benefits it has on skill enhancement and motivation. Weightlifting requires short periods of intense concentration, with both lifts (snatch and clean and jerk) lasting 3-5 seconds and 8-12 seconds respectively and the ability to control anxiety levels are vital for successful performance (Fry, Stone, Thrush, & Fleck, 1995). Due to the fact that optimal weightlifting performance requires maximal power output and fine motor control, arousal control is important to maximize performance (Fry et al., 1995).

Purpose Statement

The purpose of this thesis was to answer the overarching question of “are participant’s own descriptions of the power clean exercise more effective than generically constructed descriptions?” The study involved resistance trained individuals seeking to improve performance in the “power clean” exercise. The current line of investigation was pursued for the following reasons:

- No studies that have investigated the difference in description and content of personal descriptions of a skill when using personalised or generic imagery scripts.
- There are currently no studies that have investigated the effects of imagery on complex resistance training exercises such as the power clean.
- Research indicates that the kinematics and kinetics of the power clean transfer to a wide range of sports, meaning that the findings from this research could be used as an alternative tool in improving a highly relevant exercise in the field.

This thesis attempted to provide evidence to support the use of a participant’s language in the design of imagery scripts. Instead of using an information processing based model, Barsalous’ (2008) theory of grounded cognition formed the theoretical basis to investigate the mechanisms behind why a participant’s own descriptions of a skill may generate more effective imagery scripts than generic ones. Firstly, the current literature investigating the effects of personalised imagery scripts on strength performance and

the theoretical framework supporting grounded cognition was reviewed. Secondly, the effects of participant derived imagery scripts on the kinematics and kinetics of the power clean in resistance trained individuals were investigated. The development of participants' conceptual knowledge was also investigated by administering a recall test, whereby participants were asked to describe the power clean exercise in their own words from start to finish. This attempted to support the use of grounded cognition theory whereby participant description would become more descriptive the second time, because they used an imagery script that had been generated using their own language. This thesis contributes new knowledge in this area, specifically the use of grounded cognition theory to understand why personalised imagery scripts are effective and how they can be made more effective using participant description of a skill. Furthermore, practical recommendations regarding how imagery scripts are constructed are provided with the intention to guide future imagery interventions for skill improvement.

Research Aims and Hypotheses

The absence of research investigating the role of participant language in imagery scripts and its' effects on the development of a complex skill requires investigation.

Accordingly, the main aims of the thesis were to:

1. Is there a difference in content and descriptions when using generic and personalised scripts aimed at improving performance in the power clean?
2. If any differences are reflected, do these differences benefit the relevant kinematic and kinetic measures
3. To provide practical recommendations to sport psychology practitioners, specialist coaches and strength and conditioning coaches for administering effective personalised imagery interventions with the use of participant description

The following hypotheses were conceived for the studies undertaken within this thesis:

It was hypothesised that individuals' receiving the personalised imagery (PI) script would generate more descriptive accounts of the power clean (PC) from baseline descriptions compared to their generic counterparts. It was also hypothesised that individuals receiving the PI group would perform better (i.e. improved kinematic and kinetic performance) on the PC from pre- to post- testing than those who received generic imagery (GI) scripts.

Structure of the Thesis

This thesis consists of four chapters (see Figure 1) that come together in an overall discussion.

Chapter 2 consists of a review of the literature that covers the theoretical underpinnings of grounded cognition, the role of language in imagery, cognitive theories of imagery, comparison of personalised and generic scripts, the relevance of imagery to athletic performance, and the technical, kinematic and kinetic features of the PC. This review brings attention to areas that require further research in the field of imagery. It provides sound rationale as to why grounded cognition as a theory is a robust framework to explain the underlying mechanisms of the performance improvements in personalised imagery scripts. Additionally, this chapter provides practical recommendations based on current findings and informs direction for future research.

Chapter 3 is a proposed journal article that explores the effects of participant descriptions in imagery scripts on the kinematic and kinetics of the power clean. The reader can expect a degree of repetition in this chapter due to the structure being written to be submitted as a journal article. Key findings from this chapter were that personalised scripts generated more detailed descriptions of skill which accompanied an improvement in kinematic and kinetic variables. Furthermore, grounded cognition has shown to provide a sound theoretical explanation for the effects of personalised scripts on the performance of a complex skill such as the power clean.

Chapter 4 contains an overall discussion of findings from the research project, comments on limitations to the research study, provides recommendation for areas of future research, and provides concluding statements on the key findings from the thesis.

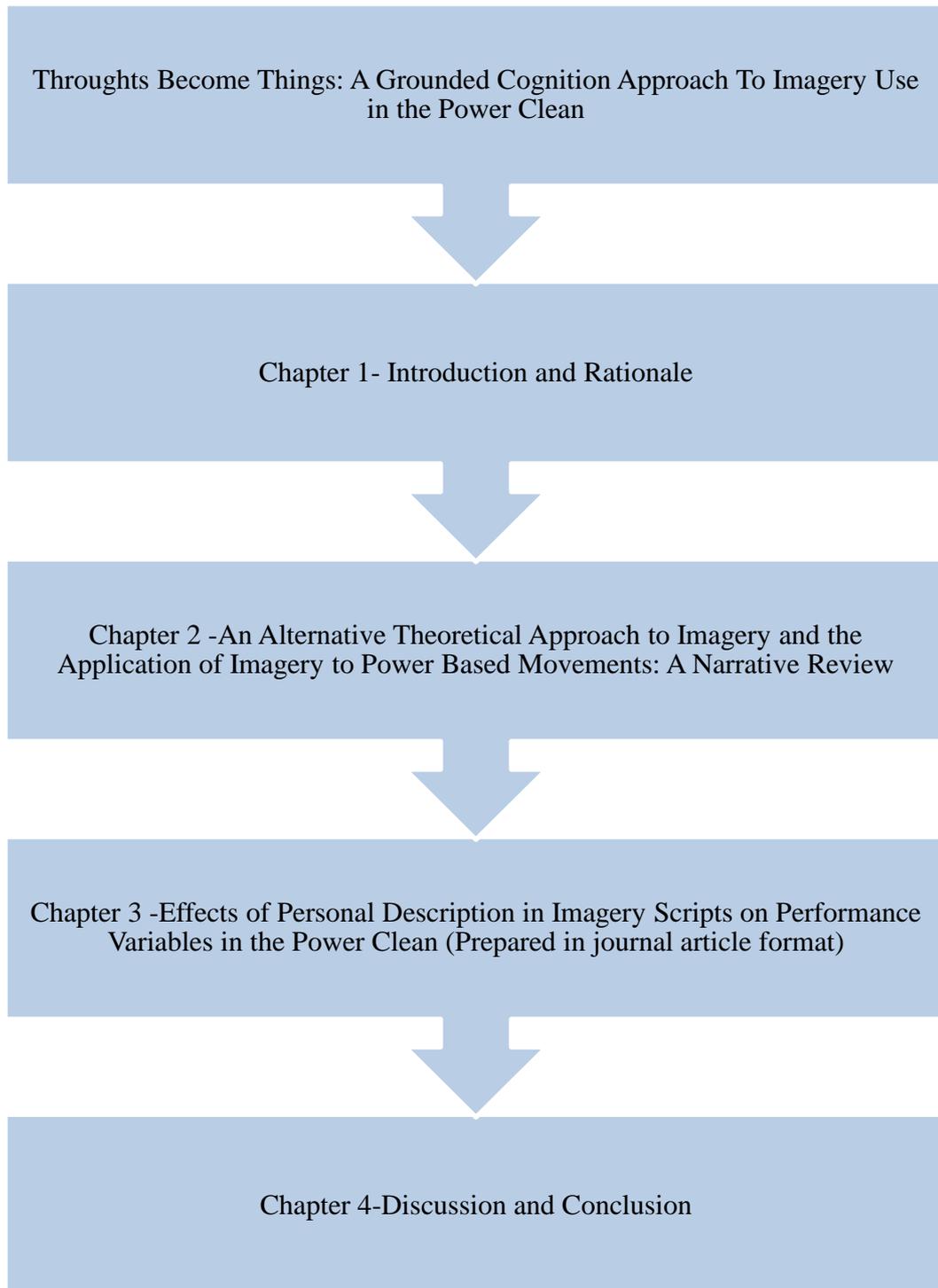


Figure 1. Thesis structure.

CHAPTER 2

AN ALTERNATIVE THEORETICAL APPROACH TO IMAGERY AND THE APPLICATION OF IMAGERY TO POWER BASED MOVEMENTS: A NARRATIVE REVIEW

Abstract

While recent research has argued that personalised imagery scripts are beneficial to performers, theory and data to support this contention is sparse. Specifically, studies examining the effects and efficacy of personalised imagery on movements that require a high degree of technical proficiency has yet to be investigated. Despite the increase in knowledge and improvements in experimental methodologies, the role of personal language in personalised imagery scripts has received little attention outside standard theories of cognition (i.e. bio-informational theory). From the investigations that have utilised personalised scripts, only one has investigated their effectiveness in comparison to generic scripts. This review critically examines standard theories of cognition and their application to imagery. Additionally, grounded cognition is proposed as an alternative to standard theories to help extrapolate why imagery scripts should be personalised, and most importantly, how they should be personalised. Research that has utilised grounded cognition theory has found that personal language, and the comprehension of that language is a process that prepares an individual for situated action. This means that the words used within imagery scripts act to shape or constrain an individual's cognition, and to a certain extent is a result of what memory generates when specific words are used. This raises the question, can an individual's language be used to create more effective scripts that benefit skill development? There are many studies that have looked at the effects of imagery on strength based tasks. However, the limitations of these studies are that the movements investigated are not relevant to athletic performance (i.e. finger abduction and adduction), and do not require high levels of skill or co-ordination. As a result, the power clean has been identified as a movement that requires a significant level of technical proficiency to perform. The technical and kinetic features of power clean have been examined in-depth to provide rationale for the movement under investigation in the experimental chapter of this thesis. Implications and direction for future research are also presented. The aim of this review is to assist in understanding current literature surrounding personalised imagery

interventions, theories that underpin them, and consequently offer an alternative theory to interpret results in future research.

Introduction

Imagery is a widely adopted practice in the sporting arena, with extensive research proving its benefit to athletes of all skill ranges over a variety of sporting disciplines (Hall et al., 1998). Imagery in applied sport psychology is defined as being an experience that mimics what is experienced in real life. Imagery differs from dreaming as the individual using imagery conscious of what image they are forming. The benefit of consciousness is not only does it permit goal directedness but control if used effectively (Munroe-Chandler, Hall, Fishburne, O, & Hall, 2007). Through a review of literature, Martin et al. (1999) developed an applied model of imagery use in sport. Four important constructs were identified in this review; 1) the type of imagery used, 2) outcomes of imagery used, 3) ability of the individual in imagery and, 4) the situation in which imagery is used. The model is centred on the idea that imagery function should match the desired response. Martin and colleagues model hinges on performers' successfully matching imagery type and function with the appropriate goal. Within this model, the works of Hall et al. (1998) were utilized to outline five functions of imagery used in sport; cognitive general (CG), cognitive specific (CS), motivational general-arousal (MG-A), motivational general-mastery (MG-M), and motivational specific (MS). The core of this model draws on Paivio's (1985) framework of imagery effects. Paivio divided imagery into two broad types of imagery, cognitive and motivational. The cognitive function focuses on imaging a specific skill (CS) and overall game strategies (CG). Conversely, motivational function focuses on arousal, confidence and coping with stress (Martin et al., 1999).

Although past studies have indicated that imagery type is best when it serves its appropriate function (i.e. CS imagery for skill development), recent studies have suggested that there is some overlap of imagery type and function. Whereby performers use multiple imagery types to serve a particular function. Nordin and Cumming (2008) tested predictions from the applied model of imagery use by examining the effectiveness of these five imagery types and how these related to serving their specific functions. For example, does an athlete use CS imagery solely for the development of sport specific skills or does this imagery type serve multiple functions. Results from this study showed that athletes perceived a range of imagery types to serve multiple functions, for example MS, MG-M, and MG-A were all perceived to be equally adequate in enhancing motivation. Additionally, it was reported that many individual

differences exist in athletes' perception of various imagery types and their theoretical functions. From these findings it is evident that a particular imagery type cannot be easily attributed to a given function as first predicted by Martin et al. (1999). What the athlete perceives the function of an imagery type to be is important to the effectiveness of the imagery intervention. For imagery to be effective the imagery type being used needs to be in line with the athlete's perceived outcome for that imagery type. For example, if CS imagery is being used to improve tennis serve accuracy, the athlete needs to understand and perceive the content of that imagery script as improving serving accuracy. If the athlete begins to perceive the script to serve a more motivational function, a regression in performance could occur as the script is no longer serving its' intended purpose (Robin et al., 2007). These findings highlight the importance of personalising imagery interventions to make imagery content more appropriate for each individual athlete. Researchers have implemented personalised imagery scripts in an attempt to make imagery content more appropriate for athletes and thus increase the efficacy of the intervention (Callow & Waters, 2005; Calmels et al., 2004; Mellalieu et al., 2009; Pain et al., 2011; Smith et al., 2001; Smith et al., 2007). However, because these studies have not used a treatment control, it is difficult to know whether personalised scripts are in fact more effective than generic ones. Only one study to date has compared personalised scripts with generic ones. Wilson et al. (2010) compared participant generated and generic scripts to investigate the effects on EMG activity and imagery ability. Results from their study showing that imagery ability ratings were higher, and EMG activity higher when participants created their own imagery scripts. A limitation of this study is that EMG is an invalid performance measure, as it is not a reflection of skill. It is possible participant generated scripts just caused performers to try harder and were not influencing the movement itself. By using EMG there is no way of ascertaining the effects of participant generated scripts of the skill element of this movement. It is difficult when the movement itself (bicep curl) requires very little skill to perform. Additionally, the use of a self-reported measure of ability presents an issue with this study. Participants in the personalised group may have been subject to an expectancy effect, where they felt as though they were meant to score higher on post-test scores (Clarke, Michie, Andreasen, Viney, & Rosenthal, 1976). This suggests that a more subjective measure of imagery ability, is required to give a true representation imagery ability and its' effects on a movement. The following questions are raised because of this study: 1) what effect does personalised imagery have on a complex skill and 2) are personalised scripts more effective than generic scripts or is

this a result of an expectancy effect that results from invalid measures of intervention efficacy.

Based on Lang's (1979) original findings, bio-informational theory has become common choice to personalize imagery scripts. Lang's (1979) bio-informational theory comes under the information processing paradigm of cognitive psychology. Information processing theory draws comparisons between the human mind and the processes of a computer, where the mind receives information from sensory inputs, is stored and processed by the mind, which leads to the appropriate behavioural response. A fundamental issue with information-processing based approaches to imagery is that symbols that represent language are processed using logic. For this to be the case, symbols would mean the same thing in all contexts regardless of the personal meaning ascribed by the individual. Additionally, the comprehension of language is viewed as a simple process, whereby meaning is extracted from words and stored in memory as propositions. When the right propositions are used the appropriate meaning connected to that proposition is drawn from memory, which leads to the desired behavioural response (Barsalou, 1999). An important point that is overlooked is that perception and action develop in tandem and are not isolated entities.

An alternative approach to information processing based models is the theory of situated cognition. Situated cognition is a sub theory which comes under the over-arching theory of grounded cognition. Situated cognition theory focuses on the emergent, and dependent nature of activity. The role of the environment and how it shapes cognition has been acknowledge within situated cognition. The key point that situated cognition addresses is that what people perceive and what they do evolve together and this is what informs linguistic descriptions of movements (Barsalou, 2008). A simple example of this is if an individual has a box, in one situation it may be used to store objects, then in another it may be used as a chair, the meaning of the box depends on individual perception and context. Subsequently, perception and the action that follows are developed in real-time and are not fixed representations, but they change in conjunction with the situation. In theory this applies to imagery, and the use of personalised language in scripts, as words are conscious representations that are utilized to shape cognition. Glenberg et al. (1987) postulate that language comprehension is a process that prepares the individual for situated action, meaning that the words that are used within imagery scripts act to shape or constrain an individuals' cognition, and to a

certain extent is a result of what memory generates when specific words are used. From a dynamic systems perspective, individual preference towards particular words represents preferred processes or attractor states that arise from successful dynamic solutions of movement problems (Barsalou, 2008). Vygotsky (1962) explains there is an associative relationship between words and meanings. Particular words recall the content associated with those words. The associations that exist between a word and its meaning can be enhanced or even weakened but it cannot change its innate characteristics, for that to occur the association between a word and its meaning would have to terminate. Current theories used in imagery interventions look to derive meaning from text/words separate to the context within which that meaning was created. By doing this words are removed from an individual's intended meaning and context (Barsalou, 2008). Word meaning varies from situation to situation and in turn the associative connection that exists between those words and subsequent thoughts vary also. This highlights the importance of language in imagery scripts, if the goal of the intervention is to elicit a specific response (e.g. skill acquisition, arousal control), the language used must be perceived by the individual in such a way that the required response is being brought to mind (Vygotsky, 1962). Due to the dynamic nature of the sporting environment, grounded cognition and more specifically situated cognition provides rationale as to why personalization of imagery scripts with the use of individual language can be used to enhance the effectiveness of imagery interventions. Further research is required into the use of a situated cognition to direct the design of personalised imagery scripts.

Imagery has been implemented regularly as a way of developing skill and various elements of motivation. Barr and Hall (1992) investigated imagery use in rowing, findings showed that imagery was primarily utilized prior to a race and reportedly used for performance benefits, controlling arousal, and staying focussed. Furthermore, White and Hardy (1998) examined imagery use in slalom canoeists and artistic gymnasts. Qualitative interviews showed that participants used imagery largely for its motivational function to gain energy for movements that needed explosive power and as a way of reducing anxiety. The skill based components of certain sports have also shown to be positively influenced by imagery, with Robin et al. (2007) reporting significant improvements in service return accuracy in experienced tennis players who utilized imagery. However, a limitation of this study is that the effects of CS imagery on tennis serving skill were inadequately tested. Shots were merely measured as to whether they

landed in the set zone. This means that players may have benefitted from affect rather than an enhancement in skill. Studies have compared the effects of different imagery types and the subsequent effects on learning and performance of a skill. For example, Burhans, Richman, and Bergey (1988) found that beginner runners who used CS imagery (focusing on running technique) showed a greater improvement in performance than those who used MS imagery (focusing on receiving a medal or finishing ahead of other runners). These findings suggest that CS imagery can be the most effective imagery type when developing a skill based movement. However, the use of bio-informational theory to support these findings does not explain the relationship between CS imagery and the development of skill. There is an evident need for investigation into personalised imagery use that sufficiently tests its effects on an athletically relevant and complex skill. A complex skill is one that involves a large attention span as the movement requires complicated co-ordination of the body and is practiced repeatedly to make it easier to perform (Fry et al., 1995). On this note, imagery use in Olympic weightlifting has not been documented to date, and based on the requirements of these movements can be classified as a complex skill based movement. A complex skill is defined as a movement Although cognitive strategies such as imagery have been shown to influence strength performance, there has not been an investigation that has used movements that are relevant to athletes' training or performance (i.e. finger adduction and abduction). Further research is required to examine the effects of personalised imagery on appropriate skill based variables (kinematics and kinetics) of complex resistance training (RT) exercises, such as Olympic weightlifting movements.

Many athletes utilize complementary exercises (e.g. hang/power snatch and hang/power clean) as part of their regular training, due to the benefits in strength and power that can be derived from these exercises, (Carlock et al., 2004; Storey & Smith, 2012). The power clean in particular is commonly used by power athletes due to the similarities between the propulsive phases in both weightlifting and jumping movements (Storey & Smith, 2012). Due to these similarities, improvements in peak power (PP), peak force (PF) and peak velocity (PV) have been observed in athletes who incorporate the power clean as part of their training programs (Carlock et al., 2004; Judge, 2007). The multi-joint, high-intensity nature of the power clean requires the utilization of fine motor skills. Bearing in mind the high level of skill needed to complete Olympic-weightlifting movements, imagery could help improve physical performance (i.e. kinematic and kinetic variables). (Robin et al., 2007; White & Hardy, 1998).

This review investigates imagery use in sport and standard theories and models that are used in current research. Attention is specifically directed towards the effects of personalised imagery scripts versus generic scripts on athletic performance.

Additionally, grounded cognition is presented as an alternative theory of cognition, where the applicability to imagery research is debated. Supporting evidence and practical applications are provided for coaches and sport psychologists for the use of personalised scripts in imagery. Additionally, recommended areas of further research have been outlined.

Relevance of Imagery to Athletic Performance

Imagery use has been examined over a range of sports (e.g. Soccer, gymnastics, canoeing, horse-racing, tennis and golf) and has been found to serve many different functions (e.g. skill improvement, reducing pre-competition anxiety and enhancing confidence). Several studies have shown promising results, with findings indicating a reliable increase in strength related variables as a result of imagery use (Bakker et al., 1996; Cupal & Brewer, 2001; De Ruiter et al., 2012; Lebon et al., 2010; Newsom et al., 2003; Ranganathan et al., 2004; Yue & Cole, 1992; Zijdewind et al., 2003). Findings from these studies indicate that the neurological adaptations that occur from imagery alone are similar if not the same as those gained from strength training (Bakker et al., 1996; Lebon et al., 2010; Ranganathan et al., 2004; Yue & Cole, 1992). Yue and Cole (1992) investigated the effects of imagined muscle contractions compared with physical training. Subjects in this study trained the group of three muscles in the palm (hypotenar muscles) over a 4-week period, five sessions per week. One group imagined the production of maximal isometric contractions of the abductor muscles in the fifth digit's metacarpophalangeal joint. The second group produced repeated maximal contractions of the same fifth digit. The third group acted as a control and did not train their fifth digit. Results from this study showed that abduction force increased by 22% for the imagining group compared to 30% for the physical training group. Findings from this study provide evidence to support that in the absence of training, imagined movements initiate an increase in motor neuron activation. A limitation with this study is that the movements used (i.e. finger adduction and abduction) are not relevant to those usually performed in a strength training environment (Bakker et al., 1996; Ranganathan et al., 2004; Yue & Cole, 1992). Lebon et al. (2010) addressed the lack of imagery research with applicable strength movements with an investigation into

the effects of mental imagery (MI) on upper and lower limb strength. Nine participants were in the MI group and 10 in the control (CTRL) group. Both groups carried out the same leg press and bench press exercises. The MI group were instructed to imagine and feel both movements (bench and leg press) during their rest, compared to the CTRL group who did a neutral task. Results showed a significantly higher ($p < 0.05$) maximal voluntary contraction (MVC) in the leg press for the MI group compared to the CTRL group. Evidence from the above studies suggests that a combination of imagery and physical training is more effective than physical training alone. However, a major limitation of this study is that there wasn't a clear measure of imagery. This makes it difficult to ascertain whether imagery was responsible for the improvements observed or was it a result of participants just trying harder than the other group. Furthermore, the type of imagery used has not been specified, this leads to the question, were improvements a result of the script being focussed on motivating the participant or focussing on the skill of executing the movement.

Although there is a decent body of literature that has investigated imagery and the effects on strength performance there is a lack of research on power-based movements (for a recent review, see Tod, Edwards, McGuigan, & Lovell, 2015). Further research is required on the effects of imagery on power based exercises, such as Olympic weightlifting movements which are multi joint exercises that require balance, speed and coordination. Investigating the effects of imagery on Olympic weightlifting movements would provide unique insights into the effectiveness of imagery when developing complex ballistic exercises.

Cognitive Theories of Imagery

Cognitive psychology looks at the processes where people change, condense, extrapolate, store, recover, and use sensory input (Morris, Spittle, & Watt, 2005). The word 'use' is probably the most important section of the above definition, because it brings attention to the idea that once information has been perceived, stored and recovered it must be used effectively to complete skills/tasks, make decisions and solve problems. Morris et al. (2005) explain that imagery is produced using memories, understanding how an individual stores and processes images is important when looking at how imagery works. Many theories have been proposed to explain the effects of imagery. Such theories include Symbolic Learning Theory (Sackett, 1934), Dual-Code

Theory (Paivio, 1975), Bio Informational Theory (Lang, 1979) and Triple-Code Theory (Ahsen, 1984). Originally these theories were not used in relation to sports performance, but the theoretical underpinnings have been shown to apply nicely to a sporting context. These theories are discussed below.

Symbolic learning theory

Symbolic learning theory posits that movements are symbolically coded in the central nervous system; thus, imagery can support coding these movements into symbols that enhance the individuals' ability to carry out the task. Subsequently, imagery enables the individual to gain familiarity with movements and assists automaticity through cognitive processes. According to this theory, imagery is seen to assist the enhancement of only the cognitive components of a skill, such as the timing of movements, sequencing and planning. Sackett posited that cognitive skills are easier to encode than strength and motor tasks. This theory was tested by Sackett and results indicated that mental rehearsal improved performance on a finger maze task. This confirmed Sackett's hypothesis as the enhancement observed was a result of the task being mainly cognitive in nature, meaning it could be symbolically encoded with ease. Furthermore, symbolic learning theory fails to acknowledge the level of ability in participants. Studies confirm (for review, see Driskell, Copper, & Moran, 1994) that participants using imagery consistently better on tasks that are mainly cognitive in comparison to those that are heavily motoric. However, it must be noted that although imagery may be more effective in cognitive tasks, recent research (Wilson et al., 2010) has shown that in motor dominant tasks, imagery is still effective at improving performance related variables.

Dual-Code Theory

Theorized by Paivio (1975), Dual-code theory suggests that images represent two independent memory codes which can lead to recall. For example, if a ball is stored in memory as an image and also a word, then an individual can recover from their memory the ball as either a word or image (Morris et al., 2005). The dual code position to imagery accounts for effects in terms of the availability to differentiate visually and verbally coded information. Within this theory, Paivio proposed that individuals have a preference on how they encode information (verbally vs. non-verbally). Processing preference in a sporting context has received surprisingly little attention. Thomas and Fogarty (1997) sought to extend this area of inquiry by measuring individual processing

differences in golfers. Participants were exposed to two different training techniques; imagery programme (visual modality) and self-talk programme (auditory modality). It was examined whether processing preferences influenced the participants to favour one training technique over the other. The hypothesis was that visualizers would favour imagery and verbalisers would favour the self-talk training programme. Results indicated that participants did not have strong preferences of one mode over the other. Additionally, participants displayed a large amount of cognitive flexibility and found it easy to adapt to both training modes (imagery and self-talk). A limitation of the dual-code theory is that it provides a simplistic representation of the interaction between verbal and visual memory codes. This has led to a heavy focus on the visual modality in imagery interventions, giving a very narrow view of imagery and how it occurs in sport (Morris et al., 2005). In a study carried out by Intraub and Hoffman (1992) it was found that readers confused pictures with texts, and it was concluded that readers were simulating the meaning of that text pictorially. This would suggest that images could be represented both visually and verbally as a simulation of text meaning and not are not two independent memory codes. Furthermore, it seems as that visual information is differentially encoded through the brain. Milner and Goodale (2008) present this idea, where it is argued that vision is divided between ventral (what and dorsal (how) streams. It is unclear to what extent Dual – code theory can be reconciled with this evidence as it argues like Paivio that there is a degree of separation but that this is a function of everyday tasks. Overall the Two-stream approach suggests that at best verbal labelling is only peripherally associated with ventral stream processing. Dorsal stream processing appears to be entirely separate, which is an issue when looking at the relationship between imagery and visual skills.

Bio-informational Theory

Bio-informational theory is a cognitive hypothesis that differs from other cognitive theories where the psychophysiology of imagery is considered (Lang, 1979, 1985). Lang developed this theory to investigate phobias and anxiety disorders, by incorporating perspectives of psychophysiology and information-processing. Bio-informational theory falls into the information processing paradigm of cognitive psychology. The idea behind information processing theory is that the human mind is viewed as an information processor/computer. This theory likens thought processes to that of a computer, where the brain receives information from the senses (input), is stored and processed by the brain, and then a behavioural response is brought about

(output). When it comes to applying these theories to the use of personalised language in imagery, it follows a very logical process. Lang proposes that all knowledge is represented in memory as abstract units of information that are already processed and relate to objects, relationships and events. Additionally, language is divided into three units of information which are described as propositions. These proposition units are divided into three essential groups: stimulus, response and meaning propositions. Simply, propositions are integrated into an imagery script as a way of eliciting appropriate behavioural responses. Propositions are received by the brain as words (input), these propositions are stored and processed by the brain, and the appropriate proposition is selected to elicit a certain behavioural response (output). The literature provides support from several studies that have utilized bio-informational theory either in part or completely (Callow & Hardy, 2001; Calmels et al., 2004; Intraub & Hoffman, 1992; Lebon et al., 2010; Mellalieu et al., 2009; Pain et al., 2011; Smith & Holmes, 2004; Smith et al., 2001; Smith et al., 2007). Recent research conducted by Wilson et al. (2010) provided support for the Lang's bio-informational theory, where it was investigated whether movement imagery results in greater physiological responses and greater ability when the script is generated by the participant. Electromyography (EMG) was used to measure left and right biceps brachii and triceps activity during physical and imagined performance. Results showed that imagery ability ratings were higher, and EMG activity was higher when participants created their own imagery scripts. Imagery interventions that have used bio-informational theory have identified that stimulus and response propositions create meaningful content that leads to more successful imagery outcomes. Personalised imagery scripts that provide meaningful content for the user are likely to bring more effective results. The individual will find it difficult to relate completely to an intervention that does not encapsulate their personal experiences (Cuthbert, Vrana, & Bradley, 1991; Lang, 1985). Essentially, bio-informational theory is effective in reinforcing the correctness of a skill but not in the development of it. There is a difference between repeating a correct performance and developing one. Thus, bio-informational theory is more likely to demonstrate effectiveness in relation to the affective dimensions of skilled performance.

Ashen's Triple-Code Theory

To investigate how imagery affects performance Ahsen (1984) proposed the triple-code theory. This theory lays out three components that are central to understanding the imagery, performance relationship. The image itself (I) is the first component, Ashen

saw this as an internal sensation that was produced centrally and consisted of all the necessary attributes of actual sensation. In line with Lang's bio-informational theory (1979), Ahsen proposed that imagery causes a psychophysiological response in the body. Thus, the second component of this theory is the somatic response (S). What separates this theory from most others is that Ahsen acknowledges image meaning. This is an aspect that is over-looked in other cognitive theories of imagery (i.e. Bio-informational and Dual-code theory). Image meaning (M) represents the third component of Ahsen's triple-code theory. Ahsen explained that when using imagery individuals bring their own past and backgrounds with them, even if imagery instructions are standardized, the participants will experience something completely different to each other (Morris et al., 2005). In many situations, the imagery function used by the individual will match the type of imagery used to achieve the anticipated outcome. Cumming and Williams (2012) explain that the proposed relationship between imagery type and outcome is not as straight-forward as Martin and colleagues' model of imagery has suggested. This is supported by a few studies which have shown varying results, for example the literature supports MG-M as being associated with confidence (Callow, Hardy, & Hall, 2001; Mills, Munroe, & Hall, 2000), though in some cases MS, CG and MG-A have all been related to confidence (Abma, Fry, Li, & Relyea, 2002). Athlete perception of what an imagery type is going to achieve will determine what function it will have for the individual. Ahsen's triple code theory addresses these perceptual differences of imagery type and function by recognizing the meaning of images for each individual, and encourages practitioners to seek the individual meanings of images to elicit the desired outcome of an intervention (Weinberg & Gould, 2014). As is common with other cognitive theories, triple-code theory does not give a sufficient explanation of where meaning comes from and how an individual develops it.

Role of Language in Imagery

Language is a representation of an individuals' personal meaning for a given concept (Barsalou, 2010). In the search for meaningful responses this can cause an individual to engage in several variations of imagery while performing a particular imagery script (Callow & Hardy, 2001; Hall et al., 1998; Nordin & Cumming, 2008; Short et al., 2002; Short, Hall, Engel, & Nigg, 2004). For example, the words used by the individual in an imagery script may elicit greater confidence and hence more persistence at a task, which

may cause an improvement on a technical level. This highlights the importance of having personally meaningful scripts, adapted to the way that an individual perceives a movement, situation or event. A way of making scripts more meaningful for the individual is the use of personalised scripts. Personalisation of imagery scripts has been shown in the literature to be an effective way of enhancing the efficacy of imagery interventions (for recent review, see Cooley, Williams, Burns, & Cumming, 2013). Williams and Cumming (2011) explain that imagery can be developed through time and effort. This could explain why personalised scripts have been so successful in the literature. Personalised scripts could be perceived as being more meaningful to the individual encouraging a greater investment in time and effort. A common theme amongst personalised imagery interventions is that they seek to find meaningful language and use it in scripts to elicit a desired response. Lang's (1979) bio-informational theory looks to identify meaningful language by dividing language into two main statements: stimulus and response propositions. Imagery scripts that contain both stimulus and response propositions are said to be more effective than scripts containing just stimulus or response propositions alone (Cumming & Williams, 2012). There is an assumption that an image is an organized set of stimulus and response propositions stored in the brain. Language is viewed as a fixed representation that leads to a desired physiological and mental response. However, this assumption would suggest that language has fixed meaning regardless of context and perception. Language is subject to a far more dynamic process than is suggested by bio-informational theory. Language comprehension during imagery draws on external perceptual information (situation, environment and body) not just previously stored structures of information (Barsalou, 1999). This is where the problem lies with bio-informational theory, a fixed association between word and meaning is assumed. Vygotsky (1962) explains that there is an associative relationship between word and meaning. A word recalls the content associated with that word. The theory of grounded cognition provides an alternative solution to the issue of context and language. Grounded cognition accepts that conceptual knowledge is founded in action and cannot be separated from the context it is developing in. In this instance context refers to the individuals' perception and the contextualization of a concept. By removing the context of language, as information-processing models have done, it removes the innate qualities that make a word a word, to remove context, you remove meaning, and to remove meaning you no longer have a word just a meaningless unit. A primary bond does not connect an individuals' thought to word, the connection manifests, changes, and grows throughout the evolution of the

individuals' thinking, making word meaning a dynamic process (Vygotsky, 1962). These issues have interesting implications for mental practice as the goal of mental practice is practice in the absence of physical action. Consequently, words with the most personal context/meaning will be most effective in the absence of the training environment. Furthermore, when imagery is undertaken in context, it strengthens that context. The sporting environment is dynamic and consistently changing. Imagery script design should reflect this continually changing environment and allow for individual perceptual differences with personal language, where meaning can develop in context with the movement being imaged.

Grounded Cognition

As mentioned in earlier sections bio-informational theory has been the popular theory of choice to support the effectiveness of personalised imagery scripts. However, the fundamental issue with this information-processing based model is that it views the comprehension of language too simplistically. Meaning is extracted from words and text and then stored in memory. Once the appropriate stimulus arises meaning is drawn from memory as part of an archival process, leading to the desired behavioural response. What is overlooked is that thought and action is dynamic and changing as a result of the immediate environment, the body, situations and simulations within the brain (Barsalou, 1999). The goal of CS imagery is not to present a perfect model of the perfect action but to present a series of contextual propositions that facilitate adaptation to the environment and the achievement of the required movement goal. Complex movements are by their nature variable and functionally adaptive (Davids, Button, Araújo, Renshaw, & Hristovski, 2006).

An alternative theory that supports this theory of situated action is that of grounded cognition, which places a heavy emphasis on the interaction of three elements; perception, action and the body (Barsalou, 2008). Situated cognition is a sub theory which comes under the larger umbrella known as grounded cognition. Aydede and Robbins (2009) explain that situated cognition is a theory that people's perception and action is linked to the activity, context and environment in which it is learned. Barsalou (1999) explains that the input to language comprehension is much more complex than first thought, with perception of the environment, situations, and the body all acting as contributing factors for language comprehension. Furthermore, information that is

stored from language comprehension is not stored in isolation but is dynamically coupled to an individual's understanding and ascribed context for the language being comprehended. To draw a comparative example between information-processing and situated cognition, information-processing is much like if someone is learning a new language, the learner can study a dictionary to increase their vocabulary. This isolated form of learning only teaches the learner the word and its meaning but not the context in which it should be used. Compared to if the learner was to develop their vocabulary from a native speaker of the language, they would learn how certain words are used in everyday social interactions. Thus, those words would gain context and not be isolated units of language. The latter part of this example represents situated cognition, whereby language is in context making certain words meaningful as they are connected to their intended meaning. Furthermore, as context changes so does the language and meaning relationship. Language used in imagery scripts is not a simple causal relationship, whereby inserting meaning propositions will elicit the desired response. These additional complexities in input, storage and output of language meaning provide alternative ways of thinking about the comprehension of language (Barsalou, 1999). However, it is important to note that this is not arguing that for CS imagery to be effective it must be performed in a dynamic context. Rather, that personalisation of imagery scripts allows for an individual to ascribe meaning according to their understanding and context for language.

Situated action focuses on the emergent, dependent nature of activity. Barsalou (2008) explains that situated cognition works closely in line with dynamic systems, where it is theorized that fixed representations of information do not exist in the mind. Past concepts in memory are developed further as a result of the interaction between consciousness, the environment, the body and situation (Barsalou, 2008). During learning, a coupling process occurs between conscious states, this coupling process mirrors patterns of interaction occurring between memory and situated consciousness which are effective in goal-achievement, also known as attractors (Barsalou, 2008). The role of the environment and how it shapes cognitive mechanisms is also acknowledged within situated theories, which is overlooked by information processing theories of cognition. Situated cognition also recognizes that consciousness and action adapts to the environment that it occurs in, thus being situated. What people perceive and what they do (action) develop in tandem. Subsequently, perception and the action that follows is largely seen as an adaptive and improvisatory process. As things are perceived, names

for these things are created, sentences are moved around, and interpretation of what statements mean for the individual occurs. This applies to imagery, and the use of personalised language in scripts, as words are conscious representations that are consciously utilized to shape cognition. Language comprehension is a process that prepares the individual for situated action, meaning that the words that are used within imagery scripts act to shape or constrain an individuals' cognition, and to certain extent is a result of what memory generates when specific words are used. When wanting to create an experience through imagery words or propositions used need to have sufficient context or meaning relevant to that experience. From a dynamic systems perspective, individual preference towards particular words represents preferred processes or attractor states that arise from successful dynamic solutions of movement problems (Barsalou, 2008). This is an important point to note in relation to the design of imagery scripts, as it supports the use of personalised imagery scripts. An analogy of when persons preferred words are not used, is kicking a ball with your non-dominant foot, it can be done but it comes at a cost to overall efficiency/effectiveness. This forms the basis of a key criticism of information-processing models, which assumes that words represent propositions that have the same meaning despite the situation. Assuming that particular words produce the same responses regardless of the situation takes away from the personal meaning of language for the individual. Each step of the perception process is not controlled by the application of grammatical limitations and previously stored plans. Rather words actively shape an adaptive reconfiguring of past ways of perceiving, conceiving and moving (Clancey, 1997). When a word is presented within the linguistic system there is an activation of associated simulations. The linguistic forms that represent this word serve as precursors to simulations that can form concepts of the words meaning. This process is what informs what words an individual will use to shape a movement (Barsalou, Santos, Simmons, & Wilson, 2008). As these simulations are situated, perception and conception become dynamically coupled with conceptual information. These concepts are represented by the recreation of patterns of activation that are connected to actual perception and action (Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008). An example would be how a fence is perceived, if you are going for a walk is it a boundary that you will go around or are you being chased and therefore will try to jump over it. Each situation shapes perception and conception differently (Clancey, 1997). Proffitt (2006) explains that the simulations of perceived effort have an effect on perception visually, for example when already in a fatigued state from running uphill, the hill can be perceived as being steeper than it really is

(Proffitt, 2006). Furthermore, due to the diversity that arises from concept simulations in a variety of conditions, it is a dynamic process. Situated cognition delves deeper into the development of knowledge, and accepts that knowledge is rooted in action and cannot be decontextualized. This highlights the importance of feedback, which is occurring within the individual (internal) and because of interactions with the environment (external). In contrast to traditional cognition theories there is a shift from input, storage, retrieval, and output models to a more dynamic process. Here formation of knowledge occurs as a result of the interaction between the body, the environment, situations and simulations that lie within the mind's systems for perception, action and reflection (Barsalou, 2010). Due to the dynamic nature of the sporting environment, situated cognition provides a sound theoretical framework to support why using individual language in imagery scripts can produce effective results. Further research is needed to support the use of situated cognition as a theoretical framework to support the role of individual language in imagery scripts.

Personalised versus Generic Scripts

Several studies have made use of personalised imagery scripts (Callow & Waters, 2005; Calmels et al., 2004; Mellalieu et al., 2009; Pain et al., 2011; Smith & Holmes, 2004; Smith et al., 2001; Smith et al., 2007), but the role of participant language in the construction of these personalised scripts has not been adequately investigated. As mentioned in earlier sections, scripts have mainly been constructed by extracting what are labelled as response and stimulus propositions and inserted to elicit a desired response. The importance of having an individualised approach in the generation of imagery scripts has been well acknowledged and research has shown the benefits this approach can have to performance. In a systematic review of guided imagery interventions by Cooley and colleagues, four main sources were identified that informed the compilation of imagery scripts for interventions; the physical task which is based on descriptive information about the environment and task, proven research models, content based on the researchers' and athletes' experiences and lastly the experience of the participant (Cooley et al., 2013). Of the reviewed studies, over half of the interventions (n=12) used personalised scripts, compared to other interventions (n=8) where generic imagery scripts were used. Additionally, it was reported that successful interventions could be associated with personalised imagery ($p < 0.05$). It is difficult to make specific comments about the compilation of imagery scripts in interventions as

they are not made readily available. What can be examined though is the theoretical framework that influences the generation of these scripts. As mentioned in previous sections a trend that is evident is that bio-informational theory has guided a large portion of interventions that have used personalised scripts (Callow & Waters, 2005; Calmels et al., 2004; Mellalieu et al., 2009; Pain et al., 2011; Smith & Holmes, 2004; Smith et al., 2001; Smith et al., 2007; Wilson et al., 2010). Despite being commonly used, studies using personalised scripts display significant methodological variation. Specifically, modification of imagery scripts, method of script presentation, timing of script use and instructions given to participants before imagery use vary a lot between studies. For example, in the methods used by Mellalieu et al. (2009) who used personalised scripts that were read by participants, compared to Pain et al. (2011) who used personalised scripts that were listened to by participants via audio recordings that were narrated by the experimenter. The methods that have been used to personalise scripts and the degree of personalisation in scripts have varied significantly. For example, Smith, Wright, and Cantwell (2008) used all three propositions (Stimulus, Response and Meaning) to personalize imagery scripts, whereas Smith et al. (2007) used only two out of the three propositions (Stimulus and Response).

Only one study to date has compared personalised scripts with generic ones. Wilson et al. (2010) compared participant generated and generic scripts to investigate the effects on EMG activity and imagery ability. Results from their study showing that imagery ability ratings were higher, and EMG activity higher when participants created their own imagery scripts. However, when looking at the effects of personalised imagery on skill development this study is limited in its' application. Firstly, EMG is an invalid performance measure, as it is not a reflection of skill. It is possible that participant generated scripts only caused performers to try harder and were not influencing the movement itself. By using EMG there is no way of ascertaining the effects of participant generated scripts of the skill element of this movement. It is difficult when the movement itself (bicep curl) requires very little skill to perform. Additionally, the use of a self-reported measure of ability presents an issue with this study. Participants in the personalised group may have been subject to an expectancy effect, where they felt as though they were meant to score higher on post-test scores. This suggests that a more subjective measure of imagery ability, is required to give a true representation imagery ability and its' effects on a movement. The following questions are raised because of this study: 1) what effects do personalised imagery scripts have on a complex skill and

2) are personalised scripts more effective than generic scripts or is this a result of an expectancy effect that results from invalid measures of the intervention efficacy. As explained in earlier sections (see section on grounded cognition), bio-informational theory does not allow for the individual meaning of a concept to be developed. Future research needs to focus on the relationship between CS imagery and the development of a movement that requires a high level of skill. This has not yet been adequately tested as personalised scripts have been used to test basic non-athletic tasks which give no indication of the effect imagery has on skill development.

Power Clean Performance

Weightlifting is a sport that is comprised of two-multi-joint, full body lifts that are performed in competition; the snatch and clean and jerk. Studies that have investigated these lifts in competitive weightlifters have recorded some of the highest PP outputs recorded in the literature (Storey & Smith, 2012). The PC is a commonly used complementary exercise by non-weightlifting athletes that are involved in strength and power sports (e.g. team sport and track and field athletes), due to the kinematic similarities that exist between the propulsive phases in both weightlifting and athletic movements, and the ability it has in improving key kinetic variables (e.g. PF and PP) (Storey & Smith, 2012; Winchester, Erickson, Blaak, & McBride, 2005). In a study carried out by Hori et al. (2008), hang PC performance was tested with twenty-nine semi-professional Australian Rules football players. The purpose of this study was to determine whether athletes who possessed a higher hang PC performance performed better in jumping, sprinting and change of direction tests than athletes who were not as skilled in the hang PC. Findings showed that the group who exhibited higher hang PC performance displayed higher maximal strength ($P < 0.01$), PP ($P < 0.01$), jumping ($P < 0.05$), and sprint performance ($P < 0.01$) compared to their lesser skilled counterparts (Hori et al., 2008). In support of this finding, Kazuhiro, Yoshimitsu, Kazuhiko, Kazunori, and Hisashi (2015) tested the relationship between power event scores (e.g. 100m sprint, shotput, discus and high jump) and power/strength tests (e.g. hang power clean, backward medicine ball throw and standing triple jump) in seventy-four male university track and field athletes using the International Association of Athletics scoring table (IAAF). Findings indicated a significant relationship between the hang PC ($P < 0.05$) and IAAF scores in throwing athletes. It is important to note that although the

literature shows that weightlifters produce some of the highest peak power outputs recorded during the performance of the Olympic lifts, inclusive of the complementary exercises and the competitive lifts themselves, there are differences that exist in power and force outputs when weightlifters are compared to athletes in other sports. The literature suggests that the reason for this difference is based on the variation of technique that exists between weightlifters and non-weightlifting athletes (Comfort, Allen, & Graham-Smith, 2011).

Due to the importance of technique in the PC, this has become an influencing factor when programming intensity/load for athletes who look to utilize the PC exercise. Track and field athletes are commonly prescribed the PC exercise with loads of 80-90% 1RM (2-5 reps). The reason that the intensity zone of 80-90% is prescribed in the power clean is multi-faceted, as it allows for appropriate speed-speed strength progression and also effectively trains the synchronisation of motor units (Judge, 2007). Additionally, 80-90% 1RM allows for the athlete to maintain appropriate technique throughout the PC, which is important for both safety and overall performance. The importance of maintaining correct technique and the subsequent effect on performance in the PC is demonstrated by Winchester et al. (2005), where it was shown that through improved technique, power output can be significantly increased.

The following section will address the importance of PC technique and its relationship to performance.

Technical Features

The competition lifts in weightlifting are very technically demanding movements that require a large degree of flexibility and muscular co-ordination in order for the lift to be completed competently (Storey & Smith, 2012). However, the PC is considerably less technically demanding when compared to the competition lifts and therefore, the time needed to learn this movement is significantly less and is a contributing factor in why it is commonly used with non-weightlifters (M Stone, Pierce, Sands, & Stone, 2006). The PC is an explosive full body movement which involves the barbell being lifted from the floor straight up and into what is known as the front rack position (i.e. bar sitting across the shoulders) in one movement (M Stone et al., 2006). Five phases comprise the PC movement; firstly the lifter starts in the set position where the *first pull* is initiated from the ground. The lifter extends the knees pulling the barbell from the ground to just

below the knee. A transition phase follows which is commonly referred to as the “double knee bend”. During this phase, the knees re-bend in towards the bar as the torso extends vertically. From this position the lifter maximally extends through the hips, knees and ankles whilst pulling the barbell upright in an effort to maximally accelerate the bar in the vertical plane. This phase is termed the second pull during which time the lifter will aim to keep the bar close to the body (Storey & Smith, 2012). At the conclusion of the second pull the lifter pulls themselves under the bar in the *turnover* phase and thrusts the elbows forward to catch the barbell across the front of the shoulders in the *catch position*. The PC differs from the full clean as it is necessary to catch the barbell no lower than parallel squat depth, in other words the lifter’s hips must not be deeper than knee level (Kawamori et al., 2005).

Bar-path parameters are often the metric by which technique is measured in weightlifting movements. Specifically, a relationship has been identified between success in weightlifting and horizontal bar displacement (M. Stone, O'bryant, Williams, Johnson, & Pierce, 1998). As a result, Winchester et al. (2005) identified the following four kinematic features as being central to success in the PC exercise: 1) backward movement of the barbell during the first pull and the transition into the second pull (Dx2); horizontal bar displacement during the second pull to the most forward position (DxV); total horizontal bar displacement from the start of the lift to the rack position (DxT); and lastly horizontal bar displacement from the most forward position in the second pull to the rack position (DxL) (Figure 2).

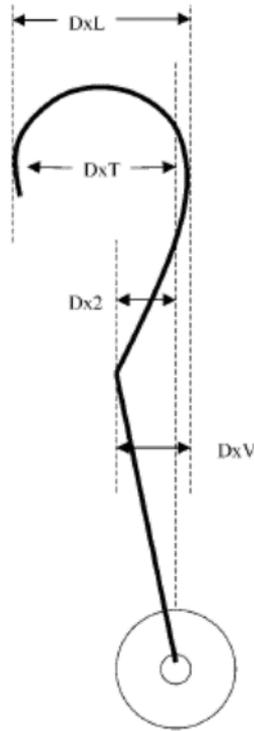


Figure 2. Kinematic Variables; Dx_2 , Dx_V , Dx_T , and Dx_L (Winchester et al., 2005).

Kinematic and Kinetic Features

Throughout the literature, horizontal bar displacement has commonly been identified as the differentiating factor between successful and unsuccessful Olympic weightlifting attempts (J Garhammer, 1993; Winchester et al., 2005). Furthermore, Winchester et al. (2005) proposed that a successful PC will have $\leq 20\text{cm}$ of total horizontal bar displacement (i.e. inclusive of both rearward and frontal bar displacement) from the most forward position to the catch position. Although bar paths seem to vary greatly in the literature (Akkus, 2012; Bartonietz, 1996; Harbili & Alptekin, 2014), what is important to note is a fundamental principle of weightlifting, which is the position of the bar relative to the body. M Stone et al. (2006) explains that as the bar is pulled from the floor, the bar should remain as close to the body as possible and actually touch the thighs through the second pull phase of the lift. If the bar is left out in front of the body during the second pull this will create a poor position from which to generate force, due to the creation of an extended-moment-arm. Additionally, as the bar drifts further away from the lifter's centre of mass, more energy is required to try and bring the bar back in towards the body so it can be caught successfully (M Stone et al., 2006).

It is important to note the connection between technique in weightlifting movements and the effect that this has on kinetic variables. Winchester et al. (2005), conducted a study comparing the kinematic (i.e. horizontal-bar displacement) and kinetic (i.e. PP & PF) variables of the PC across three loads (50%, 70% & 90% of 1RM) after a PC training intervention. Findings from this study showed that participants significantly increased PP at 50% and 90% loads. For example, at 90% of 1RM, PP increased ~11% and PF was increased across all three loads. Furthermore, significant changes (≤ 0.05) in kinematic variables were also displayed across the three testing loads. It is important to note that a new 1RM was not measured in this study and the same absolute loads of 50, 70 and 90% 1RM were used pre and post intervention. With PP increasing across all three loads and PF increasing at 2 out of 3 loads alongside significant changes in bar kinematics, this suggests that as a lifter becomes more technically efficient this will translate to increased power and force production, despite there being no increase even in training loads.

Another key kinetic variable associated with PC performance is barbell velocity (BBV). In studies carried out on skilful lifters it has been observed that BBV increases steadily, with very small or no drop in velocity being observed throughout the transition phase of the lift (i.e. from a below knee position to the second pull position). Conversely, in less-technically efficient lifters a drop in velocity can be expected around the transition phase of the lift due to the technique differences that exist between technically efficient and less efficient lifters (Chiu, Wang, & Cheng, 2010). These differences highlight the influence that the kinematic variables have on the kinetic output of a lift such as the power clean. By becoming more technically efficient a smoother transition from below knee through to the second pull can be expected which will limit or even nullify a decrease in velocity throughout this phase of the lift. During the second pull of maximal clean attempts, weightlifters have been reported to produce BBVs ranging from 0.88 m/sec to 1.73 m/sec. However, when using sub-maximal loads in supplementary movements (i.e. power clean), BBV are much higher and can exceed 2.50 m/sec (Storey & Smith, 2012). However, in lifters that are not technical efficient peak velocities are seen to be significantly lower. For example, in a study carried out by Pennington, Laubach, De Marco, and Linderman (2010) on male collegiate football players, PC peak velocities at 90% and 100% 1RM were 1.8 m/s and 1.6 m/s respectively. Such examples highlight how the power clean exercise can aid in the improvement of kinetic variables (PF, PP and PV) that are specific to other athletic activities. For example, in throwing

events such as, shot put, discus, and javelin, there is a need for high release velocities as this is a key factor to a successful throw (Judge, 2007). Throughout throwing events (shotput, discus, and javelin) it is paramount to accelerate throughout the entire movement and avoid deceleration in order to maximize release velocity. It is for this reason that practitioners utilize the PC as it allows for full acceleration of the barbell throughout the entire range of the movement without the need to decelerate, which allows for greater velocities to be reached. Additionally, the PC provides a training exercise that is similar to the actual physical performance requirements of throwing events. For example, explosive hip and the knee extension during the 2nd pull phase of the PC are similar to key aspects and positions during throwing movements (Judge, 2007). Although the above examples do highlight the effectiveness of the PC in improving kinetic variables, it also highlights the importance of learning correct technique to ensure the athlete is able to lift the prescribed loads with maximal intention and velocity. This notion is supported by the findings of (Pennington et al., 2010) where peak velocities of less technical efficient lifters were lower than those who displayed greater technical efficiency. By being more technical efficient the athlete will be able to shift the loads at sufficient speed in order to reap the benefits of speed-strength training and thus improve kinetic variables (PF, PP and PV). Bearing in mind the body of evidence that supports the relationship between technique and kinetic variables, it is important for coaches and athletes involved in other sports to give adequate attention to improving technique in order to maximize the training benefits (Winchester, Porter, & McBride, 2009).

Summary and Implications from the Literature Review

Strength and conditioning coaches that are looking to integrate the power clean into their athlete's programme should focus first and foremost on the improvement of technique. The literature indicates that there is a direct relationship between technique improvement and increases in kinetic variables (PP and PF) (Winchester et al., 2005). An alternative approach that strength and conditioning coaches could look at using to improve technique would be imagery and the use of personalised scripts. The literature confirms that imagery has been identified as a contributing factor in producing performance benefits in various sporting contexts. Important findings have been made in regards to the content that athletes use when imagining. Additionally, imagery effectiveness has been said to be blunted or even regress if the imagery content is not

appropriate for the situation for the athlete (Robin et al., 2007). In order to try and personalize imagery scripts to make treatment more appropriate for athletes, many tend to adopt Lang's (1979) bio-informational theory. This information-processing approach utilizes stimulus and response propositions. The most effective scripts are when both stimulus and response propositions are incorporated, this will help to elicit the desired physiological response from the individual. In theory this approach seems viable, Lang (1985) explains that there will be a much better match between memory and the imagined scene if the image is relevant to the individual. Stimulus and response propositions provide a theoretical basis for personalizing imagery scripts to make them more meaningful for the individual.

However, the issue with an information-processing approach to imagery is that there is an assumption that language comprehension is subject to simple processes of storage and retrieval and that language is stored with fixed meaning to be retrieved when the desired stimulus is applied. The interaction between thought and action is viewed in isolation when in fact it is a dynamic and changing process that is subject to the immediate environment, the body, situations and simulations within the mind. Grounded cognition, is an alternative theory that provides rationale as to why perception and action is linked to activity, context and the environment in which it is learned. This alternative theory of cognition focuses on the emergent, dependent nature of activity (Nardi, 1996). Importantly, grounded cognition examines the connection between perception and action and how these are influenced by the situational inputs (Prinz, 1997). The theory of grounded cognition is important to this review as it forms the theoretical basis for why personalised language is important within imagery scripts. It provides rationale as to why word meaning cannot be decontextualized in order to elicit a desired response but in order to make scripts more meaningful for an individual the language used must be their own and must be kept in context to maintain the integrity of meaning held within each text/word. This represents the nexus of this review, which is the role of language in imagery. Numerous studies have looked at the use of personalised imagery scripts, but the degree of personalization and the mechanisms behind why personalised scripts are effective has not been examined adequately in depth. The literature has shown that imagery is effective, but we do not need to know whether it is effective anymore, but rather how we can make imagery interventions more effective than they already are. Incorporating unfiltered participant language into imagery scripts could provide new insight into what degree scripts be personalised and

whether it is a method of script design that can make imagery interventions more effective for the individual when developing a complex skill such as the PC.

CHAPTER 3

EFFECTS OF PERSONAL DESCRIPTION IN IMAGERY SCRIPTS ON PERFORMANCE VARIABLES IN THE POWER CLEAN

Abstract

While it is widely argued that personalised imagery scripts are beneficial to performers, theory and data to support this contention is sparse. The current study aims to address these issues by investigating: Firstly, what differences in content and description arise from the use of generic and personalised scripts aimed at improving performance in the Power Clean (PC). Secondly, if any differences are reflected in relevant kinematic and kinetic measures. Sixteen resistance trained individuals were randomly allocated to one of two conditions: personalised imagery (PI), or generic imagery (GI). During baseline testing, participants performed a 1 repetition maximum (1RM) PC along with a recall test which consisted of giving a personal description of the power clean. Personal descriptions of the PC were used to construct imagery scripts for the PI group. Scripts for the GI group were derived from a standard description of the PC obtained from an international level Olympic-Weightlifting coach and current literature on PC technique. Participants completed three PC training sessions per week and listened to an audio-recorded version of their given imagery scripts five times per week. At the end of the training period descriptions of the PC were compared along with kinematic and performance variables including; peak power (PP), peak force (PF), peak velocity (PV) at 80, 90 and 100% of the participants' 1RM and horizontal bar displacement. There was a significant difference between post-test adjectives used between groups ($ES=1.37\pm 1.27$). The PI group showed a meaningful increase (23.4 ± 7.8 to 31.1 ± 18.1) compared to a decrease in the GI group (14.6 ± 8.7 to 13.6 ± 7.8). At 100% testing load the PI group experienced changes to $Dx2$ and DxT which saw the bar caught closer to the participants' centre of mass in post-testing. The PI group showed small to moderate improvements in PF (80 and 90%) and PV (100%). Findings suggest that personalised scripts result in different descriptions of movements and that these differences are of benefit to performance.

Introduction

Current research has identified that for imagery interventions to be most effective that using personalized or participant-generated scripts will yield the best results (Callow & Waters, 2005; Calmels et al., 2004; Mellalieu et al., 2009; Pain et al., 2011; Smith & Holmes, 2004; Smith et al., 2001). However, only one study has investigated the efficacy of participant generated scripts in comparison to generic scripts (Wilson et al., 2010). Wilson et al. (2010) compared differences in muscle activity (determined via electromyography) (EMG) between participants using either, participant generated scripts and experimenter derived scripts. The issue with this study is that EMG is not a valid measure of performance. Participants may have recorded higher EMG readings purely because they tried harder, and not because imagery facilitated performance of this the task. By using EMG there is no way of knowing the effects of participant generated scripts on the skill elements of the movement. The movement used in this study (bicep curl) requires very little skill to perform, so it does not give any indication of the relationship between skill development and personalised imagery. The effects that personalised imagery has on the development of a skill is a question that has been raised from reviewing the literature. Furthermore, movements that require high levels of skill require further investigation in relation to imagery use.

Bio-informational theory has adopted an information-processing model, where propositionally coded information that is stored in long term memory is activated during the imagery process. This theory proposes that images contain two main types of descriptions: response and stimulus propositions. Commonly not reported in the literature due to its' perceived unimportance, are meaning propositions. Mellalieu et al. (2009) utilized all three propositions (stimulus, response and meaning) in their investigation of the effects of motivational general-arousal imagery on pre-performance symptoms. Findings highlighted the importance of using personalised imagery as a means of influencing change in participants' perceptions of precompetitive experiences. An underlying theme that is common within these studies is the need to make imagery scripts meaningful to the individual. To date, the bio-informational theory has been the logical choice whether through the use of all three propositions (e.g. Pain et al., 2011) or just stimulus and response (e.g. Smith et al., 2001). The goal of these interventions has been to make scripts meaningful to participants to elicit the desired behavioural response. However, there are currently no studies that have investigated alternative

theories to construct participant generated scripts and compare them with generic scripts.

Lang (1979) proposes that all knowledge (i.e. information about imaged scenes) is represented in memory as abstract units of information that are pre-processed and relate to objects, relationships and events. When participants comprehend language within an imagery script, this is viewed as a simple process whereby meaning is extracted from a statement and that meaning response is coded and stored in memory, when the appropriate stimulus arises, that meaning is drawn from long-term memory as part of an archival process, leading to the desired response. The use of more meaningful propositions in scripts will lead to greater physiological responses and more effective imagery for the individual (Weinberg & Gould, 2014). However, it has been acknowledged in the literature that the information processing paradigm fails to adequately address how cognition interacts with perception and action. In a dynamic sporting environment where an athlete's cognition is constantly interfacing with perception and subsequently action, how can propositions stored in long-term memory be expected to be overly meaningful when individual meaning is evolving in tandem with action and perception (Barsalou, 2008).

Based on this limitation the current study proposes an alternative conceptual approach in Barsalou's (2008) theory of grounded cognition. Situated cognition is a sub-theory which comes under the larger umbrella of grounded cognition and is useful as a theoretical framework for unpacking the relationship between personal language and meaning. Situated cognition works closely in line with dynamic systems theory, where it is theorized that fixed representations of information do not exist in the mind. Past concepts in memory are developed further as a result of the interaction between consciousness, the environment, the body and situation (Barsalou, 2008). In theory this applies to imagery, and the use of personalised language in scripts, as words are conscious representations that are utilized to shape cognition. From a dynamic systems perspective, individual preference towards certain words represents preferred processes or attractor states. Scripts that contain participants own descriptions represent preferred processes that have arisen from successful dynamic solutions of movement problems (Barsalou, 2010). Athlete perception of an imagery intervention is central to the successfully generating changes in performance. Findings from Nordin and Cumming (2008) examining how imagery type (CS, CG, MG-A, MG-M, MS) relates to serving

specific functions found that athletes perceived a range of imagery types to serve multiple functions (i.e. CG imagery used for motivational purposes). Additionally, it was reported that a large number of individual differences exist in athletes' perception of various imagery types and their theoretical functions. At the core of these findings is perception. For example, an athlete may be asked to image flicking the wrists when shooting a basketball as this is seen as a technical aspect of the shot. The athlete however, may perceive this in a way that lowers anxiety, thus serving a more motivational function instead of cognitive. Perception is the key factor in effective imagery scripts and grounded cognition addresses this by putting forward the idea that what people perceive and what they do evolve together. It is this individual perceptual process that informs linguistic descriptions of a movement. Furthermore, movement behaviour (i.e. power clean) cannot be simplified into an explicit set of instructions that are followed to achieve the desired response, rather a more complex process is required to bring interacting systems into alignment (Davids & Araújo, 2010).

Imagery use in Olympic weightlifting based movements has not been documented to date, but it can be hypothesized based on studies that have investigated the effects of imagery on strength based tasks that imagery could be effective in enhancing performance in power based movements (Bakker et al., 1996; Cupal & Brewer, 2001; De Ruiter et al., 2012; Lebon et al., 2010; Newsom et al., 2003; Ranganathan et al., 2004; Wilson et al., 2010; Yue & Cole, 1992; Zijdewind et al., 2003). The skill based components of certain sports have also been shown to be positively influenced by imagery, with Robin et al. (2007) reporting significant improvements in service return accuracy in experienced tennis players who utilized imagery. These studies provide evidence to support the use of imagery as a strategy to cope with the various mental requirements of sport and a way to improve skill based movements. It can be hypothesised based on the demands of Olympic weightlifting that imagery could be a useful skill to implement due to the evident benefits to skill learning and motivational functions. In the sport of weightlifting, the competitive lifts of the snatch and clean and jerk require short periods of intense concentration, with both lifts lasting ~3-5 seconds and ~8-12 seconds respectively. Due to the fact that optimal weightlifting performance requires maximal power output and fine motor control, arousal control is important to maximize performance and therefore the ability to control anxiety levels are vital for successful performance (Fry et al., 1995). Further research is required on the effects of imagery on power based exercises, such as the PC. Investigating the effects of

personalised descriptions of the PC will provide unique insights into how personalised language facilitates the improvement of a complex motor skill.

This study directed attention towards the effects of completely personalised imagery scripts versus generic scripts on skill enhancement. It was hypothesised that by using completely individualised imagery scripts that language would become more meaningful throughout the intervention as the words being used would be situated and meaning would be allowed to evolve in tandem with participants' perception of the power clean movement and the action that followed during training.

Methods

Experimental Approach to the Problem

The aims of the current investigation were to: 1) investigate what differences in content and description arise from the use of generic and personalised scripts aimed at improving performance in the Power Clean (PC), and 2) if any differences are reflected in relevant kinematic and kinetic measures. Sixteen resistance trained individuals were randomly allocated to one of two conditions: personalised imagery (PI), or generic imagery (GI). Two-dimensional (2-D) video and linear position transducer (LPT) (Gym aware Power Tool, Kinetic Performance PTY Ltd., ACT, Australia) were used to provide a kinematic and kinetic profile of the PC at loads of 80%, 90% and 100% of 1 repetition maximum. Based on the Winchester et al. (2005) model of PC technique, four kinematic and three kinetic variables were looked at to quantify technical changes over a training period of six weeks. Each participants' own description of the power clean was used to construct the audio imagery script for those in the PI group. It is important to note that in order to limit an expectancy effect minimal interaction occurred between the primary researcher and participants. Each participant was given no guidance on what to say and the description was recorded in a room on their own. Participants in the GI group were given an audio imagery script constructed by the primary researcher based on information obtained from a national level Olympic-Weightlifting coach and current literature of the power clean. These scripts were listened to five times per week for the duration of the six-week intervention. Lastly, a sport imagery ability questionnaire (SIAQ) was used to measure changes in imagery ability over the course of the 6 weeks. Based on Barsalous' (2008) theory of grounded cognition it was

hypothesized that the inclusion of a participant's own description of the skill would generate more effective imagery scripts than generically derived ones. This is based upon the premise that personalised scripts represent a more dynamic solution to the movement problem.

Participants

22 resistance trained individuals initially volunteered to participate in this study (male; n=19, female; n=3). Due to injuries (unrelated), or personal reasons (i.e. travel, studies), six participants could not perform the entire protocol and/or the post-testing session, and were therefore removed from the study. Due to the drop out of participants this caused the groups to become uneven. Consequently, a total of sixteen participants were randomly assigned to either the PI group (n=7) or GI group (n=9), please refer to Table 1 for participant characteristics. All Participants were resistance trained individuals who had experience in using the PC as part of their usual training. The PI group comprised of competitive Olympic weightlifters (n=4), a sprinter (n=1), and recreationally trained individuals (n=2). The GI group contained, competitive Olympic weightlifters (n=4), rugby union players (n=2), a cricketer (n=1), a tennis player (n=1), and a recreationally trained individual (n=1). Due to the participant randomization process, both female participants were assigned to the PI group. However, both females were of a sufficient level of skill (i.e. a competitive Olympic weightlifter and a national level sprinter) and met all the inclusion criteria. All participants were required to have a minimum of 2 years resistance training experience along with the ability to PC $\geq 1x$ body weight (BW), as this is deemed to be a novice to intermediate standard of ability with the PC exercise (Rippetoe, Kilgore, & Bradford, 2006). All participants were free of chronic and acute injuries. Written consent was gained before the commencement of data collection. All procedures carried out in this study were approved by the Auckland University of Technology Ethics Committee (16/64).

Differences in participant characteristics

Table 1 displays the descriptive and between groups comparative statistics for participant characteristics. Chronological age showed large (ES=1.24; *likely*) between group differences. A between group difference of a moderate magnitude (ES=0.77; *likely*) was displayed for training age with the PI group having a more training experience compared to the GI group (11 ± 7.1 and 6.4 ± 2.2 , respectively). Between group differences in bodyweight were shown to be unclear. PC 1RM scores were found

to have a moderate between group difference (ES=-0.65, *likely*), with the GI group having higher baseline 1RM scores compared with the PI group (91.6 ± 18.9 and 79.8 ± 15.3 , respectively)

Table 1 Descriptive statistics of personalised and generic imagery groups

	PI Group (n=7) $\bar{x} \pm SD$	GI Group (n=9) $\bar{x} \pm SD$	ES $\pm 90\%$ CL	Inference
Age (years)	30.4 \pm 6.9	22.4 \pm 4.9	1.24 \pm 0.86	Large** (positive)
Training Age (years)	11 \pm 7.1	6.4 \pm 2.2	0.77 \pm 0.91	Moderate** (positive)
Body weight (kg)	74.5 \pm 12.3	77.9 \pm 14.3	-0.24 \pm 0.84	Unclear
PC 1RM (kg)	79.8 \pm 15.3	91.6 \pm 18.9	-0.65 \pm 0.83	Moderate** (neutral)

Values are mean \pm standard deviation, change in mean; $\pm 90\%$ confidence limits and percent change; \pm standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; *n*, sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits. Qualitative inferences are trivial (< 0.20), small ($0.20 - < 0.60$) and moderate ($0.60 - < 1.20$): * possibly, 25 – < 75 ; ** likely, 75 – $< 95\%$; ***very likely, 95-99.5%; ****most likely, $>99.5\%$. Positive and neutral descriptors qualitatively describe the differences between the pre – pre results for the generic group versus personalized group values and its importance relative to the specific variable.

Study Design

All participants were required to attend one familiarisation session prior to the first formal testing session. The familiarisation session lasted approximately two hours and was 14 days before the first formal testing session. During the familiarisation session, the participants performed the following sets and reps at the following percentage of their estimated 1RM: 8 reps at 50% of 1RM, 3 reps at 60% of 1RM, 2 reps at 70% of 1RM, until they reached a minimum of a bodyweight PC. Rest periods of 2-5minutes were given between each set. This ensured that all participants could obtain a BW PC prior to formal testing. Immediately following the 1RM familiarisation, participants were taken into a quiet room to conduct the recall test. Participants were presented a gold standard description of the PC that was constructed in conjunction with the current literature on PC technique and the technical knowledge of an international-level Olympic weightlifting coach (refer to Appendix 5 for a full description). After reading through the gold standard description, the participants were required to give a personal description of the power clean into an audio recording device (refer to Appendix 6 for example of personalised script). Following the recall test, participants completed the sport imagery ability questionnaire (SIAQ) in a quiet environment. The SIAQ 15 point questionnaire designed to measure the ability of athletes to image different content that is regularly used in their sport (see Appendix 7) (Williams & Cumming, 2011). In the 14 days leading up to the first formal testing, participants were required to take part in 4 imagery training sessions. Two sessions were conducted over a 7day period and were approximately 15 mins long. Participants would sit in a quiet room and listen to two different imagery exercises via audio recording. These exercises were geared towards getting participants to use different modalities of imagery. Imagery training was conducted to give participants an opportunity to familiarize themselves with imagery and how it is used. Additionally, it was used as a way of safeguarding participants from the discomfort of not being able to use imagery effectively prior to starting the intervention, whilst giving them the opportunity to withdraw if they wanted to.

Data Collection and Analysis

Power Clean 1RM Test Protocol

A standardized warm up, consisting of dynamic movement (e.g. leg swings, bodyweight press ups) and dynamic stretches (lunges with a twist, squats) was self-directed by each participant and completed before the start of testing. Each participant was allowed

between 1-2 sets of 3-5 reps on the 20kg Olympic weightlifting bar (Eleiko Sport, Halmstad, SWE) prior to the start of testing. Based on the 1RM testing procedure used by Winchester et al. (2005) warm-up trials were based on each participant's estimated 1RM which was determined during the familiarisation session. During the testing session, the participants performed the following sets and reps at the following percentage of their estimated 1RM 8 reps at 50% of 1RM, 3 reps at 60% of 1RM, 2 reps at 70% of 1RM, 1 rep at 80% of 1RM, 1 rep at 90% of 1RM. After 90% of their estimated 1RM, each participant was consulted as to what weight they would like to attempt for a maximal 1RM lift. The criteria for a successful PC required the participants to catch the barbell with their thighs above a parallel position before going to an upright standing position (Storey & Smith, 2012). To ensure that each lift was carried out in the same position, a piece of white tape was measured out to be in the exact centre of the platform. Participants were instructed to have the bar positioned over the piece of tape in the start position of the PC. The piece of white tape was also measured to be exactly the centre point of where the camera was set up which allowed for a more accurate side on 2-D recording of each lift. Previous research has shown that individuals with moderate PC abilities, typically performed maximal lifts at approximately $1.6 \text{ m}\cdot\text{s}^{-1}$ (Pennington et al., 2010). Therefore, a linear position transducer (LPT - Gymaware PowerTool, Kinetic Performance PTY Ltd., ACT, Australia) was used by an experienced strength coach to measure the peak concentric velocity of the PC to assist participants in selecting the next weight in order to obtain a true maximum. After each successful attempt, small weight increments (1-5kg) were chosen to get as close to a true maximum as possible. Participants were taken to complete failure where they would be allowed to miss a weight a total of two times consecutively before the testing would cease. A 2-5 minute rest period was given between each warm-up trial and maximal attempts. When testing loads were not whole numbers, the load was rounded to the closest full number (e.g. 80% of 112 kg 1RM power clean = 89.6 kg. The testing load was then rounded up to 90 kg).

Recall Test

Immediately following the 1RM PC testing participants were taken into a quiet room to conduct the recall test. To improve technique, a focus on the appropriate technical factors needed to be outlined to the participants. Thus, the recall test started with participants being presented with a gold standard PC description. This description was constructed to improve power clean technique based on current literature and the expert

knowledge of an international-Olympic weightlifting coach. What the recall test was designed to examine was the language participants used to describe well-established technical factors that have been shown to lead to improved technique. Participants would be instructed to read through the description in their own time and then once done the description would be taken away. At this point participants were asked to give a full description of the “perfect PC” in their own words. Both groups were required to complete a personalised script to compare the effects of personalised and generic scripts on the descriptive content of the PC. Each participants’ recall test was recorded using a Samsung, S6 mobile device with the audio record function.

SIAQ

The SIAQ was administered after the recall test to mitigate any possible influences of the questionnaire on recall test outcomes (i.e. interfering with images generated by participants about the PC). Participants completed the SIAQ in a quiet environment free of external distractions. Williams and Cumming (2011) outline recommendations around how to divide the SIAQ scores into separate subscales of imagery ability (Skill, strategy, goal, affect and mastery imagery ability) and then a global measure of imagery ability. The effects of personalised imagery on skill development was the aim of the current study so the subset of skill imagery was selected for analysis. Skill imagery ability was calculated by averaging the following questions: Item 3 + Item 8 + Item 12/3 (Williams & Cumming, 2011).

Kinematic Analysis of the Power Clean

Kinematic data was collected using a Casio, EXLIM, EX-F1 (Tokyo, Japan) and was filmed at 300 fps. The camera specifications and set up were selected in line with Garhammer & Newton’s (2013) recommendations of video analysis in applied settings. The centre of the platform was measured and white tape was applied on the centre of the platform. The camera was positioned 5 meters from the end of the barbell in line with the centre of the platform on the right hand side of the participants’ coronal plane (Figure 3) (J Garhammer, 1993; J. Garhammer & Newton, 2013). The camera was fixed onto a tripod that was 65cm above the lifting platform and manually zoomed to 50mm so that the view included the bottom of the weight plates on the platform and the peak height of the lift. A 75cm scaling rod was applied to the platform in the same depth of field at the end of the barbell to give a known scaling measure for analysis. A reflective marker was placed on the end of the barbell to allow a bar path to be established in

Kinovea 0.8.15 software (see Appendix 8 for Kinovea analysis steps). In a study carried out by Balsalobre-Fernández, Tejero-González, del Campo-Vecino, and Bavaresco (2014), Kinovea software was found to be a valid and highly reliable ($r= 0.9997$) method for measuring athletic movements.

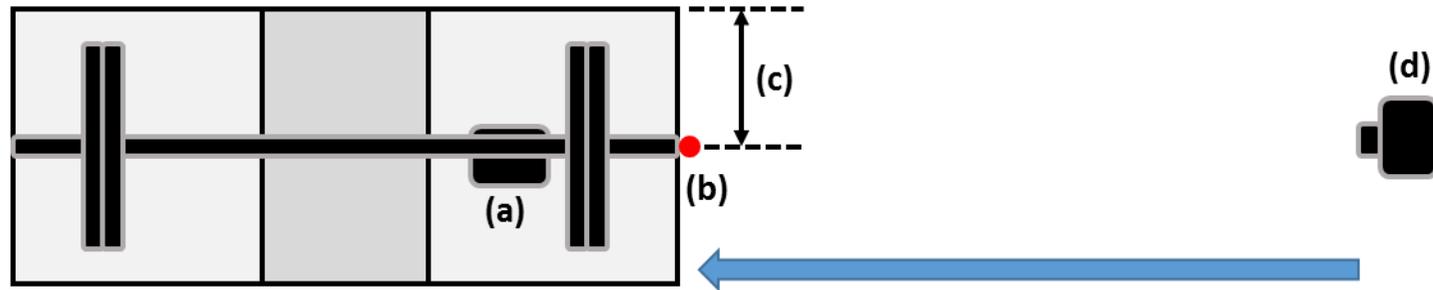


Figure 3. Representation of the power clean 1RM testing set-up.

Figure denotes (a) LPT (Gymaware power tool) attached to barbell; (b) reflective marker that was attached to the centre point of the barbell; (c) 75cm scaling measurement fixed to the floor; and (d) Casio, EXLIM, EX-F1 high speed camera at a fixed height of 65cm on a tripod mount and 5 metres away from the centre of the barbell. Note that figure is not to scale

Video footage was recording for every single repetition of the prescribed percentages (50, 60, 70, 80, 90, and 100% of 1RM). The video footage of 70, 80, 90, and 100% of 1RM were loaded in to Kinovea software where four technique variables were analysed based off the previous research by Winchester et al. (2005); 1) most forward position to catch (DxL), 2) start position to catch (DxT), 3) start position to beginning of 2nd pull (Dx2), and, 4) 2nd pull position to catch (DxV) (Figure 4).

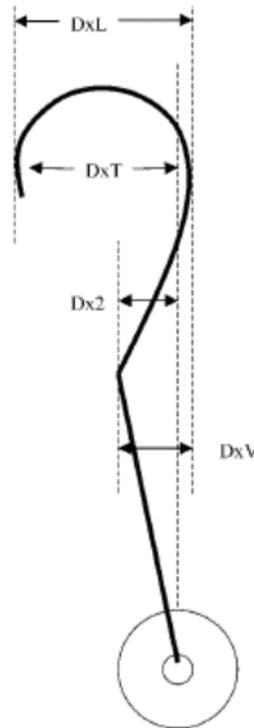


Figure 4. Kinematic variables; Dx2, DxV, DxT, and DxL (Winchester et al., 2005)

Kinetic Analysis of the Power Clean

An LPT (Gymaware PowerTool, Kinetic Performance PTY Ltd., ACT, Australia) was attached to the inside of the Olympic Barbell (Eleiko Sport, Halmstad, SWE) with a Velcro strap to measure PP, PF, and PV. The LPT calculated and recorded PP, PF and PV in real-time. Previous studies have reported valid and reliable measures for power and strength movements using this model of LPT ($r=0.59-1.00$, $p<0.05-0.001$) (Crewther et al., 2011; Drinkwater, Galna, McKenna, Hunt, & Pyne, 2007). However, (Crewther et al., 2011) examined the validity of an LPT (Gymaware, PowerTool) and Kistler portable force plate for squat jumps at 20-kg, 40-kg, 60-kg, and 80-kg load. Across all loads tested PF and PP values were not significantly different between the

two systems. However, it was noted in this study the Gymaware results were shown to have some systematic bias and large random errors for power. This is an important to consider in the interpretation of the results within this investigation. Studies have shown that key kinetic variables (PP, PF, and PV) are a contributing factor to performance in weightlifting movements. For this reason PP, PF and PV were included in this study as variables of interest (Winchester et al., 2005; Winchester et al., 2009).

Training Intervention

Participants performed three power clean training sessions per week across a six week intervention period. Both groups were given an audio recording of a PC script, this was listened to five times per week in their own time. A six week undulating periodisation model was followed which consisted of a de-loading period before retesting at the end of the intervention (Baker, Wilson, & Carlyon, 1994). Appendix 9 depicts how training days were organized, intensity was managed and sets and reps were arranged.

Participants were allowed to continue with their own training outside of the study, which included consisted of general resistance work using machine based and free weight exercises. However, all participants were asked to refrain from doing any PC variations (full cleans, hang cleans, clean pulls) as these were seen to have an influence on technical factors of the PC (Storey & Smith, 2012).

Statistical analysis methods

Prior to analyses, data was split into four categories based on the % 1RM load: (1) 70%, (2) 80%, (3) 90%, and (4) 100%. Recall test recordings were transcribed word for word. SIAQ scores were derived using the SIAQ manual (Cumming & Williams, 2014).

Following this, data was split into two categories based on: (1) total word count, and (2) total adjectives used. It may be argued that these measures are either a measure of time and effort spent using these scripts. As the intervention was based on Cognitive Specific imagery, skill imagery scores were extracted from the SIAQ scores for further analysis. Given that the principle question of the study revolves around the relative efficacy of different imagery treatments magnitude based inferences were deemed an appropriate statistical approach to analysis. This had the additional benefit of mitigating some (though not all) of the problems associated with the low numbers in this study. With low participant numbers in mind, comparisons were restricted to those identified a-priori from the research question. In many cases this meant comparisons were made at

baseline (validity) and post treatment (difference in effect) only. Magnitude Based Inference (MBI) provides a valid and reliable analysis that is able to detect the smallest worthwhile changes with a limited number of participants (W. Hopkins, Marshall, Batterham, & Hanin, 2009). Within- (Post-only crossover.xls) and between (Pre-post parallel groups trial.xls) changes were analysed using a statistical Excel spreadsheet from sportsci.org (W. G. Hopkins, 2006). The smallest worthwhile change was set at an equal value to Cohen's d of 0.20. The standardised effects calculated were then analysed using threshold values of Cohen's d <0.2, 0.2, 0.6 and 1.2. These threshold values were representative of trivial, small, moderate and large differences. The scale for interpreting the magnitude of the observed value was: 25-75%, possible; 75-95%, likely; 95-99.5%, very likely; >99.5%, most likely. When probabilities of the effect, either substantially positive or negative were >5%, the effect was deemed unclear. (W. Hopkins et al., 2009). Additionally, means and standard deviations for both groups were used to determine measures of centrality and spread of data. Changes in pre-post means and pre-post percentage change with 90% confidence limits were also calculated to give a fairer representation of changes pre-post intervention.

Results

Recall test

Table 2 and 3 displays the descriptive and between-groups comparative statistics for total words used and total adjectives used at baseline and post-intervention. Comparison of word counts between groups, pre-and post-intervention revealed no clear differences. Baseline comparison between groups for adjectives also indicated no clear differences. However, between groups analyses of post-intervention adjective use showed that the personalised group made greater use of adjectives. It should be noted that the generic group appeared to be using fewer adjectives than at baseline (13 ± 7 and 31 ± 18 , respectively). This difference in post test scores was of a large magnitude ($ES=1.37\pm1.27$).

SIAQ Scores

Tables 4 and 5 shows within and between group comparative statistics for skill imagery ability for baseline and post intervention. Baseline comparisons for SIAQ-Skill showed no clear differences. Differences in baseline scores could not be clearly differentiated between groups. A large difference in pre-post scores was shown in the GI group (ES=1.25, most likely) compared to changes of a small magnitude for the PI group (ES=0.49, likely). However, between group analyses showed no clear differences in post-test scores. Tables displaying comparative statistics for global imagery ability and the additional five subsets (skill, strategy, goal, affect, and mastery) are shown in Appendices 10 and 11

Baseline Kinematic and Kinetic differences

A small difference was detected in PP (ES=-0.32, possibly) at 90% of testing load (see Appendix 12).

80% Testing Load

Tables 6 and 7 displays significant within and between group comparative statistics for kinematic and kinetic variables for both the GI and PI groups. A small decrease in PP (ES=0.33, possibly) was found in the GI group, compared to unclear changes in the PI group. Between groups comparisons revealed a small (ES=0.56, likely) difference in PP. Additionally, the PI group experienced a small increase in PF (ES=0.21, possibly). Between group comparison showed unclear differences in the pre-post changes. For complete tables of all results see Appendices 13 and 14.

90% Testing Load

At the position of Dx2 the PI group showed trivial changes compared to unclear changes in the GI group, and unclear between group differences. The GI group showed small changes in the position of DxV and DxT versus unclear changes in the PI group. Between group comparison showed unclear changes for these same variables. An increase of a moderate magnitude was shown in PF (ES=0.60, likely) for the PI group. Unclear between group differences were detected in the pre-post changes.

100% Testing Load

At the position of Dx2 a small change (ES=0.26) was shown by PI group. Between group differences were found to be unclear at this position. At the Position for DxT a

small difference (ES=0.27) was observed for the PI group versus unclear ones in the GI group. Comparison of kinematic variables between groups at this load, pre-and post revealed no clear differences. Trivial changes in PP and PF were found in the GI group in comparison to unclear changes for the PI group. Comparison of kinetic variables between groups revealed a small difference in PP (ES=0.42). Compared to the GI group, the PI group displayed an increase of a moderate magnitude in PV (ES of 0.09 and 0.96, respectively). Between group differences were unclear.

Differences in standard deviation for kinematic variables

A graphical representation of the differences in pre-post standard deviation at the positions of Dx2, DxV, DxT, and DxL are displayed in Appendix 15. The PI group experienced a greater reduction of standard deviation across all three testing loads in comparison to the GI group. It is possible that these results indicate that the PI group experienced a stabilization of technique at a faster rate than the GI group. However, further research is required to support these claims.

Table 2 Pre-pre and Post-post comparison of total word count for personalised and generic imagery groups

Pre-Pre group comparison						Post-Post group comparison				
	GI (n=9)	PI (n=7)				GI (n=9)	PI (n=7)			
	Pre	Pre	\bar{x} diff $\pm 90\%$	ES $\pm 90\%$ CL	Inference	Post	Post	\bar{x} diff; $\pm 90\%$	ES $\pm 90\%$ CL	Inference
	$\bar{x} \pm SD$	$\bar{x} \pm SD$	CL			$\bar{x} \pm SD$	$\bar{x} \pm SD$	CL		
Total Word Count	196 \pm 108	296 \pm 114	73 \pm 141	0.59 \pm 1.17	Unclear	212 \pm 121	332 \pm 186	87 \pm 196	0.66 \pm 1.48	Unclear

Values are mean \pm standard deviation, change in mean; $\pm 90\%$ confidence limits and percent change; \pm standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; n , sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits. Qualitative inferences are trivial (< 0.20), small ($0.20 - < 0.60$) and moderate ($0.60 - < 1.20$): * possibly, 25 - < 75 ; ** likely, 75 - $< 95\%$; ***very likely, 95-99.5%; ****most likely, $> 99.5\%$. Positive and neutral descriptors qualitatively describe the differences between the pre - pre results for the generic group versus personalized group values and its importance relative to the specific variable.

Table 3 Pre-pre and Post-post comparison of total adjectives used for personalised and generic imagery groups

Pre-Pre group comparison					Post-Post group comparison					
GI (n=9)		PI (n=7)			GI (n=9)		PI (n=7)			
Pre	Pre	\bar{x} diff $\pm 90\%$ CL	ES $\pm 90\%$ CL	Inference	Post	Post	\bar{x} diff $\pm 90\%$ CL	ES $\pm 90\%$ CL	Inference	
$\bar{x} \pm SD$	$\bar{x} \pm SD$				$\bar{x} \pm SD$	$\bar{x} \pm SD$				
Adjectives used	14.6 \pm 8.7	23.4 \pm 10.1	6.4 \pm 11.7	0.66 \pm 1.2	<i>Unclear</i>	13.6 \pm 7.8	31.1 \pm 18.4	16 \pm 14.8	1.37 \pm 1.27	<i>Large** (positive)</i>

Values are mean \pm standard deviation, change in mean; $\pm 90\%$ confidence limits and percent change; \pm standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; *n*, sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits. Qualitative inferences are trivial (< 0.20), small ($0.20 - < 0.60$) and moderate ($0.60 - < 1.20$): * possibly, 25 – < 75; ** likely, 75 – < 95%; ***very likely, 95-99.5%; ****most likely, >99.5%. Positive and neutral descriptors qualitatively describe the differences between the pre – pre results for the generic group versus personalized group values and its importance relative to the specific variable

Table 4 Pre-pre and Post-post between group comparison of skill imagery ability for generic and personalised imagery groups

	Pre-Pre group comparison					Post-Post group comparison				
	GI (n=9)		PI (n=7)			GI (n=9)		PI (n=7)		
	Pre	Post	\bar{x} diff; $\pm 90\%$ CL	ES $\pm 90\%$ CL	Inference	Pre	Post	\bar{x} diff; $\pm 90\%$ CL	ES $\pm 90\%$ CL	Inference
	$\bar{x} \pm SD$	$\bar{x} \pm SD$				$\bar{x} \pm SD$	$\bar{x} \pm SD$			
Skill Imagery	5.4 \pm 0.4	4.9 \pm 1.5	-0.4 \pm 1.3	-0.86 \pm 2.93	Unclear	5.9 \pm 0.4	5.7 \pm 0.8	-0.2 \pm 0.9	-0.11 \pm 0.5	Unclear

Values are mean \pm standard deviation, change in mean; $\pm 90\%$ confidence limits and percent change; \pm standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; n , sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits. Qualitative inferences are trivial (< 0.20), small ($0.20 - < 0.60$) and moderate ($0.60 - < 1.20$): * possibly, 25 – < 75; ** likely, 75 – < 95%; ***very likely, 95-99.5%; ****most likely, >99.5%. Positive and neutral descriptors qualitatively describe the differences between the pre – pre results for the generic group versus personalized group values and its importance relative to the specific variable.

Table 5 Pre-post within group comparison of skill imagery ability for generic and personalised groups

	GI group (n=9)					PI group (n=7)				
	Pre	Post	\bar{x} diff $\pm 90\%$ CL	ES $\pm 90\%$ CL	Inference	Pre	Post	\bar{x} diff $\pm 90\%$ CL	ES $\pm 90\%$ CL	Inference
	$\bar{x} \pm SD$	$\bar{x} \pm SD$				$\bar{x} \pm SD$	$\bar{x} \pm SD$			
Skill Imagery	5.4 \pm 0.4	5.9 \pm 0.4	0.6 \pm 0.3	1.25 \pm 0.57	Large**** (positive)	4.9 \pm 1.5	5.7 \pm 0.8	0.9 \pm 1.1	0.49 \pm 0.65	Small** (positive)

Values are mean \pm standard deviation, change in mean; $\pm 90\%$ confidence limits and percent change; \pm standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; n , sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits. Qualitative inferences are trivial (< 0.20), small ($0.20 - < 0.60$) and moderate ($0.60 - < 1.20$): * possibly, 25 – < 75; ** likely, 75 – < 95%; ***very likely, 95-99.5%; ****most likely, >99.5%. Positive and neutral descriptors qualitatively describe the differences between the pre – pre results for the generic group versus personalized group values and its importance relative to the specific variable.

Table 6 Significant within group changes in kinematic and kinetic variables of the power clean

		GI group (n = 9)		PI group (n = 7)	
% of Phase		ES±90% CL	Inference	ES±90% CL	Inference
80%	PP (W)	-0.33±0.4	Small* (neutral)	0.22±0.68	Unclear
	PF (N)	0.1±0.68	Unclear	0.21±0.31	Small* (positive)
90%	Dx2 (cm)	-0.16±0.52	Unclear	-0.13±0.29	Trivial* (neutral)
	DxV (cm)	-0.3±0.28	Small* (neutral)	-0.04±0.35	Unclear
	DxT (cm)	-0.28±0.38	Small* (neutral)	0±0.4	Unclear
	PF (N)	0.24±0.5	Unclear	0.6±0.68	Moderate** (positive)
100%	Dx2 (cm)	0.19±0.51	Unclear	0.26±0.39	Small** (positive)
	DxT (cm)	0.12±0.41	Unclear	0.27±0.44	Small* (positive)
	PP (W)	-0.08±0.24	Trivial** (neutral)	0.4±0.67	Unclear
	PF (N)	-0.12±0.23	Trivial* (neutral)	-0.17±0.65	Unclear
	PV (m.s ⁻¹)	0.09±0.47	Unclear	0.96±0.57	Moderate** (positive)

Values are mean ± standard deviation, change in mean; ±90% confidence limits and percent change; ± standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; *n*, sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits; Dx2, start position to beginning of 2nd pull; DxV, 2nd pull to catch position; DxT, start to catch position; DxL, most forward to catch position cm, centimetre; W, watt; N, newton; m, metre; s, second. Qualitative inferences are trivial (< 0.20), small (0.20 – < 0.60) and moderate (0.60 – < 1.20): * possibly, 25 – < 75; ** likely, 75 – < 95%; ***very likely, 95-99.5%; ****most likely, >99.5%. Positive and neutral descriptors qualitatively describe the differences between the pre – pre results for the generic group versus personalized group values and its importance relative to the specific variable

Table 7 Significant Pre-post changes in kinematic and kinetic power clean variables between generic and personalised imagery groups

% of Phase		Post – Pre group change		PI group – GI group	
		GI group (n = 9)	PI group (n = 7)	ES±90% CL	Inference
		$\bar{x}\pm SD$	$\bar{x}\pm SD$		
80%	PP (W)	-178±348	84±348	0.56±0.71	Small** (positive)
100%	PP (W)	-49±227	165±365	0.42±0.56	Small** (positive)

Values are mean \pm standard deviation, change in mean; $\pm 90\%$ confidence limits and percent change; \pm standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; n , sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits; Dx2, start position to beginning of 2nd pull; DxV, 2nd pull to catch position; DxT, start to catch position; DxL, most forward to catch position cm, centimetre; W, watt; N, newton; m, metre; s, second. Qualitative inferences are trivial (< 0.20), small ($0.20 - < 0.60$) and moderate ($0.60 - < 1.20$): * possibly, $25 - < 75$; ** likely, $75 - < 95\%$; ***very likely, $95-99.5\%$; ****most likely, $>99.5\%$. Positive and neutral descriptors qualitatively describe the differences between the pre – pre results for the generic group versus personalized group values and its importance relative to the specific variable.

Discussion

An investigation into the literature revealed that only one study had compared participated generated scripts with generic ones (Wilson et al., 2010). Like past studies examining participant generated scripts, stimulus and response propositions were used to construct the scripts. As explained in earlier sections, the use of stimulus and response propositions does not allow for the dynamic elaboration of movement descriptions. Additionally, the effects that participant descriptions have on the development of complex movements (i.e. power clean) has not been investigated prior to the current study. The following focus points for the current study were established 1) is there a difference in content and descriptions when using generic and personalised scripts aimed at improving performance in the Power Clean (PC), and 2) if any differences are reflected, do these differences benefit the relevant kinematic and kinetic measures. It was hypothesized that individuals receiving the PI script would generate more descriptive accounts of the PC from baseline descriptions compared to their generic counterparts. It was also hypothesized that individuals receiving the PI script would perform better (i.e. improved kinematic and kinetic performance) on the PC from pre- to post-testing than those who received GI scripts.

The main findings were; 1) there was a difference of a large magnitude between post-test adjectives used between groups ($ES=1.37\pm 1.27$). The PI group showed a significant increase (23.4 ± 7.8 to 31.1 ± 18.1) compared to a decrease in the GI group (14.6 ± 8.7 to 13.6 ± 7.8), 2) at the 100% testing load the PI group experienced changes to Dx2 and DxT which caused the bar to be caught closer to the participants center of mass in the post-testing, 3) the PI group showed small to moderate improvements in PF (80 and 90%) and PV (100%).

It should be noted that, the PI group was shown to have a significantly higher training age than the GI group (11 ± 7.1 and 6.4 ± 2.2 , respectively). With greater training experience, the PI group would have a more established movement pattern, which in turn would make it more difficult to change in comparison to the GI group (Rippetoe et al., 2006). However, as explained above the PI group experienced greater changes in technique. Therefore, it would be fair to conclude that not only are PI scripts are more effective, they can influence beneficial changes in already established movement patterns. Additionally, it is important to note that between group analyses showed that

technique variables at baseline were not significantly different. It was therefore concluded that this difference in age did not have an effect on the observed changes post testing.

These findings confirm our hypotheses, that participant descriptions of skill are more effective than generic descriptions with respect to generating more detailed content and improving performance. The significant increase in adjectives taken alongside the changes in technique variables shows the PI scripts that utilise participant descriptions are effective in developing a complex movement skill. This provides evidence to suggest that image content is more meaningful when described by the individual as it allows for enhanced perception and understanding of a movement concept. This goes against Lang's (1979) bio-informational theory which suggests that knowledge about an object, situation or the environment is accessed during imagery most effectively through the use of stimulus and response propositions that are absent of context (Lang, 1979, 1985). Bio-informational theory has been proven to be good at reinforcing the correctness of a skill but not the development of it. There is a difference between repeating a correct performance and developing a new one. The changes that occurred in technique alongside increases in adjective use, show that participant description is effective in developing new movement patterns. Grounded cognition provides a sound rationale as to why the PI group experienced a more significant increase in descriptive content of their scripts. With the PI group being allowed to use their own descriptions during imagery, the language used remained in context and became situated in the movement that was being practiced throughout the intervention. As the context changed throughout training so did the language and meaning relationship of the descriptions. The descriptions that the PI group developed about the PC movement acted to shape participant's cognition, allowing for individual preference towards particular words to go uninhibited. By being given the opportunity to understand the movement through language that made sense to them personally, this aided participants to readily find dynamic solutions to the movement problem (Kostrubiec, Zanone, Fuchs, & Kelso, 2012). As a result of this process, participants could generate more elaborate concepts of the skill that were also functional. Furthermore, the personal language used actively shaped an adaptive reconfiguring of part ways of perceiving, conceiving and performing the PC. The decrease in adjectives observed in the GI group suggest that the generic scripts may have acted to constrain the participants' cognition, inhibiting participant's ability to develop more elaborate descriptions of the movement.

Within group comparisons of SIAQ-Skill scores showed change of a large magnitude for the GI group compared to a small change in the PI group (ES=1.25 and 0.49, respectively). In the only study to compare PI and GI scripts, Wilson et al. (2010) observed superior changes in SIAQ scores for the PI group compared to the generic one. A possible explanation for these differences is that the SIAQ is not a sensitive enough measure to detect changes in skill imagery ability. Past research would suggest that because the GI group were better imagers they should have experienced greater improvements in skill development. Furthermore, the increase in adjective use for the recall test observed in the PI group suggest that participants' capacity to form vivid images improved, as their descriptions were more detailed. These findings suggest that the recall test used could provide an alternative measure for skill imagery ability of individual performers, specifically, image detail of a skill.

The changes in bar-path kinematics and kinetics further support the effectiveness of PI scripts in the development of a skill. However, it is important when interpreting these results to consider the direction of these changes. As mentioned earlier, previous studies have proposed several factors that contribute to successful lifts in Olympic weightlifting movements such as the PC:

- Limited rearward displacement of the bar from the first pull to where the lift is caught (Dx2).
- Little movement of the bar away from the body from the second pull to forward most forward position of the bar (DxV).
- Tight bar path from the most forward position of the bar to where the bar is caught (DxL) in relation to the start position (DxT).
- Sufficient levels of BV and PF (M Stone et al., 2006; Winchester et al., 2005)

As noted in the results section, changes of a trivial to small magnitude were found in the position of Dx2 at two out of the three loads (90, and 100%) for the PI group. Figure 6 gives a graphical representation of the direction of those changes in relation to the start position of the participant. It is evident that the bar path improved at the position of Dx2 for the PI group with a straighter bar path observed from the start position. Findings from Ulareanu, Potop, Timnea, and Cheran (2014) would support straighter bar paths from first to second pull position as being advantageous to weightlifting performance. This study analyzed the biomechanical characteristics the clean and jerk, of which the PC is a derivative of this competition lift, in elite junior level Olympic weightlifters.

Findings suggest that small amounts of rearward displacement are advantageous as it allows for the lifter to clear the bar of their knees without losing the power that should be generated from their legs. However, too much rearward displacement forces the lifters hips to rise too fast which means they cannot use their legs to generate optimal power to get the barbell to a sufficient height to be caught. (Isaka, Okada, & Funato, 1996; M. Stone et al., 1998; M Stone et al., 2006).

Another important kinematic variable is the amount of horizontal bar displacement from the start position to the catch position (DxT). In this study, DxT was decreased at 100% for the PI group compared to an increase at 90 and 100% of testing loads for the GI group. The decrease observed in DxT by the PI group, represents an improvement in technical efficiency as it causes the bar to drop closer to the participant's center of mass. This ensures a more stable catch position as the weight is sitting directly above the hips of the participant. (M Stone et al., 2006).

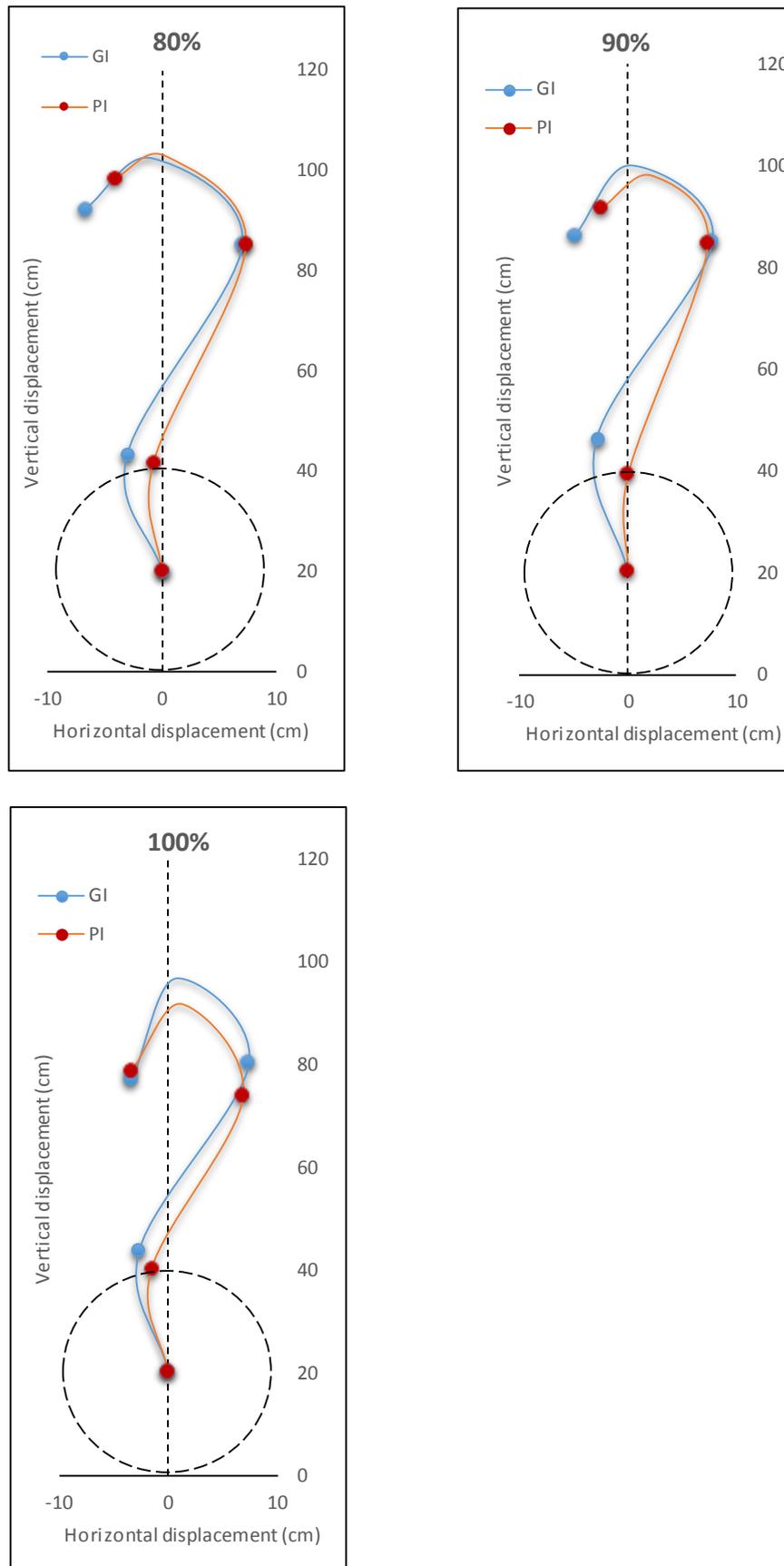


Figure 5 Mean bar path pre-pre for 80, 90, and 100% of 1RM for GI and PI imagery groups.

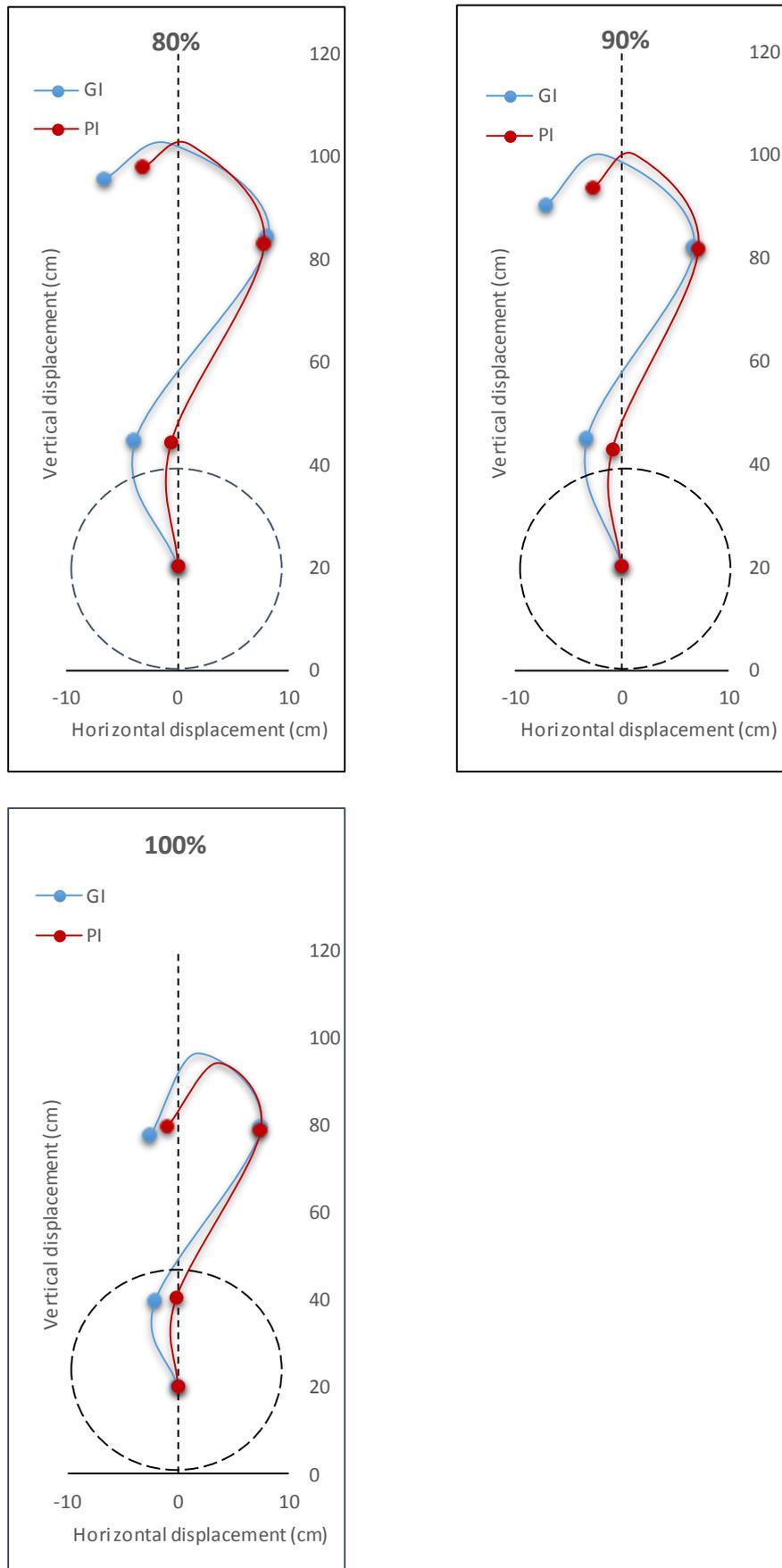


Figure 6. Mean bar path post-post for 80, 90, and 100% of 1RM for GI and PI imagery groups.

The PI group experienced greater improvements in kinetic variables with small to moderate increases in PF at 80 and 90% of testing load. Additionally, PV increased significantly in the PI group compared to the GI group (2.3-5.5%; ES=0.09-0.96; $P>0.05$; likely). By comparison, the GI group experienced decreases of a trivial to small magnitude in PP and PF at 80, and 100% of testing load. In line with previous research by Winchester et al. (2005), the results of this investigation provides further evidence to support the idea that improved bar kinematics allow for more efficient transmission of force in the appropriate direction. Thus, by focusing on correct bar kinematics, participant descriptions can develop to create a greater individual understanding of the movement leading to improved skill development. It is important to note that no between group differences were found across all kinematic and kinetic variables. This could have been explained by the large variation in bar displacement across groups, giving unclear differences. However, recent research by Akkus (2012) explains that individual techniques often display a large degree of variation. The individual differences that inherently exist in bar paths in the olympic lifts explain why limited between group changes were found due to significant variation in techniques meaning the results would often result in being unclear. Due to the high number of dependent variables that were tested it is fair to conclude that the analysis would be prone to random, and non-experimental effects. However, the changes that were detected were in line with the hypotheses specified, hence it was not deemed necessary to explain any spurious effects.

Conclusion

It is evident in the literature that the efficacy of PI scripts over GI scripts has not been adequately investigated. One of the main limitations has been the testing of PI scripts using non-athletic movements that require little skill (i.e. leg press). As a result, the effects of PI imagery on the development of a complex skill has not been examined. For this reason, the current study aimed to provide new insight into the effects of participant descriptions in imagery on the development of a complex skill compared to the use of generic descriptions. Results from this investigation showed that personal descriptions are more effective at creating more detailed concepts of a skill. Between groups comparison showed a significant difference in descriptive content, with the PI group showing a greater increase in adjectives used post-testing. The changes in descriptive content were found to benefit performance, with technique variables improving for the

PI group. These findings suggest that PI scripts are more meaningful for the individual. Conversely, by not allowing the GI group to use their own descriptions of the PC, the development of descriptive content was constrained, which resulted in limited changes in PC technique. Through the use of participant descriptions, the PI group was able to develop individual preference towards certain words. Furthermore, findings from the current study suggest that the use of participant descriptions in imagery scripts are effective in improving established movement patterns. Ultimately, this work further informs the application of personalised cognitive specific imagery on the development of highly complex skills. Future work should investigate how PI can affect the stabilization of technique of a given skill with individuals who have an established pattern of movement.

Practical Applications

- The findings in this study show that participant descriptions used in imagery are effective in the development of a complex skill.
- Practitioners should consider using personal descriptions of skill to inform the development of PI imagery scripts. This will allow for more elaborate descriptions of skill to be developed, facilitating more meaningful connections between mental images and verbal descriptions of a given skill.
- Practitioners should use PI scripts to develop technique with athletes at an intermediate level. By improving bar path kinematics this will encourage more efficient mechanics which will lead to improved force and velocity outputs during the PC.
- Based on the findings at 100% of testing load, practitioners may consider implementing PI scripts for athletes who engage in maximal effort strength and power sports as a means of limiting technique degradation at maximal loads.

CHAPTER 4

DISCUSSION AND CONCLUSION

Discussion

Past studies have implemented personalised imagery (PI) scripts by creating an explicit set of instructions that aim to achieve a specific response. However, the literature confirms that a more complex approach is required to bring interacting systems together to benefit performance. The current study looked to investigate the effects of personal movement descriptions in imagery scripts. To the authors knowledge this is the first study to use and test a PI script that contains a participants' complete description of a movement. Past studies that investigated the effects of imagery on strength based tasks used non-representative athletic movements that lack the complexity encountered in sport. Power cleans (PC) were identified as a movement that required high levels of skill and co-ordination, therefore were included in this study. Additionally, the PC is a commonly used athletic movement included in many sport training programmes, thus the applicability of these findings spans across various sporting codes (Tod et al., 2015).

As mentioned earlier (see chapter 2), bio-informational theory has been a common choice to support the effectiveness of PI scripts (Lang, 1979, 1985). Though this theory follows a logical information-processing based approach, it has become apparent, that when applied in a sports setting there are some limitations. Firstly, this approach assumes that the language used in imagery scripts is subject to a purely archival process, whereby meaning is extracted from words and text, stored in memory, and then when the appropriate stimulus arises that meaning is drawn from memory to elicit greater physiological responses. However, this process renders personal language as context-neutral. From a grounded cognition perspective, this archival process would in fact make the language used less meaningful based on the idea that they are unable to develop alongside an individuals' ongoing perception and understanding of a concept. Grounded cognition posits that past concepts in memory are further developed from the interaction between cognition, perception, the environment, the body and situation (Barsalou, 2008). Situated cognition addresses the relationship between cognition, perception and action by positing that fixed representations of information are not

present within the mind, but cognition is developed through the emergent, dependent nature of activity. The words used within imagery scripts act to shape or constrain an individual's cognition, and to a certain extent is a result of what memory generates when specific words are used. Based on this theoretical framework, the first aim of this experimental study was to elaborate on how individual description of a movement promotes greater skill development than generic descriptions. Pre-post 1RM testing provided kinematic and kinetic measures that were used to build a comparative model of PC technique for each participant. Additionally, a recall test was conducted, which consisted of a complete description of the PC in each participant's own words. This was used to inform the construction of the PI scripts. To the authors' knowledge the use of a recall test in such a manner is the first of its' kind.

The findings from the recall test showed there is a difference in elaboration of descriptive content between groups that use either PI or generic imagery (GI) scripts. Pre-post changes in total adjectives were seen increase for the PI group compared to a decrease in the GI group. With the PI group being allowed to use their own language, this allowed participants the freedom to perceive the imagery scripts in a way that was meaningful to them. Williams and Cumming (2011) explain that effective imagery can be developed through time and effort. This could explain why the PI group were successful in making beneficial changes to PC technique. With PI scripts being more meaningful this caused participants to be more willing to invest time and effort into their scripts. As a result this level of engagement in the scripts allowed for greater elaboration when describing the PC movement. As the participants were developing new ways of perceiving the movement, a connective process was occurring between their conscious state and memory (Barsalou, 2008). This connective process allowed for PI scripts to form conscious representations of the movement being practiced. As the PC was being perceived during training, names for various parts of the movement were being created, sentences within their personal descriptions were being reorganized and an interpretation of what those descriptions mean for each individual were being developed. PI scripts allowed for the development of individual preferences towards particular words, causing an elaboration of descriptive content. The linguistic forms that represent meaningful word connections cause an activation of associated mental images. As these linguistic forms develop and become more elaborate over time, so do the associated mental images. The ability of an individual to image is comprised of a combination of components and individualities (Morris et al., 2005). The changes that

were observed in SIAQ-Skill scores were not in line with the current literature, whereby the GI group recorded greater imagery ability than the PI group. In a study carried out by Robin et al. (2007) those with higher imagery ability experienced greater improvements in tennis serve accuracy compared to those with poorer imagery ability. It is important to point out that the PI group improved technical performance of the PC and also generated more descriptive accounts compared to the GI group. A possible explanation for the discrepancy in results compared to the literature could be that the SIAQ-Skill measure is not sensitive enough to pick up changes in an individual's ability to image a skill based movement. A reason for this could be that out of the fifteen questions in the SIAQ, only two of them are related to cognitive specific imagery. The clear results shown in the recall test provide a case to suggest that it may be a good alternative for measuring imagery ability. The strength of the recall test as a measure of imagery ability is that it can detect changes in imagery effectiveness and the consequent effect this has on skill development. However, this idea requires further investigation before solid conclusions can be made.

By comparing the development in descriptive qualities of both the GI and PI recall tests, the contribution of each individual's perspective of the PC and how it can either constrain or facilitate imagery is clear. PI scripts allowed for the PC description to be adaptive and dynamic in response to the movement conditions (i.e. bodily state, physical environment). Conversely, the GI scripts described the PC outside of individually meaningful context, preventing PC participants from changing their understanding of the movement and developing dynamic solutions to movement problems. These findings are supported by the theory of grounded cognition, which posits that the development of details about a movement are developed through the process of navigating through the movement problem, where individual preferred processes are found, known as attractors (Clancey, 1997). Perception and individual understanding of a movement is at the center of this adaptive process during imagery. How an individual perceives a movement and then understands its effects is what is being brought to mind about a particular mental image and determines image meaning for the individual. PI scripts facilitated this process by allowing participants to create meaningful connections between language used and mental images generated during imagery.

Alongside increased adjective use, a positive change in PC performance variables was observed in the PI group. Changes in both kinematics and kinetics were found across all three loading conditions (80, 90 and 100% 1RM). With no current research on the effects of imagery on power based exercises such as the PC, it is difficult to draw comparisons to previous research. However, findings from Winchester et al. (2005) suggest that in 4 weeks of PC training alone, significant changes to technique and kinetic variables can be expected. The results from the PI group remain in line with the findings of Winchester et al. (2005) to a large degree. Conversely, the results from the GI group are not congruent with findings in the literature. A possible explanation for these results is that the use of generic words may hinder individuals as they are unable to develop individual preferences towards particular words, which represent their preferred processes to find a solution to the movement problem. Conversely, the PI group were allowed to use their own language to generate imagery scripts, this enabled language meaning to develop in conjunction with perception of the movement problem. As a result individual preference towards certain words were generated enabling dynamic solutions to the movement problem to be developed (Barsalou, 2008).

The search for effective solutions to movement problems presents individuals with a dynamic landscape that requires highly adaptive processes to navigate successfully. Grounded cognition provides a sound theoretical framework to support why personalised movement descriptions are effective in enhancing imagery processes in a practical setting.

Thesis Limitations and Delimitations

The study featured in this thesis may have been limited by methodological constraints and these are important to consider when interpreting the results. Rationale and justification is included where necessary.

1. Participant numbers were lower than what would have been optimal, weakening the statistical power of this study. As a result, the only certainty that can be taken from this study is that a treatment effect was observed. A greater number of participants would have strengthened findings and provided more conclusive evidence of the effectiveness of participant descriptions over generic ones.
2. Although participants met the inclusion criteria some participants had significantly more training experience than others who participated in the study.

Between group analyses showed significant differences in training age and baseline 1RM scores. However, between group analyses of baseline kinematic and kinetic variables showed no significant differences. As a result it was concluded that the differences in training age and 1RM scores did not have a significant effect on the post-test differences observed.

3. Although every effort was made to contain each participants' own personal training outside of the power clean sessions. It is possible that some participants did not adhere to the restrictions placed on them which would have had a positive or negative effect on the results collected.
4. Every effort was made to ensure that the testing environment was kept as natural as possible to limit the interference on participants' performance. Despite the familiarization of the 1RM testing protocol, participants still found the LPT (Gymaware powertool) connected to the barbell to be a distraction while lifting.
5. Even though it was outlined to the coaches of participants to refrain from giving feedback during PC sessions. There were occasions that this was observed by the primary researcher (albeit a small number). Such instances may have influenced the performance of these participants to a small degree.
6. Due to the limited availability of individuals able to partake in the current study it was not possible to have a pure control group. Therefore, this limitation could be considered for future research and sport application.

Future Research

The current study has developed a better understanding about how participants' descriptions of skill can develop skill in a practical setting. However, the findings from this study have further highlighted areas in need of investigation. Future research should focus on changes in descriptive content and movement technique across a greater number of time points (i.e. pre-mid-post testing), and for longer durations (i.e. 8 weeks vs. 6 weeks). Information from such studies could better determine; 1) the rate that participants are developing more detailed concepts, and 2) the variation of individual movement patterns as participants descriptions develop over the course of the intervention. Another area that requires attention is the effect of PI and GI scripts on compliance and adherence (i.e. do participants get bored on a particular script so then this has an adverse effect on the intervention measures or do they perform better because they feel as though they are expected to). The current study looked at changes in technique across four variables, further studies might consider a more targeted

approach. By investigating the effects of participant descriptions on the correction of more specific errors of a skill (i.e. not extending completely in the second pull). Participants in this study were determined to be of an intermediate level of skill when performing the PC. Further investigations might consider looking at utilizing the methods in this study to examine more experienced athletes (i.e. national or international level) who have a greater level of skill and more ingrained movement patterns. Furthermore, given the scarcity of literature on the effects of imagery on power based movements, there is a need for further research on the effects of imagery on a more power based exercises.

Conclusion

This thesis fulfilled its aims, and showed the value of participant description in imagery scripts as a means of improving the kinematics and kinetics of the PC. The value in such an approach is the development of more detailed concepts of a specific movement which lead to beneficial changes in a particular skill. This approach allows for a more individualised prescription of imagery interventions. Findings from the current study support grounded cognition as an alternative theory to explain: 1) how participant's personalised descriptions become more detailed when used as imagery scripts, and 2) why this increased detail causes beneficial changes to technique of the PC compared to generic descriptions. By using participant's own descriptions of skill this provides the practitioner with greater insight into how their athlete may be perceiving the movement. With further research intervention protocols can be refined and implemented for complex strength training movements.

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Appendices

Appendix 1 Ethics approval and amendment form



AUTEC Secretariat

Auckland University of Technology
D-88, WU406 Level 4 WU Building City Campus
T: +64 9 921 9999 ext. 8316
E: ethics@aut.ac.nz
www.aut.ac.nz/researchethics

21 March 2016

Tony Oldham
Faculty of Health and Environmental Sciences

Dear Tony

Re Ethics Application: **16/64 Do personalised imagery scripts facilitate the improvement of kinematic and kinetic variables of the power lean in resistance trained individuals?**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 21 March 2019.

As part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online through <http://www.aut.ac.nz/researchethics>. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 21 March 2019;
- A brief report on the status of the project using form EA3, which is available online through <http://www.aut.ac.nz/researchethics>. This report is to be submitted either when the approval expires on 21 March 2019 or on completion of the project.

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to obtain this.

To enable us to provide you with efficient service, please use the application number and study title in all correspondence with us. If you have any enquiries about this application, or anything else, please do contact us at ethics@aut.ac.nz.

All the very best with your research,

Kate O'Connor
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Riki Lindsay riki.lindsay@hotmail.com, Adam Storey

AUTEC Secretariat

Auckland University of Technology
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www.aut.ac.nz/researchethics

19 April 2016

Tony Oldham
Faculty of Health and Environmental Sciences

Dear Tony

Re: Ethics Application: **16/64 Do personalised imagery scripts facilitate the improvement of kinematic and kinetic variables of the power lean in resistance trained individuals?**

Thank you for your request for approval of an amendment to your ethics application.

I have approved the minor amendment to your ethics application allowing changes to the recruitment inclusion criteria.

I remind you that as part of the ethics approval process, you are required to submit the following to the Auckland University of Technology Ethics Committee (AUTEC):

- A brief annual progress report using form EA2, which is available online through <http://www.aut.ac.nz/researchethics>. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 21 March 2019;
- A brief report on the status of the project using form EA3, which is available online through <http://www.aut.ac.nz/researchethics>. This report is to be submitted either when the approval expires on 21 March 2019 or on completion of the project.

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to obtain this. If your research is undertaken within a jurisdiction outside New Zealand, you will need to make the arrangements necessary to meet the legal and ethical requirements that apply there.

To enable us to provide you with efficient service, please use the application number and study title in all correspondence with us. If you have any enquiries about this application, or anything else, please do contact us at ethics@aut.ac.nz.

All the very best with your research,



Kate O'Connor
Executive Secretary
Auckland University of Technology Ethics Committee

Cc: Riki Lindsay riki.lindsay@hotmail.com, Adam Storey

Appendix 2 Participant information sheet

Participant Information Sheet



Date Information Sheet Produced:

15/2/16

Project Title

Do personalised imagery scripts facilitate the improvement of power clean technique in resistance trained individuals?

An Invitation

You are invited to be a part of a research project that is looking at the use of personalised imagery scripts and how this effects power clean technique in power athletes. It is important to note that if you do choose to take part in this research that your involvement is completely voluntary and you can choose to withdraw at any point.

What is the purpose of this research?

Imagery is referred to as a foundational concept in applied sport psychology and is defined as being an experience that replicates an action carried out in real life i.e imagining a squat vs actually doing a squat. In imagery, a script is used to help form the image in your head and this is either personalised, meaning created with the help of the person using it, or a generic script that is created by a coach or researcher. The purpose of this research is to investigate the use of athlete language in a personalised imagery script effects power clean technique compared to a generic script. This research will go towards the completion of a dissertation as part of the Master of Sport and Exercise programme with AUT.

How was I identified and why am I being invited to participate in this research?

You were invited to be part of this research as you have either responded to an advertisement of this study or have been approached in person and expressed your interest to be involved.

In order to be a part of this study you will need to meet the following criteria:

- Be a resistance trained individual with at least 2 years training experience
- Between the ages of 16-50
- Injury free
- Have the ability to power clean 1 times your own body weight.

If you do not understand the above criteria please contact the primary researcher for more information. Additionally if you do not meet the above criteria then unfortunately you will not be able to participate in this study.

What will happen in this research?

This study involves being a part of a 6 week training intervention (Excluding 2 week pre-intervention imagery training). You will be placed in one of two groups; personalised imagery group or generic imagery group. Initially you will need to fill out a Sport Imagery Ability Questionnaire (SIAQ) which takes 5-10 minutes and assesses you baseline imagery ability. You will then be required to undertake a 1RM power clean test. This will be a 1-hour testing session, where you will be video recorded using 2D kinematic software in Northsport Olympic weightlifting club at AUT, Millennium. Following this you will be asked to give an in depth description in your own words of how you would perform a power clean. Following this an imagery script will be generated and given to you for your own use. You will be required to practice this script five times per week. The 5-10 minute SIAQ and 1 hour power clean testing session will be carried out a total of three times; Before the imagery training, pre and post intervention.

What are the discomforts and risks?

You will be required to perform sub-maximal and maximal exercise pre, mid and post intervention and as a result you will experience a short duration of discomfort for these maximal tests. Being an

experienced athlete, these tests will be similar intensity to that of your regular training. You may experience a little bit of frustration/embarrassment in the initial stages when learning imagery and how to implement it in the training environment.

How will these discomforts and risks be alleviated?

Experienced coaches will be monitoring you during the maximal exercise tests and will ensure that you are not putting yourself in danger. Furthermore experienced practitioners will be administering the imagery training with you to provide you with the best opportunity to effectively learn how to apply imagery on your own. In addition you may choose to withdraw from the study up until the end of the 8 week data collection.

What are the benefits?

The benefits of taking part of this study will be the expert coaching during the intervention in the power clean by New Zealand Olympic weightlifting coach Adam Storey. Furthermore you will be trained in how to use imagery in your chosen sport and have your own imagery script to use when you complete the study. You will be contributing to research in the sport psychology field that could help to improve the implementation of imagery for athletes involved in higher level sport. This research will go towards the completion of a thesis as part of the Master of Sport and Exercise programme with AUT.

What compensation is available for injury or negligence?

In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my privacy be protected?

All data that is collected will only be available to the research team. No information identifying you as the participant in this research will be included in any of the research reports or publications.

What are the costs of participating in this research?

The only cost for your participation in this research is your time. If you choose to participate you will take part in two 5-10 minute questionnaires, three 1-hour testing sessions and two 5-10 minute power clean recall tests. You will also need to commit to a 6 week training period, and additionally the 2 week imagery training prior to the start of the intervention. The entire study will consist of 2 week imagery training (four 15 minute sessions) and 6 weeks of power clean training at three, 30min-1 hour sessions per week. All testing will take place at AUT Millennium, 17 Anares Place, Mairangi bay, Auckland.

What opportunity do I have to consider this invitation?

If you would like to take part in this research it is asked that you do so within two weeks of receiving this information.

How do I agree to participate in this research?

In order to take part in this research you will need to first contact the primary researcher (details at the bottom of this form). You will need to complete a consent form which will be provided to you once you have expressed your interest. Once the consent form has been completed the primary researcher will be in contact with you to commence the process.

Will I receive feedback on the results of this research?

You will have the option of receiving a summary of the findings from the research. Once these are available you can have them sent to your postal address as a hard copy or receive an electronic copy via email.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, *Tony Oldham*, tony.oldham@aut.ac.nz, (09) 921-7057.

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTECH, *Kate O'Connor*, ethics@aut.ac.nz, 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this Information Sheet and a copy of the Consent Form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Riki Lindsay, riki.lindsay@aut.ac.nz, 0277825241

Project Supervisor Contact Details:

Tony Oldham, tony.oldham@aut.ac.nz, (09) 921-7057

Approved by the Auckland University of Technology Ethics Committee on 21 March 2016 final ethics approval was granted, AUTEK Reference number 16/64.

Appendix 3 Participant consent form



Consent Form

Project title: Do personalised imagery scripts facilitate the improvement of kinematic and kinetic variables of the power clean technique in resistance trained individuals?

Project Supervisor: Dr Tony Oldham

Researcher: Riki Lindsay

- I have read and understood the information provided about this research project in the Information Sheet dated 15th February 2016
- I have had an opportunity to ask questions and to have them answered.
- I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
- I am not suffering from current injury or illness that impairs my physical or mental performance to perform the tasks required nor am I outside the limits of the required age range of 16 to 50 years.
- I understand that notes will be taken during the interviews and that they will also be audio-taped and transcribed.
- If I withdraw, I understand that all relevant information including tapes and transcripts, or parts thereof, will be destroyed.
- I agree to fill out the required questionnaires and provide physical effort to the best of my ability throughout the testing
- Are you comfortable imagining skills
- I understand that a 2D motion capture system will be used and that the copyright of the images obtained belong to the primary researcher.
- I agree to take part in this research.
- I wish to receive a copy of the report from the research (please tick one): Yes No

Participant's signature:

Participant's name:

Participant's Contact Details (if appropriate):

.....

.....

.....

.....

Date:

Approved by the Auckland University of Technology Ethics Committee on 21 March 2016 AUTEC Reference number 16/64



PARTICIPANTS NEEDED!!!

POWER CLEAN RESEARCH STUDY

Are you able to power clean your own body weight and have been weight-training for 2 years or more?

If YES you may be eligible to participate in an exciting study

We are seeking people who have been weight-training for 2 years or more and are able to power clean their own bodyweight to take part in a study measuring the effects of visualisation/imagery training on power clean technique.

The study involves 2 weeks of imagery training followed by a 6 week power clean training programme. You will be tested before and after the 6 week study at AUT Millennium, 17 Antares Place, Mairangi Bay, 0632.

You will receive high level imagery training, which will result in you learning about how to enhance your imagery ability and the positive effects this can have on your performance. You will also be given a 6 week training programme that has been designed in conjunction with one of NZ's National Olympic weightlifting coaches.

If you would like to express interest in participating in this study, or would like more information, please contact

Researcher Contact Details:

Riki Lindsay, riki.lindsay@aut.ac.nz, 0277825241

Project Supervisor Contact Details:

Tony Oldham, tony.oldham@aut.ac.nz, (09) 921-7057

Appendix 5. Gold Standard power clean description and generic imagery script

Please find a quiet place and sit down comfortably with your feet resting flat on the floor, or if it is more comfortable you can lie down. Slowly start to close your eyes as I count to 5 (1,2,3,4,5). Bring your focus onto your breathing and how your body feels at this moment. Begin to take slow and deep breaths, in your nose and out your mouth. Let any distracting thoughts enter and exit your mind freely, do not try to force any thoughts. I am going to guide you through your next breath, breathing in slowly in time with my counting (1,2,3,4) hold 1,2 and now release 4,3,2,1 and now we will do that again, breathing in 1,2,3,4 and hold 1,2 and release 4,3,2,1.

Imagine yourself approaching the loaded bar, you have just put chalk on your hands and you walk up to the bar to begin your set up.

You bend down placing one hand on the bar.....feel the cool rough steel on your hands.....you place your other hand onto the bar.....feel your arms relax as you set into the bar.....you bring tension into all the muscles in your back but you remain calm and confident.

Your shins are set into the bar, shoulders are over the bar and head is up. You take a deep breath and start to pull the bar from the floor, your back is flat and shoulders continue to stay over the bar throughout the first pull.

Your legs and back rise from the floor in one motion, your back is tight.....arms relaxed. The bar is close to your body the whole way. The bar slides up your thighs into your hips, your hips extend into the bar and the bar moves upwards upon contact..... you keep pulling the bar to completely extend and guide the bar onto your shoulders.....Your elbows are high and back is tight as you catch the bar successfully.

Appendix 6 Example of recall test used for personalised imagery script

Please find a quiet place and sit down comfortably with your feet resting flat on the floor, or if it is more comfortable you can lie down. Slowly start to close your eyes as I count to 5 (1,2,3,4,5). Bring your focus onto your breathing and how your body feels at this moment. Begin to take slow and deep breaths, in your nose and out your mouth. Let any distracting thoughts enter and exit your mind freely, do not try to force any thoughts. I am going to guide you through your next breath, breathing in slowly in time with my counting (1,2,3,4) hold 1,2 and now release 4,3,2,1 and now we will do that again, breathing in 1,2,3,4 and hold 1,2 and release 4,3,2,1.

So I approach the bar, get real close to it so my shins, essentially touching the bar, I then bend down keeping my knees over my heels, I take the bar with my hands wider than my knees on the first kinda gnarled point on the bar, I get my shoulder blades over the top of the bar, my hips back, torso really really long, ribcage high and long, pelvis back as in top of the crest of my pelvis back, I then begin the movement by driving through shin bones through ankles through my heels, that rises the bar into the power position, when I get there, lights go on, I drive my shins through the platform, that drives the bar up, I stay in it as long as I can and then catch it at the top.

Appendix 7 Sport Imagery Ability Questionnaire

The purpose of this questionnaire is to obtain information about your ability to generate a number of images athletes use in relation to their sport.

For each item, bring the image to your mind with your eyes CLOSED. Then rate how easy it is for you to form this image (1 = very hard, 4 = not easy or hard to 7 = very easy). Circle the appropriate rating based on the scale provided. For example, some athletes may find imaging themselves kicking a football neither easy nor hard and therefore select 4.

Please be as accurate as possible and take as long as you feel necessary to arrive at the proper ratings for each image. There are no right or wrong answers, because we are simply interested in your response (Williams & Cumming, 2011).

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

Appendix 8 Kinovea analysis steps

1. Import video in to Kinovea 0.8.15 software
2. Play video until one frame before the beginning of the lift which is when the bar begins to flex
3. Zoom the video in and right click on the reflective marker at the centre of the bar
4. Select "track path"

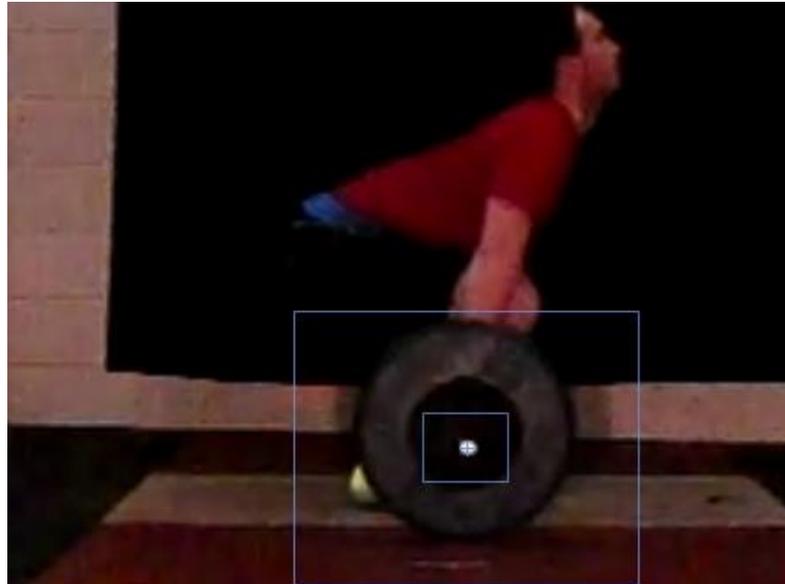


Figure 7 Bar path tracking

5. Insert a "stop watch" into the video and right click to start the stop watch to sync with lift off and the bar path data

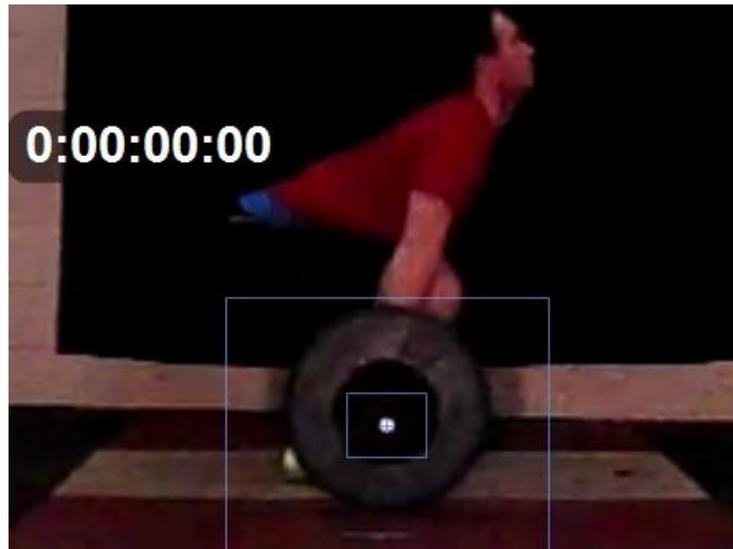


Figure 8 Syncing stop watch and bar path

Allow the video to run through in slow motion to develop a bar path. Adjust the barbell tracker manually if needed.

6. At the end point of the lift, right click on the path, select "End Path", then "configure" and change the line style to a thin line.
7. Click file, Export to spreadsheet, and select "trajectories to text".
8. Use "Line" function to trace over standardised calibration stick that is included in the original video. Right click on the line to calibrate it to the known length. Note: the calibration line must be in the same depth of field as the barbell reflective marker.

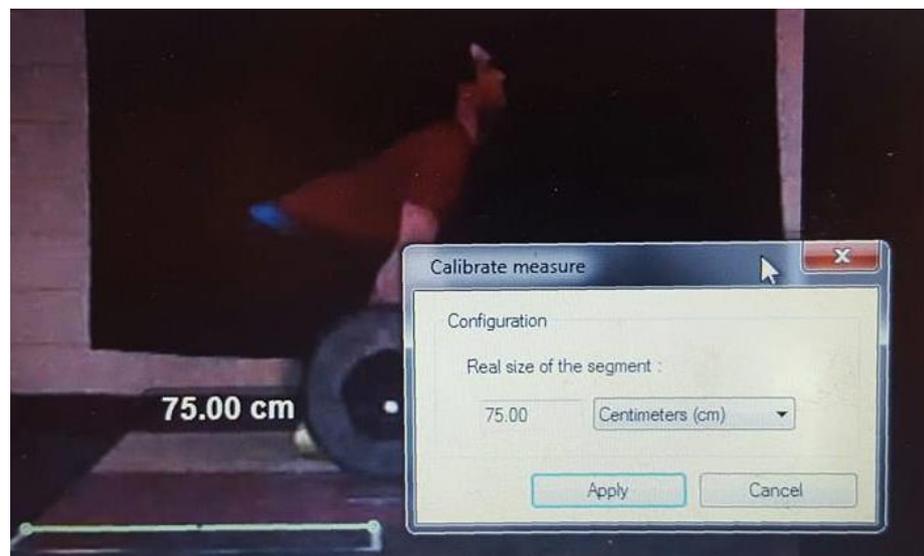


Figure 9 Calibration of measuring stick

Dx2 (start position to second pull) is measured using the following steps:

1. Move the video to the start of the second pull. To increase accuracy, use the trajectories in the exported excel file and match the time and distance co-ordinates with the video. If more than one time reference exists for the same distance, use the median time point.
2. Using the "Angle" function, draw a vertical 180deg line from the start of the vertical lift upwards.
3. Using the "Line" tool, measure the horizontal distance between the vertical line and the reflective marker at the start of the second pull.



Figure 10 Measuring of Dx2 using angle and line tools

DxV (second pull position to the most forward position) is measured using the following steps:

1. Play the video to the most forward position after the second pull. To increase accuracy, use the trajectories in the exported excel file and match the time and distance co-ordinates with the video. If more than one time reference exists for the same distance, use the median time point.
2. Using the "Line" tool, draw a vertical line up from the second pull to in line with the most forward position. Use the "Angle" tool to ensure the line is vertically straight.
3. Using the "Line" tool, measure the horizontal distance between the vertical line and the reflective marker on the barbell. To ensure line is accurate,

use the "Angle" function at 270°.

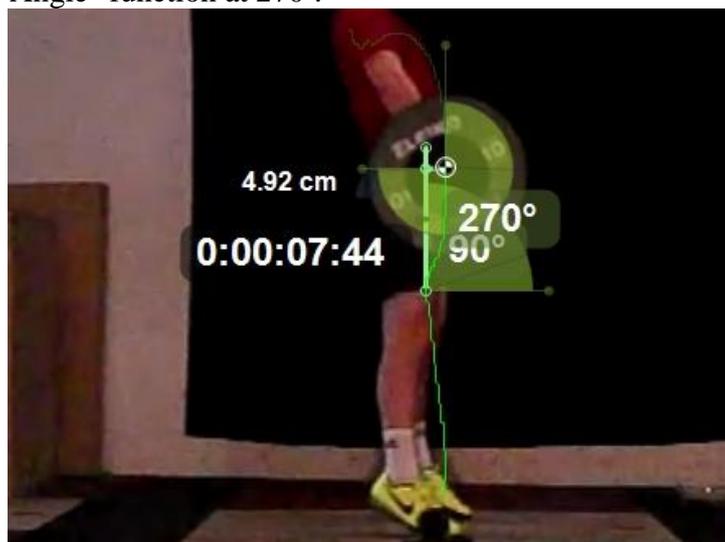


Figure 11 Measuring of DxV using angle and line tools

DxT (start position to catch position), is measured using the following steps:

1. Play the video to the point where the participant catches the barbell and stops moving in a downward motion. To increase accuracy, use the trajectories in the exported excel file and match the time and distance co-ordinates with the video. If more than one time reference exists for the same distance, use the median time point.
2. Using the "Line" tool, draw a line vertically from the reflective marker. Use the "Angle" function to ensure accuracy.
3. Measure the horizontal distance between the vertical line and the start point. To ensure line is accurate use the "Angle" function at 270°.

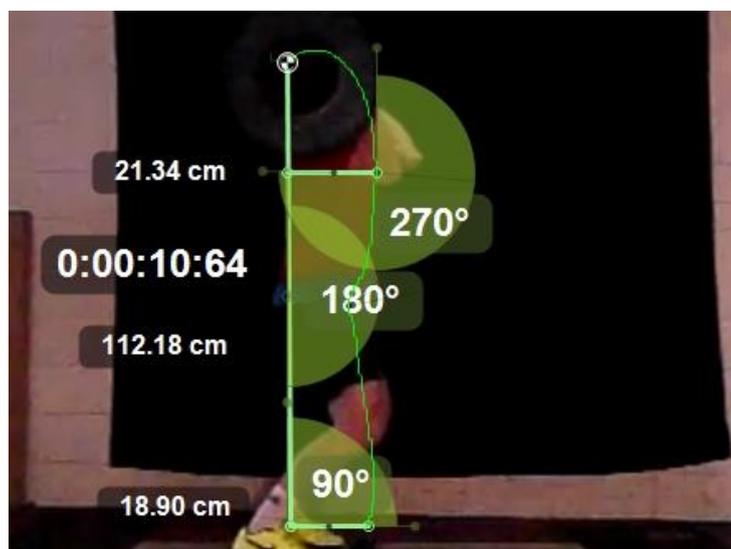


Figure 12 Measuring of DxT using angle and line tools

DxL (catch position to forward most position), is measured using the following steps:

1. Using the same vertical line drawn for DxT, measure the horizontal distance between the vertical line and the "forward most position" points. To ensure line is accurate use the "Angle" function at 270°.
2. From the vertical line drawn for DxT, draw a horizontal line to the forward most position. To ensure line is accurate use the "Angle" function at 270°.

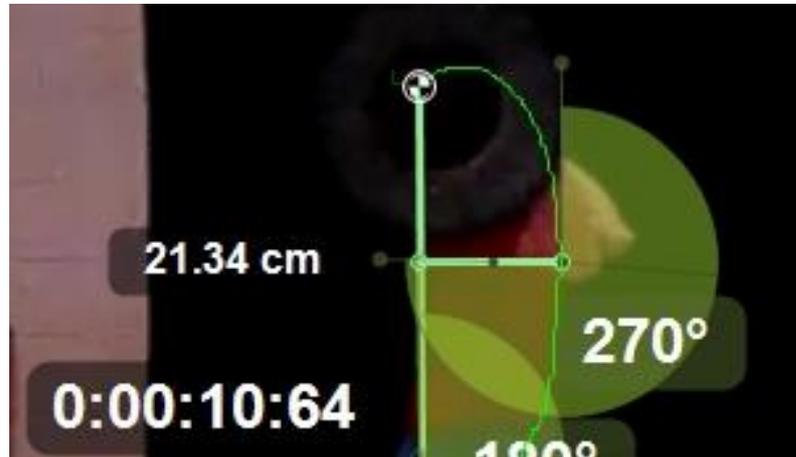


Figure 13 Measuring of DxL using angle and line tools

Appendix 9 Composition of 6-week training intervention for personalised and generic imagery groups.

Training week	1			2			3			4			5			6		
Weekly load	Moderate			Heavy			Heavy			Moderate			Moderate			Light		
Session	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Intensity (% 1RM)	80%	85%	75%	85%	90%	80%	80%	90%	95%	80%	90%	75%	80%	90%	75%	70%	60%	Test
Working Sets x Reps	3x2	3x1	3x3	3x2	3x1	3x3	2x2	3x1	3x3	3x2	2x1	3x2	3x2	2x1	3x2	2x3	1x3	

Appendix 10 Pre-pre and post-post comparison of SIAQ scores and subsets for generic and personalised imagery groups

Imagery Subset	Pre-Pre group comparison					Post-Post group comparison				
	GI (n=9)	PI (n=7)	\bar{x} diff $\pm 90\%$ CL	ES $\pm 90\%$ CL	Inference	GI (n=9)	PI (n=7)	\bar{x} diff $\pm 90\%$ CL	ES $\pm 90\%$ CL	Inference
	Pre $\bar{x} \pm SD$	Pre $\bar{x} \pm SD$				Post $\bar{x} \pm SD$	Post $\bar{x} \pm SD$			
Global	5.2 \pm 0.6	4.4 \pm 1.2	-0.9 \pm 1.1	-1.32 \pm 1.51	Large** (neutral)	5.7 \pm 0.7	5.3 \pm 0.7	0.6 \pm 0.8	-0.38 \pm 0.55	Small* (neutral)
Skill	5.4 \pm 0.4	4.9 \pm 1.5	-0.4 \pm 1.3	-0.86 \pm 2.93	Unclear	5.9 \pm 0.4	5.7 \pm 0.8	-0.2 \pm 0.9	-0.11 \pm 0.5	Unclear
Strategy	5.4 \pm 0.5	4.5 \pm 1.3	-0.9 \pm 1.1	-1.39 \pm 1.78	Unclear	5.5 \pm 0.7	5.2 \pm 0.7	-0.3 \pm 0.9	-0.22 \pm 0.6	Unclear
Goal	5.1 \pm 1.5	3.8 \pm 2.1	-1.7 \pm 1.5	-1.03 \pm 0.88	Moderate** (neutral)	5.4 \pm 1.6	4.6 \pm 1.9	-1.3 \pm 1.7	-0.55 \pm 0.69	Moderate** (neutral)
Affect	5.4 \pm 1.1	5.1 \pm 1.5	-0.5 \pm 1.5	-0.43 \pm 1.26	Unclear	5.9 \pm 1.3	6 \pm 0.7	-0.3 \pm 0.6	-0.19 \pm 0.36	Trivial* (neutral)
Mastery	5 \pm 0.6	3.8 \pm 0.9	-1.2 \pm 0.8	-1.61 \pm 1.11	Large*** (neutral)	5.6 \pm 0.7	5.1 \pm 0.7	-0.6 \pm 0.8	-0.55 \pm 0.74	Small** (neutral)

Values are mean \pm standard deviation, change in mean; $\pm 90\%$ confidence limits and percent change; \pm standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; n , sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits. Qualitative inferences are trivial (< 0.20), small ($0.20 - < 0.60$) and moderate ($0.60 - < 1.20$): * possibly, 25 – < 75; ** likely, 75 – < 95%; ***very likely, 95-99.5%; ****most likely, >99.5%. Positive and neutral descriptors qualitatively describe the differences between the pre – pre results for the generic group versus personalized group values and its importance relative to the specific variable.

Appendix 11 Pre-post within group comparison of SIAQ scores for generic and personalised imagery groups

Imagery Subset	GI group (n=9)					PI group (n=7)				
	Pre $\bar{x} \pm SD$	Post $\bar{x} \pm SD$	\bar{x} diff $\pm 90\% CL$	ES $\pm 90\% CL$	Inference	Pre $\bar{x} \pm SD$	Post $\bar{x} \pm SD$	\bar{x} diff $\pm 90\% CL$	ES $\pm 90\% CL$	Inference
Global	5.2±0.6	5.7±0.7	0.4±0.3	0.59±0.47	Small** (positive)	4.4±1.2	5.3±0.7	0.9±1.1	0.62±0.73	Moderate** (positive)
Skill	5.4±0.4	5.9±0.4	0.6±0.3	1.25±0.57	Large**** (positive)	4.9±1.5	5.7±0.8	0.9±1.1	0.49±0.65	Small** (positive)
Strategy	5.4±0.5	5.5±0.7	0.1±0.5	0.12± 0.82	Unclear	4.5±1.3	5.2±0.7	0.7±1.1	0.43±0.74	Unclear
Goal	5.1±1.5	5.4±1.6	0.3±0.5	0.16±0.32	Trivial* (positive)	3.8±2.1	4.6±1.9	0.8±0.9	0.31±0.39	Small* (positive)
Affect	5.4±1.1	5.9±1.3	0.6±0.5	0.46±0.38	Small** (positive)	5.1±1.5	6±0.7	1±1.3	0.53±0.75	Unclear
Mastery	5±0.6	5.6±0.7	0.6±0.4	0.85±0.6	Moderate**** (positive)	3.8±0.9	5.1±0.7	1.3±1	1.14±0.87	Large**** (positive)

Values are mean \pm standard deviation, change in mean; $\pm 90\%$ confidence limits and percent change; \pm standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; n , sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits. Qualitative inferences are trivial (< 0.20), small ($0.20 - < 0.60$) and moderate ($0.60 - < 1.20$): * possibly, 25 - < 75 ; ** likely, 75 - $< 95\%$; ***very likely, 95-99.5%; ****most likely, $>99.5\%$. Positive and neutral descriptors qualitatively describe the differences between the pre - pre results for the generic group versus personalized group values and its importance relative to the specific variable.

Appendix 12 Between group comparison of baseline kinematic and kinetic variables for personalised and generic imagery groups

		Pre-Pre group comparison			
		GI group (n=9)	PI group (n=9)	Pre-Pre	
% of 1RM		Pre $\bar{x} \pm SD$	Pre $\bar{x} \pm SD$	ES $\pm 90\%$ CL	Inference
80%	Dx2 (cm)	-3 \pm 2.7	-7 \pm 4.7	0.84 \pm 1.54	Unclear
	DxV (cm)	7 \pm 2.5	7.3 \pm 3.8	0 \pm 0.99	Unclear
	DxT (cm)	-6.7 \pm 8.4	-4 \pm 8.7	0.27 \pm 1.05	Unclear
	DxL (cm)	11.1 \pm 4.8	12 \pm 4.6	0.08 \pm 0.96	Unclear
	PP (W)	1691 \pm 482	1508 \pm 325	-0.33 \pm 0.6	Unclear
	PF (N)	1138 \pm 294	983 \pm 196	-0.41 \pm 0.81	Unclear
	PV (m.s ⁻¹)	1.68 \pm 0.18	1.74 \pm 0.1	0.41 \pm 0.9	Unclear
90%	Dx2 (cm)	-2.8 \pm 3.3	0.04 \pm 5.3	0.88 \pm 1.41	Unclear
	DxV (cm)	7.7 \pm 2.9	7.4 \pm 3.8	-0.33 \pm 1.07	Unclear
	DxT (cm)	-4.7 \pm 7.2	-2.4 \pm 8.2	0.29 \pm 1.38	Unclear
	DxL (cm)	9.9 \pm 3.9	10.5 \pm 4.5	0.13 \pm 1.28	Unclear
	PP (W)	1690 \pm 542	1462 \pm 310	-0.32 \pm 0.5	Small*(neutral)
	PF (N)	1229 \pm 299	1026 \pm 151	-0.46 \pm 0.72	Unclear
	PV (m.s ⁻¹)	1.57 \pm 0.23	1.64 \pm 0.23	0.14 \pm 0.95	Unclear
100%	Dx2 (cm)	-2.6 \pm 3	-1.5 \pm 4.5	0.55 \pm 1.28	Unclear
	DxV (cm)	7.3 \pm 2.2	6.8 \pm 4.9	-0.32 \pm 1.68	Unclear
	DxT (cm)	-3.3 \pm 7.1	-3.3 \pm 7.4	0.04 \pm 1.02	Unclear
	DxL (cm)	8 \pm 3.5	9.2 \pm 3.5	0.28 \pm 1.09	Unclear
	PP (W)	1728 \pm 526	1501 \pm 350	-0.28 \pm 0.74	Unclear
	PF (N)	1333 \pm 326	1345 \pm 638	0.2 \pm 1.01	Unclear
	PV (m.s ⁻¹)	1.49 \pm 0.19	1.49 \pm 0.07	-0.03 \pm 0.63	Unclear

Values are mean \pm standard deviation, change in mean; $\pm 90\%$ confidence limits and percent change; \pm standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; n , sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits; Dx2, start position to beginning of 2nd pull; DxV, 2nd pull to catch position; DxT, start to catch position; DxL, most forward to catch position cm, centimetre; W, watt; N, newton; m, metre; s, second. Qualitative inferences are trivial (< 0.20), small ($0.20 - < 0.60$) and moderate ($0.60 - < 1.20$): * possibly, 25 - < 75 ; ** likely, 75 - $< 95\%$; ***very likely, 95-99.5%; ****most likely, $> 99.5\%$. Positive and neutral descriptors qualitatively describe the differences between the pre - pre results for the generic group versus personalized group values and its importance relative to the specific variable

Appendix 13 Kinematic and Kinetic power clean variables during pre and post testing for the generic and personalised imagery groups.

% of 1RM	GI Group (n= 9)				PI Group (n= 7)				
	Pre	Post	Post – Pre	Inference	Pre	Post	Post – Pre	Inference	
	$\bar{x} \pm SD$	$\bar{x} \pm SD$	ES \pm 90% CL		$\bar{x} \pm SD$	$\bar{x} \pm SD$	ES \pm 90% CL		
80%	Dx2 (cm)	-3 \pm 2.7	-3.8 \pm 2.6	-0.24 \pm 0.68	Unclear	-0.7 \pm 4.7	-0.6 \pm 3.9	0.02 \pm 0.26	Unclear
	DxV (cm)	7 \pm 2.5	8.1 \pm 3.7	0.4 \pm 0.67	Unclear	7.3 \pm 3.8	7.7 \pm 3.9	0.1 \pm 0.56	Unclear
	DxT (cm)	-6.7 \pm 8.4	-6.5 \pm 6.7	0.02 \pm 0.42	Unclear	-4 \pm 8.7	-3.1 \pm 5.5	0.09 \pm 0.36	Unclear
	DxL (cm)	11.1 \pm 4.8	10.8 \pm 3.7	-0.05 \pm 0.38	Unclear	12 \pm 4.6	10.9 \pm 3	-0.2 \pm 0.43	Unclear
	PP (W)	1691 \pm 482	1512 \pm 499	-0.33 \pm 0.4	Small*(neutral)	1508 \pm 325	1592 \pm 298	0.22 \pm 0.68	Unclear
	PF (N)	1138 \pm 294	1169 \pm 392	0.1 \pm 0.68	Unclear	983 \pm 196	1030 \pm 232	0.21 \pm 0.31	Small*(positive)
	PV (m.s ⁻¹)	1.68 \pm 0.18	1.65 \pm 0.18	-0.18 \pm 0.68	Unclear	1.74 \pm 0.1	1.78 \pm 0.25	0.1 \pm 0.96	Unclear
90%	Dx2 (cm)	-2.8 \pm 3.3	-3.2 \pm 2	-0.16 \pm 0.52	Unclear	0.04 \pm 5.3	-0.7 \pm 3.3	-0.13 \pm 0.29	Trivial*(neutral)
	DxV (cm)	7.7 \pm 2.9	6.7 \pm 2.8	-0.3 \pm 0.28	Small*(neutral)	7.4 \pm 3.8	7.2 \pm 3.6	-0.04 \pm 0.35	Unclear
	DxT (cm)	-4.7 \pm 7.2	-7 \pm 6.8	-0.28 \pm 0.38	Small*(neutral)	-2.4 \pm 8.2	-2.5 \pm 3.9	0 \pm 0.4	Unclear
	DxL (cm)	9.9 \pm 3.9	10.8 \pm 3.9	0.22 \pm 0.43	Unclear	10.5 \pm 4.5	9.5 \pm 2.5	-0.2 \pm 0.5	Unclear
	PP (W)	1690 \pm 542	1675 \pm 520	-0.03 \pm 0.32	Unclear	1462 \pm 310	1610 \pm 404	0.42 \pm 0.77	Unclear
	PF (N)	1229 \pm 299	1308 \pm 369	0.24 \pm 0.5	Unclear	1026 \pm 151	1153 \pm 320	0.6 \pm 0.68	Moderate**(positive)
	PV (m.s ⁻¹)	1.57 \pm 0.23	1.62 \pm 0.17	0.18 \pm 0.4	Unclear	1.64 \pm 0.23	1.61 \pm 0.17	-0.10 \pm 0.56	Unclear
100%	Dx2 (cm)	-2.6 \pm 3	-2 \pm 2.3	0.19 \pm 0.51	Unclear	-1.5 \pm 4.5	-0.1 \pm 4.1	0.26 \pm 0.39	Small**(positive)
	DxV (cm)	7.3 \pm 2.2	7.4 \pm 3.6	0.03 \pm 0.69	Unclear	6.8 \pm 4.9	7.5 \pm 3.2	0.12 \pm 0.42	Unclear
	DxT (cm)	-3.3 \pm 7.1	-2.4 \pm 6.7	0.12 \pm 0.41	Unclear	-3.3 \pm 7.4	-0.9 \pm 6.2	0.27 \pm 0.44	Small*(positive)
	DxL (cm)	8 \pm 3.5	8.2 \pm 3.1	0.05 \pm 0.52	Unclear	9.2 \pm 3.5	8.3 \pm 4.3	-0.23 \pm 0.59	Unclear
	PP (W)	1728 \pm 526	1678 \pm 438	-0.08 \pm 0.24	Trivial**(neutral)	1501 \pm 350	1666 \pm 406	0.41 \pm 0.67	Unclear
	PF (N)	1333 \pm 326	1290 \pm 326	-0.12 \pm 0.23	Trivial*(neutral)	1345 \pm 638	1220 \pm 267	-0.17 \pm 0.65	Unclear
	PV (m.s ⁻¹)	1.49 \pm 0.19	1.51 \pm 0.11	0.09 \pm 0.47	Unclear	1.49 \pm 0.07	1.57 \pm 0.05	0.96 \pm 0.57	Moderate**(positive)

Values are mean \pm standard deviation, change in mean; \pm 90% confidence limits and percent change; \pm standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; *n*, sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits; Dx2, start position to beginning of 2nd pull; DxV, 2nd pull to catch position; DxT, start to catch position; DxL, most forward to catch position cm, centimetre; W, watt; N, newton; m, metre; s, second. Qualitative inferences are trivial (< 0.20), small (0.20 – < 0.60) and moderate (0.60 – < 1.20): * possibly, 25 – < 75; ** likely, 75 – < 95%; ***very likely, 95-99.5%; ****most likely, >99.5%. Positive and neutral descriptors qualitatively describe the differences between the pre – pre results for the generic group versus personalized group values and its importance relative to the specific variable.

Appendix 14 Pre-post changes in kinematic and kinetic power clean variables between generic and personalised imagery groups

% of Phase	Post – Pre group change		PI group – GI group		Inference
	GI group (<i>n</i> = 9)	PI group (<i>n</i> = 7)	ES ±90% CL		
	$\bar{x} \pm SD$	$\bar{x} \pm SD$			
80%	Dx2 (cm)	-0.7 ± 3.3	0.22 ± 1.9	0.20 ±0.54	Unclear
	DxV (cm)	1.1 ± 2.9	0.4 ± 2.9	-0.22 ±0.84	Unclear
	DxT (cm)	0.1 ± 6.2	0.9 ± 4.9	0.08 ±0.53	Unclear
	DxL (cm)	-0.29 ± 3.3	-1 ± 3.1	-0.15 ±0.55	Unclear
	PP (W)	-178 ± 348	84 ± 348	0.56 ±0.71	Small** (positive)
	PF (N)	31 ± 355	47 ± 96	0.06 ±0.77	Unclear
	PV (m.s ⁻¹)	-0.04 ± 0.22	0.03 ± 0.34	0.34 ±1.14	Unclear
90%	Dx2 (cm)	-0.39 ± 2.4	-0.8 ± 2.4	0.08 ±0.44	Unclear
	DxV (cm)	-0.9 ± 1.4	-0.1 ± 2.1	0.22 ±0.47	Unclear
	DxT (cm)	-2.2 ± 4.83	0 ± 5.6	0.26 ±0.57	Unclear
	DxL (cm)	0.9 ± 3	-1 ± 3.5	-0.43 ±0.66	Unclear
	PP (W)	-15 ± 309	148 ± 371	0.32 ±0.61	Unclear
	PF (N)	79 ± 268	127 ± 197	0.16 ±0.68	Unclear
	PV (m.s ⁻¹)	0.05 ± 0.16	-0.03 ± 0.2	-0.28 ±0.67	Unclear
100%	Dx2 (cm)	0.6 ± 2.7	1.3 ± 2.7	0.17 ±0.59	Unclear
	DxV (cm)	0 ± 2.7	0.6 ± 3.2	0.15 ±0.69	Unclear
	DxT (cm)	0.9 ± 5.1	2.3 ± 5.1	0.18 ±0.58	Unclear
	DxL (cm)	0.2 ± 3.3	-0.9 ± 3.3	-0.29 ±0.75	Unclear
	PP (W)	-49 ± 227	165 ± 365	0.42 ±0.56	Small** (positive)
	PF (N)	-43 ± 132	-125 ± 651	-0.16 ±0.92	Unclear
	PV (m.s ⁻¹)	0.02 ± 0.16	0.08 ± 0.06	0.36 ±0.63	Unclear

Values are mean ± standard deviation, change in mean; ±90% confidence limits and percent change; ± standard deviation. Abbreviations: GI, generic imagery; PI, personalised imagery; *n*, sample size; \bar{x} , mean; SD, standard deviation; 90% CL, 90% confidence limits; Dx2, start position to beginning of 2nd pull; DxV, 2nd pull to catch position; DxT, start to catch position; DxL, most forward to catch position cm, centimetre; W, watt; N, newton; m, metre; s, second. Qualitative inferences are trivial (< 0.20), small (0.20 – < 0.60) and moderate (0.60 – < 1.20): * possibly, 25 – < 75; ** likely, 75 – < 95%; ***very likely, 95-99.5%; ****most likely, >99.5%. Positive and neutral descriptors qualitatively describe the differences between the pre – pre results for the generic group versus personalized group values and its importance relative to the specific variables.

Appendix 15 Pre-post standard deviations of 80%, 90%, and 100% of testing loads for personalised and generic imagery groups

