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Assessing Athlete Imagery Ability and Intervention

アスリートのイメージ能力および介入の尺度作成

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Abstract

ASSESSING ATHLETE IMAGERY ABILITY AND INTERVENTION

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The primary objective of this thesis was to advance the current understanding of sports-specific imagery used by athletes through further research. Chapter 1 and Chapter 2 provide a comprehensive review of the rationale behind developing both the Japanese version of the Sport Imagery Ability Questionnaire and the Sport Imagery Intervention Questionnaire. Chapter 3 examines the trend of imagery research to ensure the direction of research. In Chapter 4, the adaptation process of the widely-used Sports Imagery Ability Questionnaire to the Japanese language and cultural context is thoroughly explained. Chapter 5 presents the development of the Sport Imagery Intervention Questionnaire, which is based on the well-established PETTELP imagery model. The assessment of psychometric properties has established that both questionnaires are reliable, valid, and effective in measuring imagery ability and intervention, yielding consistent and accurate results. Furthermore, the analysis revealed that the subscales of the Sports Imagery Ability Questionnaire were predicted by the subscales of the Sports Imagery Intervention Questionnaire. This research provided two independent and reliable means of evaluation for imagery ability and imagery intervention. Its findings further highlight the important role in evaluating imagery ability and intervention in various fields, including sports psychology research and practice in the Japanese context. The study also shed light on the potential benefits of intentional imagery interventions for improving imagery ability, thereby further underscoring its importance.

Dedication

This thesis is dedicated to my wife, Naim Kim, whose unwavering love and support have been a constant source of inspiration and strength.

Our time together in Japan, particularly the unforgettable moments we shared in Koganei Park with our dear buddy and sports enthusiast Hengsoo, hold a special place in my heart. These precious memories serve as a testament to the joy and inspiration that have accompanied us throughout our journey.

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In closing I am filled with a deep sense of gratitude and consider myself incredibly fortunate to have the opportunity to express my heartfelt appreciation in this manner.

Publications Included in this Thesis

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Table of Contents

CHAPTER 1: INTRODUCTION

CHAPTER 2: THEORETICAL FRAMEWORK

CHAPTER 3: TRENDS IN RESEARCH ON IMAGERY IN SPORTS SCIENCE

CHAPTER 4: PSYCHOMETRIC SUPPORT FOR A JAPANESE VERSION OF THE SPORT IMAGERY ABILITY QUESTIONNAIRE

CHAPTER 5: THE SPORT IMAGERY INTERVENTION QUESTIONNAIRE: DEVELOPMENT AND PSYCHOMETRIC EVALUATION

CHAPTER 6: GENERAL DISCUSSION

APPENDICES

LIST OF TABLES

Chapter 3: Trends in Research n Imagery in Sports Science

Chapter 4: Psychometric Support for a Japanese Version of the Sport Imagery Ability Questionnaire

Chapter 5: The port Imagery Intervention Questionnaire: Development and Psychometric Evaluation

LIST OF FIGURES

Chapter 3: Trends in Research n Imagery in Sports Science

Chapter 4: Psychometric Support for a Japanese Version of the Sport Imagery Ability Questionnaire

LIST OF ABBREVIATIONS

1PP First-person perspective

3PP Third-person perspective

AVE Average Variance Extracted

CFA Confirmatory Factor Analysis

CFI Comparative Fit Index

CG Cognitive general

CR Composite Reliability

CS Cognitive-specific

DCV diagnostic content validation

EEG electroencephalography

EFA Exploratory Factor Analysis

EMG Electromyogram

Emo Emotion

Env Environment

fMRI functional magnetic resonance imaging

Lrn Learning

MG-A Motivational general-arousal

MG-M Motivational general-mastery MS Motivational specific

PETTLEP Physical, Environment, Task, Timing, Learning, Emotion and Perspective

Phys Physical

RMSEA Root Mean Square Error of Approximation

SEM Structural Equation Modelling

SIAQ Sport Imagery Ability Questionnaire

SIIQ Sport Imagery Intervention Questionnaire

SIQ Sport Imagery Questionnaire

SRMR Standardized Root Mean Square Residual

Ti-f Timing fast

Ti-r Timing real

Ti-s Timing slow

TLI Tucker–Lewis Index

Tsk Task

CHAPTER 1: INTRODUCTION

Statement of the Problem

Mental imagery, also known as visualization or mental rehearsal, is a cognitive technique in which sensory experiences are created or recreated in the mind (Holmes & Collins, 2001). Athletes have widely used this technique to enhance their performance by mentally rehearsing skills and strategies, managing emotions, and increasing confidence (Vealey, 2007). In the field of sports psychology, the effectiveness of imagery training has been extensively studied. Several studies have demonstrated that imagery training can improve sports performance significantly (Driskell, Copper, & Moran, 1994). For example, Smith et al. (2007) found that athletes who used imagery training performed significantly better than those who did not use this technique. Moreover, after neurofeedback imagery training, elite archers' beta waves stabilized and vibration frequency decreased (Kim & Chang, 2020). However, the effectiveness of imagery training can vary depending on the athlete's skill level, the task, and the type of imagery used (Cumming & Ramsey, 2009). Martin et al. (1999) reported mixed results in their study, with some athletes showing significant improvements while others showing no significant differences. This variation in results underscores the importance of taking individual differences into account when encouraging imagery training.

The assessment of imagery ability is a challenge in measuring the effectiveness of imagery training. Imagery ability is an athlete's ability to create clear, controlled images in a sporting situation to achieve a desired outcome (Singnoy et al., 2015). Individuals differ in this ability, which is influenced by factors such as age, experience, and cognitive style (Holmes & Collins, 2001). Furthermore, assessing imagery ability is often subjective and relies on self-report measures that can be influenced by social desirability biases. A groundbreaking study identified a five-factor sports imagery ability model, including skill, strategy, goal, affect, and mastery imagery, and developed the Sport Imagery Ability Questionnaire (SIAQ; Williams & Cumming, 2011). This measure considers individual differences and provides a more accurate evaluation of an athlete’s imagery ability. The study using SIAQ have found no significant gender differences in sport imagery ability. However, evidence suggests that athletes competing at higher levels have greater imagery ability than those competing at lower levels (e.g., the athletes who compete at the international level display greater imagery ability). This objective evidence suggests that an athlete’s ability to use mental imagery effectively in sports is related to their level of competitiveness. Since its inception, the SIAQ, which has strong psychometric properties, has been thoroughly researched and validated. According to Lee and Horino (2023), the English version has received considerable attention, and there have been 11 publications that confirm the questionnaire’s efficacy in nine different languages. However, no comprehensive Japanese version of the SIAQ has been developed that assesses all five imagery contents (skill, strategy, goal, affect, and mastery imagery) related to imagery ability. To comprehensively assess imagery ability and determine the efficacy of imagery training, a Japanese version of the SIAQ must be developed and used.

Using the SIAQ as a measurement tool, numerous studies have investigated the relationship between sport imagery ability and its influence on performance. Athletes with higher levels of competition demonstrate greater imagery ability (Williams & Cumming, 2011), and improving imagery ability could potentially increase an athlete’s competitiveness (Anuar, Cumming, & Williams, 2017; Anuar, Williams, & Cumming, 2017; Williams & Cumming, 2016). These studies serve as the foundation for developing effective imagery training techniques. Williams and Cumming’s (2016) study investigated the relationship between athlete imagery ability (SIAQ) and levels of confidence and anxiety in sports. The results revealed that athletes with strong imagery abilities have higher levels of confidence and lower levels of anxiety. In contrast, athletes with low imagery ability tend to have lower levels of confidence and higher levels of anxiety. This suggests that developing imagery ability may have positive impact on an athlete’s confidence and anxiety levels, which can in turn improve their performance.

Anuar, Cumming, and Williams (2017) found that emotion regulation is important in predicting imagery ability (SIAQ). They investigated the relationship between emotion regulation and imagery ability in athletes and found that individuals with better emotion regulation skills also had higher imagery ability. This study highlights the importance of emotion regulation skills in enhancing an athlete’s ability to generate and control mental images, which can lead to better sports performance.

Anuar, Williams, and Cumming (2017) examined the relationship between imagery ability (SIAQ) and physical and environmental components of the PETTLEP imagery intervention model. This model encourages individuals to create conditions conducive to imagery (Holmes & Collins, 2001). Anuar, Williams, and Cumming (2017) proposed that when physical and environmental elements of imagery intervention are incorporated as a single element, namely “imagery framing,” it predicts positively imagery ability as measured by the SIAQ.

The PETTLEP imagery intervention model (Holmes & Collins, 2001) and its various tenets have received a lot of attention in the literature on applied sports psychology (e.g., Wakefield & Smith 2012; Smith & Cantwell, 2008; Wright & Smith, 2007).

This model promotes creating conditions for imagery by integrating seven different elements into imagery to improve the effectiveness of the imagery experience (e.g., physical, environment, task, timing, learning, emotion, and perspective). According to Holmes and Collins (2002), the effectiveness of imagery interventions is determined by the extent to which the same brain areas are activated during imagery as they are during actual movement execution. This concept is known as functional equivalence and is the basis for the PETTLEP model of imagery intervention. The PETTLEP model of imagery intervention has garnered significant attention in the literature on applied sports psychology. Numerous studies have investigated the model's various tenets and their effectiveness in improving athletes' performance outcomes. For example, Wakefield and Smith (2012) found that incorporating PETTLEP elements into mental imagery practice can improve performance outcomes in athletes. Similarly, Smith et al. (2008) found that PETTLEP-based imagery interventions can improve motor skill learning and retention. PETTLEP-based imagery interventions have been found to improve accuracy and consistency in golf short-game performance (Baughman, 2017). PETTLEP-based imagery interventions can improve goal scoring and decision-making in soccer (Moran et al., 2012).

Anuar, Williams, and Cumming (2017) developed a set of items called "imagery framing" to investigate the frequency with which athletes incorporate the PETTLEP model's physical and environmental elements into their mental imagery practice. This study was specific to those two elements: physical and environment. However, there is no questionnaire based on the elements of all PETTLEP imagery intervention models (e.g., physical, environment, task, timing, learning, emotion, perspective). It is important to understand whether these imagery interventions can be quantitatively measured and generalized, and the development of a questionnaire based on all seven elements of the PETTLEP model can contribute to a better understanding of the role of imagery interventions in improving athletic performance. Researchers and practitioners can identify which elements are most important for enhancing performance outcomes and tailor their interventions accordingly by measuring how often athletes integrate all seven elements in their mental imagery practice. This could lead to a more effective use of imagery in sports training.

The study has two primary objectives: (1) to translate the SIAQ; Williams & Cumming, 2011) into Japanese and (2) to develop a standardized Sport Imagery Intervention Questionnaire (SIIQ) based on Holmes and Collins' (2001) PETTLEP imagery intervention model.

The translated SIAQ assesses athletes' imagery ability in relation to performance. The SIIQ can be used to assess the frequency of imagery experiences as a part of an intentional imagery intervention.

It would be possible to investigate whether the imagery intervention (SIIQ) positively predicts imagery ability (SIAQ) if these research objectives were met. This research will help in the development of assessment tools for better understanding of the role of imagery in psychological processes, ultimately leading to improved athletic performance.

It is important to note that currently there are no questionnaires based on the PETTLEP imagery intervention model nor are there any that measure the five critical imagery contents required to evaluate Japanese athletes' imagery ability. This research gap highlights the need to develop assessment tools to better understand the role of imagery in psychological processes.

Researchers and practitioners can systematically evaluate the effectiveness of sports imagery interventions and athletes' imagery ability by developing the SIIQ and translating the SIAQ into Japanese. This will ultimately enhance athletic performance while also providing valuable insights into the role of imagery in psychological processes.

In summary

Develop and translate a comprehensive imagery ability questionnaire, SIAQ, and develop an imagery intervention questionnaire, SIIQ, as there is currently no measurement available for either in Japan

Significance of the Study and Research Design

This study is significant because it aims to achieve two main objectives: (1) developing a questionnaire for measuring imagery ability (SIAQ) and (2) developing a questionnaire for measuring imagery intervention (SIIQ). This study extends existing research by developing standardized measures for both intentional imagery interventions and imagery ability, which can provide a more reliable and valid means of assessing the efficacy of imagery-based interventions in sports.

The SIIQ, which is based on the PETTLEP model, is specifically designed to assess athletes' use of intentional imagery interventions to improve their performance. Meanwhile, the SIAQ, which has been translated into Japanese, aims to easily assess an athlete's ability to generate mental imagery. Using these two tools, this study can provide a more comprehensive assessment of the role of imagery in athletic performance.

Achieving the purpose of the study would allow for the possibility of investigating the effects of intentional imagery intervention, measured by the SIIQ, on imagery ability, measured by the SIAQ.

Finally, this research will help us understand the impact of imagery interventions on athletes' imagery ability, as well as the effectiveness of mental imagery as a training method in sports. This study's findings could lead to more targeted and effective interventions that use mental imagery to enhance athletic performance.

Developing SIAQ questionnaires in Japanese has several advantages, including:

Language-specific adaptation: The SIAQ was originally developed in English, and developing a Japanese version of the questionnaire can extend existing research while also ensuring that it is culturally and linguistically appropriate for Japanese athletes.

Bridging the research gap: The lack of a measure of sport imagery questionnaires in Japanese has limited the comparability and generalizability of findings. Adapting the SIAQ to Japanese will provide a validated and widely used measure of imagery ability, enabling a more rigorous and comprehensive research on this important topic.

The advantages of developing a questionnaire for measuring imagery intervention using PETTLEP and creating a Sport Imagery Intervention Questionnaire (SIIQ) are:

Efficacy: The PETTLEP model has been shown to improve sport performance by providing a framework for the effective execution of imagery interventions. A reliable measure is required to assess the effectiveness of imagery interventions based on this model. The SIIQ, developed specifically for this purpose, can provide a validated tool for assessing the effectiveness of imagery interventions in improving sport performance.

Comprehensive Assessment: The SIIQ enables comprehensive assessment of intentional imagery interventions in sports, covering all elements of the PETTLEP model, such as physical, environment, task, timing, learning, emotion, and perspective.

Overall, developing SIAQ and SIIQ in Japanese can help improve the accuracy and accessibility of the tool for assessing sports-specific imagery in Japanese athletes. The development of both the SIAQ and the SIIQ can provide a means to evaluate the effectiveness of imagery interventions on athletes' imagery ability and sport performance. This enables a more comprehensive understanding of the role of imagery in sports, such as validating the efficacy of imagery training programs.

The ultimate goal of this research

1. Translate and developing a questionnaire for measuring imagery ability (Japanese Version of Sports Imagery Ability Questionnaire; SIAQ-J)

2. Developing a questionnaire for measuring imagery intervention (SIIQ)

CHAPTER 2: THEORETICAL FRAMEWORK

The Role and Evaluation of Imagery in Sports

Imagery in sport

Sport psychologists define imagery as a simulation of real experiences that recreates or creates meaningful images by combining the use of various sensory modalities in the absence of perception to shape-relevant information(Cumming & Ramsey, 2008; Weinberg & Gould, 2018). Following Carpenter's (1894, cited in Hale, 1982) initial hypothesis of imagery, research has progressed to account for the effect of imagery on various aspects of cognition, affect, and behavior. For example, psychoneuromuscular theory (Carpenter, 1894; Jacobson, 1931; Washburn, 1916), symbolic learning theory (Sackett, 1934), bioinformational theory (Lang, 1977, 1979), triple-code model (Ashen, 1984), and Paivio's (1985) framework have all been generated explicitly to explain why imagery may benefit motor performance (for a review, see Martin et al., 1999). In terms of neural and behavioral similarities, imagery resembles genuine experience (Cumming & Williams, 2012). According to Holmes and Collins (2001), an effective imagery intervention depends on how well the same brain areas are activated. This functional relationship enables researchers to investigate covert motor processes that are important in everyday life, such as anticipating the effects of an action, planning or intending to move, learning or relearning motor skills, or remembering an action (Jeannerod, 1995). In sports science, imagery research has primarily focused on the role of performance enhancement, with applied domains including sports psychology and neurology-based models (MacIntyre, 2018). For example, after neurofeedback imagery training, elite archers' beta waves stabilized and their vibration frequency decreased (Kim & Chang, 2020). Williams and Cumming (2011) measured the individual's ability to generate imagery in sports settings, and Jiang et al. (2017) found that small voluntary muscle contractions combined with motor imagery resulted in greater strength improvements than instances without motor imagery. Because of its wide applicability and effects, imagery is considered in sports science as a cognitive process that is fundamental to motor learning and performance improvement (Cumming & Williams, 2012), and as such, it is involved in various aspects of psychological preparation, such as skill rehearsal, pre-competition routine, problem solving, strategy development, and dealing with injuries and pain (Ruiz et al., 2019). Imagery can also be used to enhance motivation and confidence by creating positive mental images that increase an athlete's belief in their ability to succeed (Hardy, Gammage, & Hall, 2001; Martin, Moritz, & Hall, 1999). Furthermore, imagery can help athletes in dealing with stress and anxiety by providing a mental escape from negative thoughts and emotions (Weinberg & Gould, 2023).

In conclusion, imagery is a valuable skill that can benefit athletes in multiple ways, including performance enhancement, motivation and confidence, and stress management. Athletes can develop and refine their imagery ability with practice and guidance from trained professionals to improve their overall athletic performance.

Imagery ability and its evaluation

According to Martin, Moritz, and Hall (1999), an individual's ability to create and control images has a significant impact on the effectiveness of imagery as a performance-enhancing technique. According to Gregg and Hall (2006), Mumford and Hall (1985), and Roberts, Callow, Hardy, Markland, and Bringer (2008), there is evidence to suggest that athletes who can generate more vivid and detailed mental images have a higher likelihood of achieving success in their respective sports and that athletes competing at a higher level of competition display greater imagery ability when compared to athletes competing at a lower level. Short, Tenute, and Feltz (2005) suggest that while everyone has the ability to generate images, the ability to do so with vividness and detail varies among individuals. Morris, Spittle, and Watt (2005, p. 60) defined imagery ability as “an individual’s capability of forming vivid, controllable images.”

Thus, the term “imagery ability” implies that imagery is a skill that can be developed and refined with time and effort. Hall (2011) and Kosslyn, Brunn, Cave, and Wallach (1984) propose that imagery ability is not a fixed trait, but rather a malleable skill that can be strengthened and improved through deliberate practice and experience.

It is critical to have a reliable and valid method of assessing imagery ability because it is a trainable ability that can be enhanced through suitable interventions.

Researchers frequently use objective or subjective self-report measures to assess an individual’s imagery ability. Objective methods include assessing physiological and behavioral responses with techniques such as EEG, fMRI, EMG, HR, skin conductance, and chronometry; however, these techniques can be both expensive and time-consuming (Amedi et al., 2005; Cremades & Pease, 2007; Cui et al., 2007; Decety, 1996; Guillot & Collet, 2005; Guillot et al., 2007; Guillet et al., 2004; Lutz, 2003; Marks & Isaac, 1995; Roure et al., 1999).

As a result, self-report questionnaires are the most commonly used method.

Researchers have widely used mental imagery measures to assess athletes’ imagery ability over the past 40 years (Singnoy, 2015). Examples of these measures include the Questionnaire Upon Mental Imagery (Betts, 1909), the Shortened form of the Questionnaire on mental imagery (SQMI; Sheehan, 1967), The Survey of mental Imagery (Switras, 1978), The Vividness of Visual Imagery Questionnaire (Marks, 1973), the Vividness of Movement Imagery Questionnaire (VMIQ; Isaac, Marks, & Russell, 1986), the Movement Imagery Questionnaire (MIQ; Hall & Pongrac, 1983), the Revised versions of the Movement Imagery Questionnaire (MIQ-R; Hall & Martin, 1997), The Florida Praxis Imagery Questionnaire (Ochipa, Rapcsak, Maher, Gonzalez Rothi, Bowers, & Heilman, 1997), the Sport Imagery

Questionnaire (SIQ; Hall, Mack, Paivio, & Hausenblas, 1998), Kinesthetic and Visual Imagery Questionnaire (Malouin, Richards, Jackson, Lafleur, Durand, & Doyon, 2007), the Sport Imagery Ability Measure (Watt, 2003), Motivational Imagery Ability Measure for Sport (Gregg & Hall, 2006), and the revised version of Vividness of Movement Imagery Questionnaire (VMIQ-2; Roberts, Callow, Hardy, Markland, & Bringer, 2008), and Revised second version of Movement Imagery Questionnaire (MIQ-RS; Gregg, Hall, & Butler, 2010).

However, Williams and Cumming (2011) developed the SIAQ to assess athletes' imagery ability. The SIAQ was based on the well-established SIQ and its underlying framework (Hall et al., 1998; Paivio, 1985). Although there are many existing measures, this new measure allows for a more comprehensive assessment of different aspects of imagery ability (Budnik-Przybylska & Karasiewicz, 2020; Singnoy, 2015), and the SIAQ was specifically designed to provide a more nuanced evaluation of an athlete's imagery ability. This demonstrates the researchers' ongoing efforts to refine and improve measures of mental imagery ability in sports.

PETTLEP imagery model and functional equivalence

As highlighted in the "Imagery ability and its evaluation" section, the SIAQ assesses an individual's ability to generate vivid and controllable images of motor skills and athletic performance as a result of images. Meanwhile, the PETTLEP imagery model emphasizes the importance of creating optimal conditions for mental imagery by integrating seven elements—including physical, environmental, task, timing, learning, emotion, and perspective—to improve the effectiveness of the imagery experience (Holmes & Collins, 2002). According to this model, imagery interventions should aim to simulate all closely as possible aspects of participants' execution situations, including sensations associated with relevant movements and the subsequent emotional impact (Wakefield et al., 2013).

The PETTLEP model integrates insights from sport psychology, cognitive psychology, and neuroscience to offer practitioners with practical guidelines for optimizing their imagery use. The PETTLEP approach differs from traditional imagery methods in that traditional approaches tend to treat imagery and physical practice as distinct entities. In contrast, PETTLEP considers physical practice and imagery to be on a continuum and proposes that imagery interventions are more effective when they closely simulate physical performance (Wakefield et al., 2013). The PETTLEP model is based on the functional equivalence principle, which posits that the neural processes involved in motor imagery and actual movement execution are similar (Wakefield et al., 2013). This assumption is supported by evidence that motor imagery and actual movement execution share similar neural activation patterns (Lotze et al., 1999; Miller et al., 2010), implying that motor imagery can stimulate the same neural activity as actual movement. The PETTLEP model aims to use functional equivalence to improve motor skill development through targeted imagery interventions (Holmes & Collins, 2001). These interventions are designed to closely mimic the actual execution situation, encompassing all relevant elements, to facilitate shared neural activity patterning and plasticity in motor regions of interest (Morone et al., 2022). This concept of functional equivalence is also referred to as similarity in EMG patterning (Wakefield et al., 2013).

PETTLEP elements of seven imagery interventions, which are essential for creating effective images for motor skills learning and performance, are as follows (Holmes & Collins, 2001): Physical—The physical element refers to the kinesthetic sensations experienced in executing a particular motor skill. Mental imagery—Athletes should focus on creating vivid sensory experiences by imagining the physical sensations associated with the movement. Environment—The environmental element involves considering the context in which the motor skills will be performed. Imagery should include environmental factors such as temperature, noise, and other sensory stimuli present in the actual performance setting. Task—The task element refers to the specific motor skill that the athlete is attempting to learn or improve. Imagery should be tailored to the specific task and should involve visualizing the key elements and movements involved in executing the skill. Timing—The timing element involves considering the rhythm and timing of the movement. Imagery should involve visualizing the exact timing of each movement and the overall timing of the skill as a whole. Learning—The learning element refers to the athlete's stage of learning for a particular skill. Imagery should be adapted to the athlete's stage of learning, with more detail and focus on the basics for novice athletes and more complex imagery for advanced athletes. Emotion—The emotional element involves considering the athlete's emotional state during the performance of the skill. Imagery should incorporate emotional experiences and reactions. Perspective—The perspective element refers to the athlete's point of view while performing the skill. Imagery should involve visualizing the skill from the athlete's perspective as well as from other perspectives, such as a coach or a spectator.

However, there is currently no standardized questionnaire based on the PETTLEP imagery intervention model, which makes quantifying and generalizing the efficacy of such interventions difficult. As a result, developing a reliable and valid method of assessing imagery interventions is critical, as this could help athletes make a more effective use of imagery in enhancing their motor skill learning and performance.

Assessing sport Imagery in Japan

Imagery plays a crucial role in performance (Robin et al., 2007), but there is a lack of imagery questionnaires in Japan.

One promising approach in Japan is the use of neuroimaging techniques such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) to study the neural correlates of imagery. For example, fMRI can be used to identify brain regions that are activated during imagery tasks, while EEG can provide information about the timing and frequency of brain activity (Mizuguchi et al., 2012; Zippo et al., 2017; Sugino and Ushiyama, 2021). However, as previously highlighted, these techniques can be both expensive and time-consuming.

While several imagery questionnaires exist, most of them are not tailored to a sport-specific context. Hasegawa (2004) developed a Japanese version of the of the Movement Imagery Questionnaire-Revised (MIQ-R) and Nakano et al., (2022) Developed a Japanese version of the Movement Imagery Questionnaire-Revised Second Version (MIQ-RS) which comprises two subscales: kinesthetic and visual. The kinesthetic subscale evaluates an individual's capacity to generate mental imagery of movement-based on proprioceptive and kinesthetic sensations, while the visual subscale assesses an individual's ability to generate mental imagery of movement-based on visual cues (Hall and Martin, 1997, Gregg et al., 2010). Momma's (2014) research investigates various evaluation methods for assessing motor imagery ability using Japanese sample. It focuses specifically on the Vividness of Movement Imagery Questionnaire-2 (VMIQ-2), which is used to measure an individual's ability to generate and experience vivid mental images of movements (Roberts et al., 2008). While questionnaires can effectively measure an individual's ability to imagery of movement-based exercises, they may not be suitable for evaluating an individual's capacity to depict competitive tactics or manage tension in high-stress competitive situations in sport-specific context (Aikawa et al., 2019).

To address this issue, one tool that has been developed specifically for sport is the Japanese adapted version of Sport Imagery Ability Questionnaire (SIAQ; Williams and Cumming, 2011). Aikawa et al. (2019) present the SIAQ as a potential solution to the issue of imagery questionnaires not being tailored to a sport-specific context in Japan, which assesses athletes' ability to generate imagery related to their sport.

Although the Japanese adapted version of the Sport Imagery Ability Questionnaire (SIAQ) is a valuable tool designed specifically for sport, it should be noted that the structure differs from the original questionnaire. The original SIAQ comprises five subscales (Skill, Strategy, Goal, Affect, and Mastery imagery), but Aikawa et al. (2019) identified a four-factor SIAQ model that excluded the affect imagery subscale. The four-factor SIAQ identified by Aikawa et al. (2019) deviates from the original SIAQ in that it excludes the affect imagery subscale. As a result, the adapted questionnaire may not provide a comprehensive assessment of athletes' ability to generate imagery that related to their sport. This limitation could impact the usefulness of the tool for sport-specific contexts in Japan.

Given the potential limitations of the adapted four-factor SIAQ in assessing imagery ability in Japanese athletes, further research is needed to identify the most suitable questionnaire structure. Further research should aim to empirically evaluate whether the SIAQ should have a four- or five-factor structure in a Japanese athlete context.

To fully comprehend the role of imagery in sport performance and its effectiveness in use of imagery for athletes, it is crucial to have reliable and valid means of assessing imagery ability. Moreover, in contrast to leading sports nations, Japan currently lacks questionnaires specifically designed to assess various aspects of sports imagery. It is essential to secure various questionnaires, including those related to imagery intervention. Therefore, addressing the current limitations of tools for sport-specific situations in Japan is imperative.

CHAPTER 3: TRENDS IN RESEARCH ON IMAGERY IN SPORTS SCIENCE

Chapter 3 was initially written with the intention of being published. However, to comply with the copyright policy of certain journals, the chapter 3 has been replaced with an overview. The full manuscript is included in the appendix to avoid any potential issues with duplicate publication.

Introduction

This chapter discusses publications that examine imagery from various perspectives in sports science. Using bibliographic analysis this chapter aims to provide a detailed understanding of current imagery research trends, to provide an in-depth understanding of research trends and meta-analytic reviews from leading research groups and scientists.

In sports science, imagery research has focused largely on performance enhancement, with applied domains including sport psychology and neurology-based models. Imagery is considered fundamental to motor learning and performance improvement and is involved in numerous aspects of psychological preparation. Thus, it is crucial to gain an understanding of the current trends in the study of imagery from various aspects.

Bibliographic analysis, which uses mathematical and statistical approaches to comprehend the knowledge structure and investigate development patterns, is useful in understanding current trends in imagery research.

Materials and Methods

The data source was Web of Science (WOS) and 792 studies were included in the analysis from 1979 to 2022. VOSviewer was used for analyzing and visualizing bibliometric networks in this study (Van Eck & Waltman, 2022). It is a software program that can create networks of scientific publications, researchers, research organizations, countries, keywords, and terms by linking nodes via co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation.

Results

Trends in Global Publication

Research on imagery in sports science appeared on Web of Science (WOS) in 1979.

The number of annual publications on imagery research has steadily increased since 1993, with over 30 documents being published each year since 2012. The average number of publications during the decade was 38.5, and the highest number of documents were published in 2018 (48). This suggests that interest in imagery research is growing.

Distribution by Country/Region

WoS identified 44 countries/regions that contributed publications in imagery research in sports science, with the United States, England, and Canada being the top three contributors (68% of global publications). These three countries have a strong citation/cooperation relationship with each other, as revealed by VOSviewer analysis. Overall, the results suggest that these three countries are key players in imagery research in sports science, and they have a strong collaborative relationship.

Influential Authors

2,132 authors contributed 792 publications in 90 different journals on imagery research in sports science. Hall C. was the most prolific author with 62 publications and the most cited with 2,432 citations. Jackson et al. (2001) was the most influential work with 335 citations.

Co-occurrence Analysis of Keywords

According to the keyword research, there are four main areas of imagery research in sports science: (1) the connection between an athlete's performance and their mental imagery; (2) movement and human motor learning; (3) imagery training and mental practice; and (4) medical studies and clinical on recovery, pain and injury using an imagery approach.

Discussion

Over the past four decades, research on imagery in sports science has been on the rise. This type of research has shown the benefits of mental practice of movements without physical execution and has been useful in various fields. Despite Japan's international standing, including its hosting of the Olympics, there appears to be a relative dearth of research on imagery compared to other top-tier sports nations. In order to promote greater global publication and interest in imagery research, it will be essential to encourage international collaboration among key stakeholders and across nations.

CHAPTER 4: PSYCHOMETRIC SUPPORT FOR A JAPANESE VERSION OF THE SPORT IMAGERY ABILITY QUESTIONNAIRE

Abstract

In this two-part study, we addressed psychometric properties of the Japanese version of the Sport Imagery Ability Questionnaire (SIAQ-J). We analyzed the SIAQ-J factor structure, assessed gender, competitive level, sport type and years of experience differences on the SIAQ-J, and we investigated whether the SIAQ-J was predicted by goal clarity. In Study 1, we translated the original SIAQ (15 items) into Japanese and performed an exploratory factor analysis (n = 366). In Study 2 (n = 422), we verified the measurement model established in Study 1 with exploratory factor analysis (EFA). Study 1 found five exploratory factors—skill, strategy, goal, affect and mastery imagery—and these were confirmed through the confirmatory factor analysis (CFA) conducted in Study 2. Structural equation modelling supported a model wherein goal clarity positively predicted all SIAQ-J subscales. This study provided additional validation of the original SIAQ. Overall, the SIAQ-J demonstrated good factorial validity, temporal reliability and gender invariance and discriminated among athletes of different competitive levels and years of experience.

Keywords: imagery scale, visualization, translation, development and validation, reliability

Introduction

The use of imagery is part of a widely accepted set of strategies that enhance athletic performance (for reviews, see Cumming & Ramsey, 2009; Murphy et al., 2008). Cognitive or mental imagery is essential for motor learning and promoting performance (Williams & Cumming, 2011), and it combines the use of various sensory modalities to simulate real experience in the absence of direct perception (Cumming & Ramsey, 2008); this technique serves different functions in varied situations (Williams & Cumming, 2011). For example, athletes can use imagery to improve their skills, prepare mentally for an important competition, or focus on specific tasks (Munroe et al., 2000). For all these functions, athletes come up with vivid images of a potential play situation (Gregg et al., 2016). Researchers have extensively attended to various specific aspects of athletes' imagery abilities (Gregg et al., 2011; Morris et al., 2005; Williams & Cumming, 2011), including the ability to create an image of a particular situation (Short et al., 2005) or to form vivid, controllable images (Morris et al., 2005, p. 60). Imagery can be defined as an athlete's ability to create clear, controlled images within a sporting situation to achieve a desired outcome (Singnoy et al., 2015). In a seminal study, investigators identified a five-factor sports imagery model (skill, strategy, goal, affect and mastery imagery) and developed a measurement instrument for it named the Sport Imagery Ability Questionnaire (SIAQ; Williams & Cumming, 2011).

An underlying theory for this five-factor structure was supplied by Paivio's (1985) imagery framework, which described how imagery affects human motor performance and is measured by the Sport Imagery Questionnaire (Hall et al., 1998). The Paivio (1985) framework proposed that when applied to a specific or general purpose, following both cognitive and motivational functions, individuals tend to employ four types of imagery: (a) cognitive specific (images of skills), (b) cognitive general (images of strategies and routines), (c) motivational specific (images of goals and their achievement) and (d) motivational general (MG, images of arousal and emotion). However, Martin et al. (1999) recognized that these imagery types do not constitute an exhaustive list. Hall et al. (1998) developed the Sport Imagery Questionnaire by subdividing MG into MG-A (images of affect, mood, and emotions) and MG-M (images of mastery cognitions) to assess athletes' imagery uses. From these five types of imagery, the initial structure of the SIAQ was formulated to assess the athlete's ability to create images of different cognitive and motivational content (Williams & Cumming, 2011).

From its original establishment, due to good psychometric support (Budnik-Przybylska & Karasiewicz, 2020), the SIAQ has been widely investigated. Beyond its original English version, there have been 11 publications that validate this tool in nine languages: Chinese (Huang et al., 2015), Persian (Ashrafi et al., 2015; Tahmasbi et al., 2020), Thai (Singnoy et al., 2015), German (Simonsmeier & Hannemann, 2017), Spanish (Alcaraz-Ibanez et al., 2017; Gabilondo et al., 2018), Japanese (Aikawa et al., 2019), Latvian (Volgemute et al., 2019), Polish (Budnik-Przybylska & Karasiewicz, 2020) and Brazilian Portuguese (Filgueiras et al., 2020). All these versions, except the Japanese version, produced a five-factor structure version identical to the original English version. However, Aikawa et al. (2019) identified a four-factor SIAQ model that excluded affect imagery because of characteristics unique to the Japanese, including a cultural tendency to suppress emotional expression in everyday life (Hirabayashi, 1995; Nakamura, 1991). Perhaps because of these Japanese characteristics, the item 'excitement' used in the SIAQ to refer to affect imagery could have been misunderstood by Japanese participants as 'hyper' or 'uptight.' Although affect imagery is a complex SIAQ factor, emotional suppression has separately been thought to have no influence on athletes' ability to imagine sports content (Anuar et al., 2017). Rather, because athletes may benefit from emotional suppression, it has been posited that athletes' perceptions affect the content of the imagery they produce, and these perceptions can be best supported by the research that has demonstrated a five-factor structure (e.g., Filgueiras et al., 2020; Huang et al., 2015; Williams & Cumming, 2011).

Moreover, Aikawa et al. (2019) used 20 items in the SIAQ instead of the 15 items in the original English version. The 20-item SIAQ is the result of an exploratory factor analysis of the pilot study of the original SIAQ. Therefore, a reference citation for the original version of the instrument and data (and citations) regarding the reliability and validity of the original instrument has not been reported. Because Williams and Cumming (2011) conducted four studies after the pilot for further verification of SIAQ, they pooled the 30 items drawn from the Sports Imagery Questionnaire (SIQ) in their pilot study and made modifications to the words in the items. Thirty-five items in the questionnaire were developed to evaluate five types of imagery. Factor analysis providing load scores in this structure reduced 35 items to 20 items with a four-factor structure. In Study 1, the loading score for factor analysis reduced the items from 20 to 12. These results were confirmed using a new sample from Study 2 by applying confirmatory factor analysis (CFA) and cross-validating the findings in Study 1 to demonstrate good fit with the data of the four-factor model. In Study 3, items were added to create a fifth mastery imagery subscale reworded from Study 1, which was confirmed through CFA, thereby demonstrating good factorial validity for the five-factor model and internal and temporal reliability. In Study 4, the SIAQ was compared with the movement imagery questionnaire-3. Significant bivariate correlations showed that the SIAQ was valid, but both questionnaires showed differences in imagery ability of different content.

As such, the 20-item SIAQ is incomplete, internal consistency and inter-factor correlations were not provided, and mastery subscales were not developed. However, Aikawa et al. (2019) established mastery imagery instead of affect imagery. Thus, this Japanese version of the SIAQ based on the 20-item SIAQ creates confusion.

New research is necessary to empirically examine whether the SIAQ in a Japanese sample should contain a four- or five-factor structure using a validated final 15-item version of the SIAQ. Additionally, the regression weights examined to determine whether goal clarity would positively predict SIAQ-J and suggest how the SIAQ can be practically applied in the sporting field because imagery ability reflects the ease of imagining associated with the clarity and depth of the image (Williams & Cumming, 2011). Test–retest reliability was conducted to support temporal reliability.

From the 28th Athens Olympics to the 32nd Tokyo Olympics, Japan always ranked among the top 10 countries, except for its 11th place finish in the London Olympics. Despite their achievements, psychometric properties of the SIAQ are not widely known worldwide, thereby necessitating this study. Our study had three purposes: (a) newly translate the 15-item SIAQ into a Japanese version and analyze the structure of the factors; (b) investigate whether the Japanese version of the SIAQ can differentiate among athletes of different competitive levels, genders, sport types and years of experience and (3) test the practicality of the SIAQ in the sporting field by determining whether SIAQ-measured imagery is predicted by goal clarity. We conducted two studies. In Study 1: we translated and culturally adapted the SIAQ to Japanese and then performed exploratory factor analysis (EFA) to identify its factor structure. In Study 2, we verified the measurement of the Study 1 model by using CFA and then used multivariate analysis of variance (MANOVA) to determine any differences in imagery ability according to the athlete participants' competitive level, gender, sport type and years of experience. Finally, we investigated whether assigned regression weights would positively predict SIAQ from goal clarity using structural equation modelling (SEM).

Method: Study 1 – Translation and Cross-Cultural Adaptation

Study 1 aimed to translate the 15 items of the original English version of the SIAQ, develop a Japanese version of the SIAQ (SIAQ-J) and examine the factor structure of the

SIAQ-J. In this study, we translated the original English version of the SIAQ into a Japanese version (SIAQ-J) and examined the SIAQ-J factor structure. We conducted the translation process in four stages (Del Greco et al., 1987). First, a preliminary translation of the SIAQ from English into Japanese was completed by three bilingual sports psychologists with experience in conducting research in sports imagery. The three translators unanimously agreed that the direct translation of the word ‘excitement’ in two affect imagery items of the original English version (e.g., #7. “The anticipation and excitement associated with my sport,” and #11. “The excitement associated with performing”) could lead to confusion among Japanese athletes because the direct Japanese translation of ‘excitement’ probably refers to erethism, thereby implying characteristics such as ‘hyper’ or ‘uptight’. Notably, the existing Japanese version of SIAQ used ‘excitement’ as a direct translation (Aikawa et al., 2019), but in this study, ‘excitement’ was translated using synonyms (e.g., ワクワク感; ‘an intensely pleasant feeling’ and 情熱と期待感; ‘a feeling of passion with expectation’). Second, after this preliminary translation, three graduate students in sports science who were bilingual in English and Japanese and had no prior knowledge of the original instrument back-translated the SIAQ-J into English. Third, the initial translators then compared and discussed the translated and back-translated versions to derive a final agreed-upon translation. Equivalence was established for alternative translations by bilingual Japanese experts serving as instructors. Moreover, two collegiate soccer athletes provided nearly identical responses to all 15 items of the translated and original versions. Fourth, we established the reliability and content validity of the translated questionnaire using diagnostic content validation (DCV; Fehring, 1987) to determine whether imagery ability could be measured properly with the SIAQ-J at an expert meeting of four incumbent coaches, four sports psychologists and two sports science experts with experience in questionnaire development. In the DCV, the experts rated the characteristics of the tested items on a scale from 1 to 5 (1 = not characteristic or indicator of diagnosis at all; 2 = few characteristics of diagnosis; 3 = somewhat characteristic; 4 = quite characteristic and 5 = highly characteristic). Next, we calculated the weighted ratio for the characteristics of each item (1 = 0, 2 = 0.25, 3 = 0.50, 4 = 0.75 and 5 = 1). All 15 items passed our threshold criterion for discarding items (i.e., a weighted ratio of < 0.5) because they scored ≥ 0.65.

Procedures

After receiving ethical approval by the ethical review committee at the university where we are affiliated, we began our research with a sample of collegiate athletes from a university in Tokyo, Japan. An investigator directly contacted individuals at their training locations and collected data using a random convenience sampling method. All participants received a consent form with detailed written explanations of the study's purpose and privacy protection methods. The survey was conducted anonymously, and the participants had the option to refuse/withdraw their consent at any given time without any disadvantage. For questions regarding their rights as a volunteer, participants were provided with an institutional phone number and email address. The consent form helped the participants make an informed decision regarding whether they should participate in the study. Those who expressed their consent to participate understood that it was voluntary. Data collection for each participant lasted approximately 10–15 minutes.

Participants

Study 1 comprised 366 collegiate athlete participants (male = 180, female = 186) from 27 sports. Their age ranged from 18 to 24 years (M = 20.1, SD = .85) and they had 1–20 years of experience (M = 9.69, SD = 4.60). Participants were recruited at the university where we are affiliated after ethical approval. Athletes belonging to the university's sports club were the participants who met the inclusion criteria. They were informed that participation was voluntary, and they expressed consent to participate. Participants provided information regarding their age, gender, sport played, competitive level and years of experience. A total of 380 questionnaires were returned. Of those, 14 missing data cases were removed from the dataset, resulting in a final sample.

Measures

SIAQ-J. We used the 15-item SIAQ-J to assess how easily participants could produce imagery reflective of the cognitive and motivational functions used in their sport (i.e., skill, strategy, goal, affect and mastery imagery). The questionnaire instructed the athletes to imagine a series of scenarios related to their sport and then rate the ease with which they could do so for each scenario. Athletes rated the scenario imageries on a 7-point Likert scale (1 = very hard to image, 2 = hard to image, 3 = somewhat hard to image, 4 = neutral, 5 = somewhat easy to image, 6 = easy to image and 7 = very easy to image). The original SIAQ has shown good validity and reliability for this purpose ($\chi 2$ (80) = 108.59, $p < .05$, comparative fit index (CFI) = .98, TLI = .97, standardized root mean squared residual (SRMR) = .04, root mean square error of approximation (RMSEA) = .04) and factor loadings (0.61–0.88), composite reliability (CR) ranged between .78 and .86 and average variance extracted (AVE) ranged between .55 and .67.

Data Analysis

We conducted statistical analyses using the Statistical Package for the Social Sciences (SPSS version 27). We tested means and standard deviations with the Kolmogorov–Smirnov test to identify the null hypothesis that our dataset represented a normal distribution, and we calculated skewness and kurtosis for the entire set of items, with skewness and kurtosis values ranging from −2.0 to +2.0, indicative of normality (George & Mallery, 2010).

We conducted an exploratory factor analysis (EFA) with principal axis factoring and direct oblimin rotation to determine the factors and factor loadings of the measured variables (Williams & Cumming, 2011). Additionally, we calculated the Kaiser–Meyer–Olkin (Cerny & Kaiser, 1977) value to assess sampling adequacy, performed Bartlett's test of sphericity to assess the strength of the relationship between variables (Bartlett, 1954) and conducted Cronbach's (1951) alpha coefficient to estimate the internal consistency (reliability) of test items within the instrument.

Results: Study 1

Data Screening and Item Characteristics

All 15 items of the SIAQ-J, along with their means, standard deviations, skewness and kurtosis values, are presented in Table 1. The mean ratings of the separate items ranged from 3.62 to 5.16. Response variability was deemed satisfactory, as an examination of each item's standard deviation revealed values >1.00, a method employed during the initial stages of developing other imagery questionnaires (SIQ, Hall et al., 1998; SIAQ, Williams & Cumming, 2011). Item skewness and kurtosis values were distributed within the tolerance levels of normality assumptions.

Table 1. Study 1 Items: Means, Standard Deviations, Skewness and Kurtosis values, Factor Loadings and Internal Consistency.

Descriptions					Factor loadings					Internal consistency
Item	*M*	*SD*	Skewness	Kurtosis	Skill	Strategy	Goal	Affect	Mastery	Cronbach's alpha
Skill 1	3.81	1.52	.006	−.879	.743					.845
Skill 2	3.84	1.52	.078	−.872	.932					
Skill 3	3.93	1.53	.019	−.882	.702					
Strategy 1	4.08	1.47	.008	−.783		.768				.889
Strategy 2	3.69	1.51	.268	−.708		.907				
Strategy 3	3.62	1.55	.244	−.614		.825				
Goal 1	3.66	1.87	.172	−1.013			.795			.851
Goal 2	3.95	1.86	−.050	−1.052			.854			
Goal 3	4.67	1.54	−.413	−.299			.574			
Affect 1	4.78	1.55	−.481	−.422				.617		.860
Affect 2	5.09	1.42	−.665	.123				.915		
Affect 3	5.16	1.39	−.624	.013				.773		
Mastery 1	4.55	1.48	−.329	−.468					.591	.808
Mastery 2	4.20	1.52	−.066	−.582					.917	
Mastery 3	4.07	1.62	−.089	−.796					.732	

Exploratory Factor Analysis

We used principal axis factoring with direct oblimin rotation to evaluate the Kaiser–Meyer–Olkin measure of sampling adequacy and Bartlett's test of sphericity with no determinate number of factors. The results showed that the amount of data available was adequate for factor analysis (sampling adequacy = .84, sphericity p = .000). Using Kaiser's criteria of eigenvalues >1 and the scree plot (Pallant, 2020), we identified five factors (Table 1) with eigenvalues ranging from 1.03 to 5.74 that explained 78.47% of the cumulative proportion of variance. According to Cattell's (1996) criteria, factors that can explain 70%–80% of the variance were retained. The factor loading between item and factor was as follows: skill imagery (.70–.93), strategy imagery (.77–.91), goal imagery (.57–.85), affect imagery (.62–.92) and mastery imagery (.59–.92). If the factor loading was >.5 with an average of >.7 for each factor, the convergent validity was considered sufficient (Hair et al., 2010). The correlation between factors ranged from .15 to .54.

Internal Consistency

We estimated internal consistency using Cronbach's alpha reliability coefficient, with items ranging from a minimum of .81 to a maximum of .89 (skill = 0.85, strategy = 0.89, goal = 0.85, affect = 0.86 and mastery = 0.81). This value was .88 for all participants, showing adequate internal consistency (George & Mallery, 2003). Thus, the five factors of SIAQ-J exhibited good internal consistency reliability.

Method - Study 2: Confirmatory Factor Analysis, Group Difference and Relationship to Goal Clarity

Having established a five-factor structure of the SIAQ-J through EFA in Study 1, in Study 2, we aimed to confirm this factor structure in a new participant sample. We used CFA to compare a final five-factor CFA solution with alternative models, investigate its gender invariance and test whether athlete respondents' gender, competitive levels, sport type and years of experience were related to imagery ability. Although the literature has assumed no gender differences in imagery ability among athletes, differences based on their level of competition might be observed (e.g., Gregg & Hall, 2006; Roberts et al., 2008). We also sought to determine whether the SIAQ-J could be practically applied to the sporting field by investigating the relationship between goal clarity and SIAQ-J. Goal clarity refers to the specificity and clarity of an athlete's goals (Kwan et al., 2013), and imagery ability reflects the ease of imagining that may be associated with the clarity and depth of the image (Williams & Cumming, 2011). Finally, we examined test–retest reliability after four months.

Procedures

After receiving ethical approval, we collected data from five universities in the Kanto region of Japan. Using the same procedure and ethical consideration as in Study 1, we relied on random convenience sampling. We used a separate group of 29 athletes who agreed to participate in the test–retest reliability procedure and complete the SIAQ twice with a four-month interval under the same conditions.

Participants

Study 2 comprised 422 collegiate athlete participants (men = 214; women = 208) from 30 sports. Their age ranged from 18 to 28 years (M = 20.00, SD = 1.22) and they had 1–19 years of playing experience (M = 8.63, SD = 4.85). Participants were recruited from universities in the Kanto region, a surrounding area of Tokyo, Japan. The participants who met the inclusion criteria were the ones who took part in the university's sports club as collegiate athletes. All participants received consent forms with information sheets. Interested participants expressed their consent to participate, and they were aware that their participation was entirely voluntary.

Participants supplied information such as their age, gender, sports played, competitive level, and years of experience. The number of returned questionnaires was 450, and 28 questionnaires were excluded because of missing data; thus, the final sample was 422.

Measures

Japanese version of the SIAQ. We used the same 15-item SIAQ-J in Studies 1 and 2. The SIAQ-J's internal reliability was good with the Cronbach alpha coefficient of each subscale (skill = 0.85, strategy = 0.89, goal = 0.85, affect = 0.86, mastery = 0.81).

Goal-Setting Questionnaire. We used a 42-item goal-setting questionnaire (Kwan et al., 2013) to assess the participants' goal-setting clarity. This instrument used the respondent's 5-point Likert-type scale ratings for 42 items, with responses ranging from (1) strongly disagree to (5) strongly agree. From this instrument, we used only the 6-item goal clarity subscale (reported Cronbach's alpha = 0.88) and modified the items' wording to fit the athletes' sport goal setting (e.g., 'I have specific, clear goals to aim for on my job' modified to 'I have specific, clear goals to aim for on my sport'). The goal clarity subscale was used as the independent variable to verify how the SIAQ-J can be practically applied in the sporting field using the structural model. The model demonstrated adequate CR = .903 and AVE = .655.

Data Analysis

The CFA we used relied on the maximum likelihood estimation approach to verify the five-factor structure of the SIAQ-J as identified by EFA in Study 1. We tested the model's overall goodness of fit using the chi-squared statistic (χ^2), SRMR, Tucker–Lewis index (TLI), CFI and RMSEA. We tested convergent and discriminant construct validity using CR, AVE, maximum reliability (MaxR(H)), maximum shared variance (MSV) and the square root of AVE. A series of one-way MANOVAs were conducted to verify the hypothesis that gender, competitive level, sport type and years of experience are related to imagery ability. We investigated regression weights using SEM to test whether goal clarity was related to SIAQ-J subscales. The five SIAQ subscales were the dependent variables, and goal clarity was the independent variable. The analyses were performed using the IBM SPSS program (version 27) and AMOS 27.

Results - Study 2

Confirmatory Factor Analysis.

The CFA was performed using a maximum likelihood estimator to test the goodness of fit indices based on the results of Study 1 for a five-structure model of the 15-item SIAQ-J established by EFA. We calculated the goodness of fit indices \ by inspecting the CFI, $\chi2$, TLI, SRMR and RMSEA. The cut-off criteria for fit indices (Hu & Bentler, 1999) and adequate fit required that the CFI value be greater than .95, the TLI value be greater than .90, the SRMR and RMSEA produce values less than .08 and the $\chi2$/df values be less than 3 to show an acceptable fit between the hypothetical model and the sample data (Carmines & McIver, 1981; Iacobucci, 2010). The results showed a good model fit for the five-factor model with correlated traits ($\chi2(73) = 176.769$; $\chi2/df = 2.421$; CFI = .965; TLI = .950; SRMR = .036; RMSEA = .058).

Convergent and Discriminant Construct Validity.

To assess convergent validity, we examined CR, AVE and MaxR(H). Convergent validity is indicated if CR is greater than the threshold value of .70 (Hair et al., 1997), AVE is more than .5 (Fornell & Larcker, 1981) and the MaxR(H) value is greater than the CR value (Fornell & Larcker, 1981; Hair et al., 2014). These criteria were fulfilled in this case. For assessing discriminant validity, Fornell–Larcker’s (1981) criteria are that the MSV value should be smaller than AVE and that the square root of AVE (in bold†) should be greater than the interconstruct correlation. Additionally, Kline (2011) suggested that if the correlations between latent variables are less than .85, discriminant validity is established. The criteria for all coefficients related to discriminant validity were sufficiently satisfied. Thus, the results for convergent and discriminant validity are presented in Table 2.

Table 2. Results of Convergent and Discriminant Validity.

	CR	AVE	MSV	MaxR(H)	Mastery	Skill	Strategy	Goal	Affect
Mastery	0.785	0.552	0.490	0.810	0.743†				
Skill	0.828	0.617	0.455	0.829	0.662	0.785†			
Strategy	0.852	0.658	0.445	0.853	0.561	0.667	0.811†		
Goal	0.831	0.623	0.404	0.854	0.636	0.554	0.495	0.789†	
Affect	0.836	0.630	0.490	0.841	0.700	0.527	0.398	0.619	0.794†

Note. †, square root of AVE

Alternative Models

To confirm the factor loading for each item and the correlations among the latent variables, we performed alternative CFAs to conduct a comparison with the five-factor model and its correlated traits. The unidimensional model tested in the first step produced poor results ($\chi^2(90) = 918.83$; $\chi2/df = 10.209$; CFI = .720; TLI = .673; SRMR = .092; RMSEA = .148), thereby supporting that support imagery ability is multidimensional.

Two- and four-factor model CFAs were examined next because Paivio's framework and the SIQ provided an underlying structure for the SIAQ with two basic functions (cognitive and motivational), each function operating at a specific or general level (Hall et al., 1998; Paivio, 1985; Williams & Cumming, 2011). A two-factor correlated traits model was investigated wherein skill and strategy items were enforced on a single latent variable as a cognitive subscale and goal, and we forced affect and mastery items onto a single latent variable as a motivational subscale. The results showed an inappropriate fit ($\chi^2(89) = 623.084$; $\chi^2/df = 7.0009$; CFI = .819; TLI = .787; SRMR = .072; RMSEA = .119), thereby indicating that skill imagery and strategy imagery expressed in the cognitive-specific and cognitive-general scales are independent measures of different contents and cannot be explained through forced loading onto cognitive factors. A four-factor correlated traits model was examined in which affect imagery and mastery imagery items were enforced onto an MG subscale. The result was an improvement to the unidimensional and two-factor models, but the fit remained inadequate ($\chi^2(84) = 270.32$; $\chi^2/\text{df} = 3.218$; CFI = .937; TLI = .921; SRMR = .047; RMSEA = .073), thereby suggesting that MG is best explained when separated into two specific components: affect (MG-A) and mastery imagery (MG-M). The results for the alternative models are shown in Table 3.

Table 3. CFA Fit Indices for Alternative CFAs.

Model	χ^2	df	χ^2/df	CFI	TLI	SRMR	RMSEA
Unidimensional	918.83	90	10.209	0.720	0.673	0.092	0.148
Two factor	623.08	89	7.001	0.819	0.787	0.072	0.119
Four factor	270.32	84	3.218	0.937	0.921	0.047	0.073
Five factor	176.76	73	2.421	0.965	0.950	0.036	0.058

Gender Invariance

We performed a multigroup CFA to test whether the SIAQ factor structure of the model was invariant with respect to gender. After Model 1 (unconstrained model) was established, we compared Model 2 (invariance model in measurement weights), Model 3 (invariant structural covariances) and Model 4 (invariant measurement residues) against Model 1. We found no significant differences between the unconstrained model (Model 1) and invariant measurement weights (Model 2; $p = .45$), invariant structural covariances (Model 3; $p = 0.109$) or invariant measurement residues (Model 3; $p = .12$). A change in the CFI of $\leq .01$ was also appraised to demonstrate model invariance (Cheung & Rensvold, 2002). The difference in CFI between all four steps was <.01, which confirms the factorial invariance of the scale across gender. The results of multigroup CFA are shown in Table 4.

Table 4. Results of Gender Invariance Testing.

	χ^2 (df)	Model comparison	$\Delta\chi^2$ (Δdf)	*p*	CFI (ΔCFI)	RMSEA
Model 1	288.42 (150)	–	–	–	0.954	0.047
Model 2	298.35 (160)	Model 2 – Model 1	9.93 (10)	0.447	0.954 (<0.001)	0.045
Model 3	322.37 (175)	Model 3 – Model 1	33.95 (25)	0.109	0.951 (0.004)	0.045
Model 4	339.06 (190)	Model 4 – Model 1	50.54 (40)	0.121	0.950 (0.005)	0.043

Note. $\Delta\chi2$, chi-square difference; Δdf, difference in degrees of freedom; ΔCFI, change in CFI, when the fit of the more constrained model is compared with that of the previous, less constrained model (Cheung & Rensvold, 2002).

Group differences in SIAQ-J

Test validity was further tested using two MANOVAs to determine whether imagery ability differed by participants' (a) gender, (b) competitive level (level 1, international level, n = 69; level 2, top level of national competition, n = 122; level 3, participating in national competitions and winning provincial competitions, n = 111; level 4, participating in provincial competitions and winning local competitions, n =58 and level 5, no experience participating in regular competitions, n = 62), (3) sport type (team, n = 178; individual, n = 244) and (4) years of experience (experience 1, 1–5 years, n = 132; experience 2, 6–10 years, n = 133; experience 3, 11–19 years, n = 157) The five SIAQ subscales were positioned as the dependent variables in each analysis; the independent variables were gender, competitive level, sport type and years of experience.

Gender Differences.

Box's M statistic had a value of gender of 23.168, p = .087, indicating that the homogeneity of covariance matrices was assumed and that the linearity and multicollinearity were satisfactory. Because of the use of Pillai's trace, gender was significantly different when displaying imagery ability (Pillai's trace = .042, F(5, 416) = 3.637, p = .003, partial η2 = .042, observed power = 93%). To investigate the impact of each effect on the individual dependent variables, we performed a univariate F test using an alpha level of .05. Although this finding was contrary to the hypothesis that there would be no gender differences in imagery ability (e.g. Gregg & Hall, 2006; Roberts et al., 2008), a test of between-subject effects indicated a significant effect for gender with strategy imagery [F(1, 420) = 4.584, p = .033, partial η2 = .011], such that women had lower mean SIAQ-J scores (M = 3.59, SD = 1.24) than men (M = 3.86, SD = 1.32). Additionally, gender had no significant effect on skill, goal, affect and mastery imagery.

Competitive Level.

Box's M statistic had a value of competitive level of 65.272, p = .357, indicating that the homogeneity of covariance matrices could be assumed and that the linearity and multicollinearity of these data were satisfactory. With the use of Pillai's trace, the competitive level was found to be significantly different for displaying imagery ability [Pillai's trace = .232, F(20, 1664) = 5.121, p < .001, partial η2 = .058, observed power = 100%]. To investigate the impact of each effect on individual dependent variables, we conducted a univariate F test with an alpha level of .05 and found that the competitive level had a significant effect on imagery ability, skill [F(4, 417) = 4.483, p < .001, partial η2 = .041], strategy [F(4, 417) = 10.721, p < .001, partial η2 = .093], goal [F(4, 417) = 17.268, p < .001, partial η2 = .142] and mastery imagery [F(4, 417) = 2.644, p = .033, partial η2 = .025]. However, same as the original SIAQ result, affect imagery had no significant predictive effect [F(4, 417) = 2.010, p = .092, partial η2 = .019] on the competitive level. Multiple comparisons using Tukey's honest significant difference test (HSD) were performed to investigate the differences in mean scores for the five competitive levels on each SIAQ-J subscale. The overall result showed that athletes at competitive level 1 (international level) showed greater imagery ability than those at competitive levels lower than 1 on each SIAQ-J subscale. Furthermore, in strategy imagery, the mean score difference showed the same pattern as the difference in competitive levels (i.e., low- vs. high-level athletes). The results of multiple comparisons are shown in Table 5.

Table 5. Results of Competitive Level Differences in SIAQ-J.

	Competitive level									
	Level 1 (N = 69)	Level 2 (N = 122)	Level 3 (N = 111)	Level 4 (N = 58)	Level 5 (N = 62)	ANOVA		Multiple comparisons		
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	*f*	*p*	Tukey HSD		
Skill	4.82 (1.33)	4.24 (1.25)	4.24 (1.28)	4.07 (1.09)	4.01 (1.17)	4.48	0.001	1 > 2, 3, 4, 5		
Strategy	4.37 (1.33)	3.90 (1.20)	3.69 (1.27)	3.38 (1.10)	3.08 (1.27)	10.72	0.001	1 > 3, 4, 5	2 > 5	3 > 5
Goal	4.81 (1.57)	4.23 (1.33)	3.70 (1.26)	3.07 (1.57)	3.40 (1.42)	12.27	0.001	1 > 3, 5, 4	2 > 5, 4	3 > 4
Affect	5.04 (1.31)	4.64 (1.24)	4.58 (1.27)	4.48 (1.33)	4.73 (1.34)	2.01	0.092	1 > 4		
Mastery	4.53 (1.24)	4.02 (1.20)	4.09 (1.23)	3.98 (1.31)	3.92 (1.33)	2.64	0.033	1 > 5		

Note. level 1, international level; level 2, top level of national competition; level 3, participating in national competitions and winning provincial competitions; level 4, participating in provincial competitions and winning local competitions and level 5, no experience participating in regular competitions.

Sport Type.

Box's M statistic had a sport type value of 12.653, p = .642, thereby indicating that the homogeneity of covariance matrices was assumed and that the linearity and multicollinearity were satisfactory. Using Pillai's trace, playing imagery ability (Pillai's trace

= .03, F(5, 416) = 2.605, p = .025, partial η2 = .03, observed power = 80.1%) was found to be significantly different by sport type (i.e., team or individual). To investigate the impact of each effect on individual dependent variables, we used a univariate F test with an alpha level of .05. A test of between-subject effects indicated a significant effect of sport type on affect imagery [F(1, 420) = 4.459, p = .035, partial η2 = .011] such that individual sports had lower mean SIAQ-J scores (M = 4.57, SD = 1.30) than team sports (M = 4.84, SD = 1.20). Additionally, sport type had no significant effect on skill, strategy, goal, and mastery imagery.

Years of Experience.

Box's M statistic had a years of experience value of 41.191, p = .096, thereby indicating that the homogeneity of covariance matrices was assumed and that the linearity and multicollinearity were satisfactory. Using Pillai's trace, years of experience was found to be significantly different for displaying imagery ability (Pillai's trace = .108, F(10, 832) = 4.727, p = .001, partial η2 = .054, observed power = 100%). A univariate F test with an alpha level of.05 was used to investigate the impact of each effect on individual dependent variables. We found that years of experience had a significant effect on imagery ability, skill [F(2, 419) = 3.417, p = .034, partial η2 = .016], strategy [F(2, 419) = 9.556, p = .001, partial η2 = .044], goal [F(2, 419) = 6.770, p = .001, partial η2 = .031] and mastery imagery [F(2, 419) = 3.979, p = .019, partial η2 = .019]. However, affect imagery had no significant effect [F(2, 419) = 1.645, p = .194, partial η2 = .008]. Except affect imagery, the overall mean score difference showed that as athletes' duration of experience increased, their imagery ability increased on each SIAQ subscale. The results of multiple comparisons are shown in Table 6.

Table 6. Results of Years of Experience Differences on SIAQ-J.

	Years of experience					
	Experience 1 (N = 132)	Experience 2 (N = 133)	Experience 3 (N = 157)	ANOVA		Multiple comparisons
	M (SD)	M (SD)	M (SD)	*f*	*p*	Tukey HSD
Skill	4.05 (1.09)	4.37 (1.37)	4.40 (1.27)	3.42	0.034	3 > 1
Strategy	3.35 (1.13)	3.80 (1.33)	3.99 (1.32)	9.56	0.001	3 > 1,2 2 > 1
Goal	3.56 (1.42)	3.94 (1.58)	4.19 (1.45)	6.77	0.001	3 > 1
Affect	4.77 (1.18)	4.52 (1.35)	4.75 (1.26)	1.65	0.194	
Mastery	3.85 (1.29)	4.19 (1.26)	4.24 (1.20)	3.98	0.019	3 > 1

Note. Experience 1; 1–5 years, Experience 2; 6–10 years, Experience 3; 11–19 years

Structural Equation Modelling

We used maximum likelihood estimation to analyze the data using SEM. We tested the CFA measurement model of goal clarity and revealed a good fit to the data ($\chi2$ (8) = 20.21; $\chi2$/ df = 2.572; CFI = .980; TLI = .963; SRMR = .035; RMSEA = .060). For testing the hypothesized model, regression lines were drawn from goal clarity to each subscale of the SIAQ-J (i.e., skill, strategy, goal, affect and mastery imagery ability). The structural model revealed an adequate fit ($\chi2$ (166) = 337.88; $\chi2$/ df = 2.035; CFI = .953; TLI = .940; SRMR = .044; RMSEA = .050). The examination of the regression weights revealed that goal clarity positively predicted all SIAQ-J subscales at ($p < .001$) values shown in Figure 1.

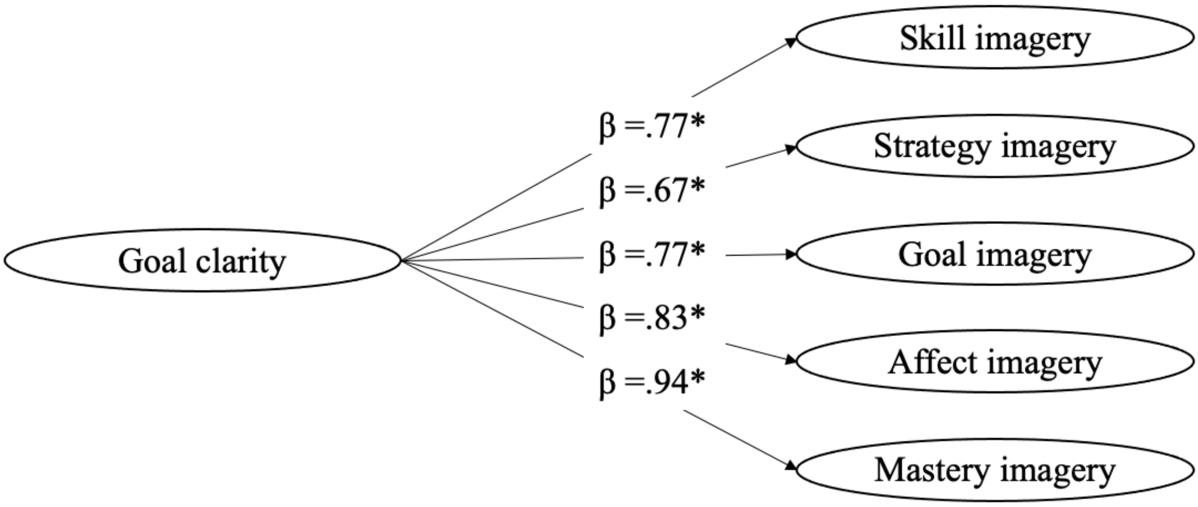

Figure 1. SEM Result: Goal Clarity Predicts all SIAQ Subscales.

Note. All coefficients are standardized, and variances were all significant. *p < .001.

Test–Retest Reliability

To establish test–retest reliability on a 4- month interval between test sessions, we calculated the intraclass correlation coefficient for skill (.757), strategy (.848), goal (.854), affect (.827) and mastery imagery (.705). The coefficient for global scale (.791) revealed acceptable temporal stability. According to Cicchetti (1994), a test–retest reliability coefficient of 0.60–0.74 is good and 0.75 and higher is excellent.

Discussion: Studies 1 and 2

In this two-part research, we created a Japanese version of the SIAQ with the SIAQ's traditional five structures; moreover, we provided preliminary psychometric support for this adapted measure (the SIAQ-J). We found that this SIAQ-J was a comprehensive imagery ability assessment tool for evaluating five types of mental imagery in sports. First, we satisfactorily translated the original English version of the SIAQ into Japanese and demonstrated that it had the same factor structure as the original version of the SIAQ (Williams & Cumming, 2011), which has been previously found suitable in other language versions, as well (Aikawa et al., 2019). The difference between our five-factor, 15-item SIAQ-J and the four-factor, 12-item Japanese adaptation of the SIAQ (Aikawa et al. 2019) was specifically related to affect imagery. The first Japanese version of the SIAQ only identified a four-factor SIAQ without affect imagery due to cross-loading that may have been related to how ‘excitement’ was translated in Japanese.

Paivio (1985) had initially proposed MG imagery as a single type of imagery. Only later did Hall et al. (1998) suggest that MG imagery would be best understood by dividing it into MG-A (affect imagery) and MG-M (mastery imagery). Because affect imagery was absent in the first Japanese version of the SIAQ by Aikawa et al. (2019), there was a limit to its measurement of cognitive anxiety that depends on measuring affect imagery related to moods, feelings, and competitive anxiety (Hall et al., 1998; Williams & Cumming, 2011; Williams & Cumming, 2016). This absence may have been due to an inherent characteristic of Japanese people to suppress emotional expression in everyday life and Anuar et al.’s (2017) argument that there is no link between suppression and the SIAQ subscales because emotional suppression in athletes is an effective emotion regulation strategy that should be unrelated to whether they can image sports content. Likewise, suppression is associated with neither positive nor negative emotions (Uphill et al., 2012).

In Study 2, we compared a four-factor alternative model with the five-factor structure model by forcing mastery and affect imagery items onto a single MG imagery factor. The resulting four-factor model showed a poorer model fit than the five-factor model, thereby suggesting that MG is best explained when separated into the two specific components of mastery and affect imagery. We confirmed our five-factor SIAQ-J, initially developed through EFA, in a separate large participant sample using CFA. Moreover, in Study 2, we confirmed gender invariance on the SIAQ-J and showed through a MANOVA that the SIAQ-

J could distinguish athletes based on competitive level, gender, sport type and years of experience.

This newly formed SIAQ-J provided good psychometric properties for evaluating imagery ability. We demonstrated satisfactory convergent and discriminant construct validity and showed through MANOVA that the SIAQ-J distinguished among athletes of different competitive levels. The detailed examination of the tests of between-subject effects revealed that the competitive level was significantly related to skill strategy, goal and mastery, and slightly nonsignificant differences were found for affect imagery. Overall, the multiple comparisons results revealed a similar pattern of differences across competitive levels. Among the athletes with experience in regular competition, the higher the competitive level, the greater the imagery ability. This finding is consistent with existing literature (Budnik-Przybylska & Karasiewicz, 2020; Murphy et al., 2008; Roberts et al., 2008; Williams & Cumming, 2011). For goal imagery alone, the mean score at level 5 was higher than that at level 4. Although goal setting can indicate the degree of performance improvement (Locke & Latham, 2002, 2013), notably, in this study, level 5 athletes without experience participating in regular competitions showed greater imagery ability than level 4 athletes with regular competition experience. Clarity is crucial to achieving goals (Locke, 1967), and goals should not be too difficult to achieve (Locke & Latham, 1985). Thus, achieving goals in non-regular competitions (e.g., friendly, scrimmage and practice matches) is objectively easier and clearer than in regular competitions.

We observed no significant mean differences in skill, goal, affect or mastery imagery between genders. However, a significant mean gender difference was discovered in strategy imagery, with men achieving significantly higher results than women, in opposition to our hypothesis. However, this finding is consistent with other reports that indicated gender differences in imagery ability, including with the original SIAQ (Budnik-Przybylska &

Karasiewicz, 2020, Williams & Cumming, 2011). These findings may support the theory of an evolutionary tendency for males to produce imagery of rivalry and dominance (Buss, 2015).

No significant mean differences were found in skill, goal, strategy, or mastery imagery between sport types (i.e., team or individual). However, a significant mean difference was discovered in the affect imagery, with team sports achieving significantly higher results than individual sports. Affect imagery serves moods, feelings, and emotions; it is also related to competitive anxiety (Hall et al., 1998; Williams & Cumming, 2011). This finding suggests that affect imagery can be influenced and increased by teammates. In this regard, Pluhar et al. (2019) reported that team sports participants may be less likely than individual sports participants to experience anxiety or depression.

A significant mean difference was observed in skill, goal, strategy, or mastery imagery, with imagery ability increasing with the increased duration of experience. Thus, SIAQ-J can distinguish athletes with different years of experience based on their skill, goal, strategy, or mastery imagery. However, there were no significant mean differences observed between years of experience for affect imagery, showing as the V-shaped chart. The V-shape charts were also shown at the competitive level. Athletes who have not participated in regular competitions or have limited experience in sports displayed greater affect imagery by merely participating in sports. Despite their lack of displaying skill, strategy, goal or mastery imagery, their motivation is evident when it comes to their sport through affect imagery.

To verify how the SIAQ can be practically applied to the sporting field, we hypothesised and demonstrated that greater goal clarity would positively predict SIAQ-J subscales. SEM, performed to inspect the regression weights, revealed significant paths from goal clarity to all SIAQ-J subscales. Thus, goal clarity could help athletes increase the ease with which they generate images related to their sport.

An intriguing consideration is how imagery ability is universal across cultures, which indicates that SIAQ offers globally applicable measurements. The result was identical with the original version of SIAQ, namely, no significant differences were observed in affect imagery in the difference in imagery ability according to the competitive level or between the five-factor structure and the original. From an international view, this study presents the same perspective on Japanese athletes' imagery ability with five types of imagery. Psychometric properties such as imagery ability should be dealt with from an international perspective because of Japanese athletes' achievements on the world stage.

Limitations and Directions for Further Research

Notably, this study has three main limitations. First, our sample was comprised of only collegiate athletes, perhaps limiting generalization of these results to other populations; future investigators might examine athletes in other age groups. Second, we have not yet established concurrent validity nor considered the amount of imagery intervention each participant had. Therefore, further research on concurrent validity testing and imagery intervention with other imagery questionnaires (e.g., SIQ) will be valuable.

Conclusion

Our newly developed SIAQ-J had good psychometric properties for assessing imagery ability. The newly identified five structures for the SIAQ-J need to be highlighted. Using this measure of five types of imagery ability will enhance further research on Japanese athletes. For example, the SIAQ-J can support researchers in developing the most effective imagery training program or imagery intervention methods for Japanese athletes. Researchers can further expand their research on improving performance by evaluating imagery ability along with other measurements.

CHAPTER 5: THE SPORT IMAGERY INTERVENTION QUESTIONNAIRE: DEVELOPMENT AND PSYCHOMETRIC EVALUATION

Chapter 5 was initially written with the intention of being published. However, to comply with the copyright policy of certain journals, the chapter 5 has been replaced with an overview. The full manuscript is included in the appendix to avoid any potential issues with duplicate publication.

Introduction

This chapter discusses the measuring use of imagery intervention for performance improvement in athletes based of PETTLEP model.

The PETTLEP model of imagery intervention, which considers the physical, environment, task, timing, learning, emotion, and perspective, is presented as a framework for effective imagery intervention (Holmes and Collins, 2001). The PETTLEP model is based on the theoretical premise that imagery and performance have certain related neural activities and that these predicted similarities allow for performance development (Wakefield et al., 2013). Several studies have shown that PETTLEP intervention can improve sports performance (Morone et al., 2022), but such interventions have been mainly conducted using "imagery scripts" in which the researcher instructs or encourages the participants to perform imagery interventions contextually. A questionnaire is proposed as a highly practical way to collect data from a large population within a short period with interpretable and generalizable results, which can measure imagery ability and imagery used. The usefulness of the PETTLEP model has led to the proposal of developing an imagery intervention questionnaire.

Pilot Study- Instrument Development

Pilot study focused on developing the Sport Imagery Intervention Questionnaire (SIIQ), which evaluates how frequently the imagery elements of PETTLEP intentionally intervene in an individual's sport. The study aimed to identify a suitable pool of items for the SIIQ through various analytical steps to examine the psychometric properties of the items.

After developing 38 items based on the definition of each element of the PETTLEP imagery intervention model, 366 college athletes responded to a survey. Despite the PETTLEP imagery intervention model having seven components, exploratory factor analysis

(EFA) identified 10-factor structure (The timing element is divided into three categories: fast, slow, and real-time. Additionally, the perspective element includes both first-person and third-person perspectives). The study also ensured content validation, satisfactory item characteristics, factorial validity, and internal consistency. However, some factors had an insufficient number of items, which necessitated modifications for the further studies.

Study 1- Confirmatory Factor Analysis and Group Differences

The goal of Study 1 was to determine the 10-factor structure of the 35-item SIIQ through confirmatory factor analysis (CFA). The primary concerns included Convergent and Discriminant Construct Validity. The SIIQ was utilized to investigate potential variations in imagery intervention based on group differences such as gender, sport, subjective performance level, and years of experience.

442 collegiate athletes responded 35-item SIIQ to a survey. This 35-item SIIQ has been modified based on the results of previous studies. As the results of CFA, the 10-factor structure of the 35-item SIIQ demonstrated good convergent and discriminant construct validity. Significant mean differences were found in SIIQ subscales for subjective performance, experience duration, and sport type. Athletes with higher perceived performance levels used more intentional imagery intervention. However, the mean scores of SIIQ did not show any significant differences between genders

Study 2- CFA and Relation with Imagery Ability

Study 2 aimed to confirm the validity and reliability of the 35-item SIIQ through further assessment by recruiting a new group of participants, as well as investigate the relationship between the SIIQ and athletes' experience with imagery intervention, and the concurrent validity between the SIIQ and another questionnaire (SIAQ) was tested.

A total of 378 collegiate athletes responded to the 35-Item SIIQ, which was the same version used in Study 1. The 35-item, 10-factor structure of the SIIQ demonstrated good model fit and convergent validity through CFA.

The SIIQ scores of experienced athletes in implementing imagery intervention were higher than those of inexperienced athletes, indicating the questionnaire's appropriateness. The SIIQ demonstrated reliable test-retest results and a moderate correlation with the SIAQ, which measures imagery ability, indicating that imagery intervention and image ability are distinct concepts. Furthermore, SIIQ's imagery intervention was found to positively predict SIAQ's imagery ability.

Discussion and conclusion of all 3 studies

This three-part study developed and validated the Sport Imagery Intervention Questionnaire (SIIQ) with 10 structures to assess the use of intentional imagery interventions in sports, based on the PETTLEP framework. The results of the study showed good reliability and validity of the SIIQ. Group differences were observed for subjective performance, experience duration, and sport type, while emotion subscale was affected by years of experience. The SIIQ can distinguish athletes of different groups and predict athletes' subjectively perceived performance levels. The timing-slow subscale was significantly higher in team sports than individual sports. The SIIQ showed moderate correlation with the Sport Imagery Ability Questionnaire (SIAQ), indicating that both questionnaires measure sport-specific imagery but do not assess the same constructs. Overall, the SIIQ is a comprehensive tool for evaluating 10 types of imagery interventions in sports.

CHAPTER 6: GENERAL DISCUSSION

The primary goal of this study was twofold. First, it aimed to extend the existing research on an individual's ability to generate and control vivid images, also referred to as imagery ability. Second, the frequency of experience with effective imagery was assessed using intentional imagery intervention.

This research aims to improve our understanding of the impact of imagery in sports. Given that imagery is a trainable skill that can be improved with appropriate interventions, it is important to ensure reliable and valid assessments for measuring imagery. The findings from this study could lead to more targeted and effective strategy for using imagery to enhance athletic performance.

Summary of Result

Chapter 4

In this two-part study, we developed a Japanese version of the SIAQ, a tool for assessing mental imagery ability in sports. Our adapted version (SIAQ-J) consists of five structures and is a comprehensive assessment tool for evaluating five types of mental imagery in sports. Our study showed that the SIAQ-J had the same factor structure as the original SIAQ (Williams & Cumming, 2011) and provided preliminary psychometric support. However, our SIAQ-J differed from the previous four-factor Japanese adaptation in that it included affect imagery (Aikawa et al., 2019), which was previously absent due to cross-loading issues. We also found that mastery and affected imagery should be separated into two distinct components (Hall et al., 1998; Williams & Cumming, 2011). We gender invariance on the SIAQ-J and demonstrated that the tool could distinguish athletes based on competitive level, gender, sports type, and years of experience. We found no significant gender differences in skill, goal, affect, or mastery imagery. However, a significant mean gender difference in strategy imagery was discovered, with males outperforming females, which is consistent with other reports indicating gender differences in imagery ability. We also found that team sports outperformed individual sports in affect imagery, implying that teammates can influence and increase affect imagery. Overall, our research found that the SIAQ-J has good psychometric properties for assessing imagery ability in Japanese athletes.

The strength of research

The translated and developed Japanese version of the Sports Image Competency Questionnaire (SIAQ-J) has the following advantages:

Comprehensive imagery ability assessment: The SIAQ-J is a comprehensive tool for evaluating five different types of mental imagery in sports, providing a comprehensive assessment of imagery ability.

Psychometric support: The study provided preliminary psychometric support for the adapted measure, demonstrating satisfactory convergent and discriminant construct validity.

Same factor structure as the original: The translated version of the SIAQ-J has the same factor structure as the original English version, which has been previously found to be appropriate in other language versions as well.

The inclusion of affect imagery: The SIAQ-J includes affect imagery, which is related to moods, feelings, and competitive anxiety. The inclusion of this type of imagery in the assessment of cognitive anxiety is important because it allows for a more comprehensive evaluation of an athlete’s emotional state.

Gender invariance: The SIAQ-J showed gender invariance, indicating that the tool can be used to assess imagery ability in both male and female athletes.

Distinguishes athletes based on competitive level, gender, sport type, and years of experience: The SIAQ-J can distinguish athletes based on their competitive level, gender, sport type, and years of experience, providing valuable insights for coaches and trainers.

Objective measurement of performance improvement: The SIAQ-J can be used to measure the degree of performance improvement, especially in goal setting, which is crucial in achieving clarity and setting achievable goals.

Influenced by teammates: Teammates influence and increase affect imagery, implying that the tool can be used to evaluate the impact of team dynamics on an athlete’s emotional state.

Overall, the SIAQ-J is a valuable tool for assessing an athlete’s imagery ability and improving performance, providing insights for coaches and trainers to enhance an athlete’s performance.

Chapter 5

The sport Imagery Intervention Questionnaire (SIIQ) was developed to assess the effectiveness of intentional imagery interventions in sports. Physical, environment, task, timing-real, timing-fast, timing-slow, learning, emotion, third-person perspective, and first-person perspective are the ten structures of the SIIQ. The study established the questionnaire's validity and reliability and provided preliminary psychometric support. Holmes and Collins's (2001) PETTLEP model was used as a framework to evaluate imagery interventions as the SIIQ, and it was found that the timing element could be divided into timing-real, timing-slow, and timing-fast, while the perspective element could be divided into perspective-third-person and perspective-first-person. The study showed that the ten-factor model provided a better fit than the seven-factor model, indicating that the subscales are independent measures of different contents. The SIIQ demonstrated satisfactory convergent and discriminant construct validity and was able to differentiate between athletes of different groups based on subjective performance, duration of experience, and sport types. The study also found that athletes with higher subjectively perceived performance levels intentionally used more imagery intervention than those with lower ratings.

In Chapter 5, regression analysis was used to examine the relationship between imagery intervention (SIIQ) and imagery ability (SIAQ). The primary aim of this investigation was to suggest how the SIIQ can be applied in sports. To accomplish this, regression analysis was performed using SIIQ and SIAQ. Stepwise regression was used to select predictor variables and determine which SIIQ subscales positively predict imagery ability (SIAQ). Ten subscales of SIIQ were designated as independent variables, and one of the five SIAQ subscales was designated as the dependent variable.

The study found that specific SIIQ subscales, as measured by the SIAQ, positively predicted all five imagery ability contents, including skill imagery, strategy imagery, goal imagery, affect imagery, and mastery imagery.

Specifically, task and timing-slow predicted skill imagery ability, while timing-fast and learning predicted strategy imagery ability, emotion and first-person perspective predicted goal imagery ability, learning and third-person perspective predicted affect imagery ability, and third-person perspective, timing-fast, and first-person perspective predicted mastery imagery ability.

Interestingly, physical, environment, and timing-real did not predict imagery ability. This finding supports previous research indicating that physical and environmental factors do not influence imagery ability. When physical and environmental factors were combined, imagery ability (SIAQ) was positively predicted (Anuar, Cumming, & Williams, 2017).

The strength of research

The following are the strengths of the ten-structure Sports Image Intervention Questionnaire (SIIQ) developed to measure image intervention using PETLEP:

Validity and Reliability: The main goal in developing the SIIQ was to ensure accuracy and consistency. The questionnaire has demonstrated good reliability and validity, making it an effective assessment tool for evaluating ten types of imagery intervention in sports.

Comprehensive Assessment: The SIIQ can assess the use of intentional imagery interventions in sports on ten structures including physical, environment, task, timing-real, timing-fast, timing-slow, learning, emotion, third-person perspective, and first-person perspective.

Efficacy: The PETTLEP model has been shown to be effective in improving sport performance when used as a framework for the effective execution of imagery interventions, making SIIQ a reliable measure of the effectiveness of imagery interventions.

Differentiated factors: The timing element was divided into three factors: timing-real, timing-slow, and timing-fast, whereas the perspective element was divided into two factors: perspective-third-person and perspective-first-person. This provides a more differentiated and detailed measurement of imagery intervention.

Discrimination among groups: The SIIQ distinguished among athletes of various groups, which included subjective performance, the duration of experience, and sport types. This information can help coaches and trainers to tailor the use of imagery interventions to specific groups.

Predictive value: The SIIQ is a useful tool for assessing an individual's motivation, engagement, and satisfaction with their athletic pursuits because it can predict subjectively perceived performance levels in athletes. Furthermore, several SIIQ subscales positively predicted SIAQ.

Correlation with other measures: The correlation analysis between SIIQ and SIAQ establishes concurrent validity, demonstrating that the SIIQ is a valid measure of the effectiveness of imagery interventions.

Limitations and Directions for Further Research

This study has limitations in terms of the population sample. Specifically, the sample population was limited to collegiate athletes, which may restrict the generalizability of the results to populations with varying levels of physical activity ability and age. This is especially important because some research indicates that the ability to generate imagery declines with age (Campos, Pérez-Fabello, & Gómez-Juncal, 2004; Mulder et al., 2007). The studies presented in this thesis predominantly focus on the use of imagery to enhance athletes' performance. The study participants, who were mostly university athletes aged 18 to 28, were chosen based on their involvement in sports clubs. Previous research indicates that athletes aged 7 to 17 years improve significantly in their imagery ability during this time (Hall & Pongrac, 1983; Wolmer, Laor, & Token, 1999). Hence, it was determined that athletes over the age of 17 should be included in the study to ensure a comprehensive representation of the target population that uses imagery in sports. Future research could benefit from a larger sample size to improve the generalizability of the findings beyond the current study's limited sample population. For instance, including athletes from various backgrounds, professions, and age groups, to enhance the applicability of the results to a more diverse population.

The study's sample population is limited to Japanese collegiate athletes, limiting the generalizability of the results to populations with cultural differences, including linguistic aspects. Although the SIAQ-J yielded similar results to the original English version of the questionnaire (SIAQ; William and Cumming, 2011) and revealed no significant cultural differences in athletes' imagery ability, it is important to note that the conclusion of SIIQ is based on the analysis of a Japanese-based questionnaire as an original. It is possible that cultural and linguistic differences influence athletes' intentional imagery intervention, and further research using multiple translated versions of the questionnaire is needed to confirm the findings.

It is important to note that language and cultural differences can have a significant impact on the validity of questionnaires used in research. As noted in Bradley's (1994) work on the translation of questionnaires for use in different languages and cultures, even small variations in wording or cultural interpretation can affect the accuracy and reliability of results. Therefore, when conducting research with a specific population, it is essential to consider the potential impact of cultural and linguistic differences and take appropriate measures to ensure the validity and reliability of the results.

SIIQ was used as a predictor for imagery ability in this study (SIAQ). However, because the SIIQ is designed with a single-item scale, subjective performance rating can have an impact on the score. Future studies should use a valid questionnaire specifically designed for this purpose to better understand the factors that may influence the SIIQ subscale.

To investigate the role of motivation in intentional imagery intervention, future research could use tools such as the Sport Motivation Scale (Pelletier et al., 1995), a widely used and validated questionnaire for assessing athletes' motivation in sports and physical activity. Researchers may gain valuable insights into how to optimize the use of mental imagery in sports training and performance by investigating how an athlete's motivation level influences their use of intentional imagery interventions. These insights could help coaches and trainers tailor their interventions to individual athletes, taking into account differences in motivation, and ultimately lead to a more effective use of imagery in enhancing athletic performance.

Conclusion

The goal of this thesis was to gain a better understanding of the role of imagery ability and imagery intervention in the use of sport-specific imagery. Self-report indicators were used in a combination of cross-sectional and experimental studies to examine imagery ability and intervention. The SIAQ-J and SIIQ questionnaires were developed and validated to provide a comprehensive representation of sport-specific imagery.

The results demonstrated that the SIAQ-J produced a five-factor structure that was identical to the original version and discriminated among athletes of varying competitive levels and years of experience. The goal clarity of the goal -setting theory was found to positively predict imagery ability as measured by SIAQ-J scores.

Based on the PETTLEP imagery intervention model, the SIIQ questionnaire established a ten-factor structure and revealed that imagery intervention varies depending on the athlete's subjective performance ratings. SIIQ scores did not differ by gender, but some factors did vary by sport type and years of experience. Furthermore, imagery intervention was found to positively predict all five subscales of imagery ability as measured by the SIAQ.

Overall, this research provided researchers with two reliable and valid questionnaires to aid in the assessment of imagery ability and imagery intervention, which will contribute to future research in this area. Although much work remains to be done, these findings represent a significant step forward in understanding the role of imagery in the use of sport-specific imagery.

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Appendix I: Original Manuscript

CHAPTER 3: TRENDS IN RESEARCH ON IMAGERY IN SPORTS SCIENCE

Abstract

This study examined 792 publications on imagery research in sports science published in 1979–2022. Data were drawn from the Web of Science database and analyzed in terms of annual publication volume, country-/region-wise distribution, and authors. The visualization software program VOSviewer was used to generate keywords co-occurrence clustering, chronology, and density views. The results revealed that the number of annual publications has steadily increased since 1979. The United States, England, and Canada have contributed the most publications. Hall C. has authored the most publications and is the most cited author. The most cited paper was by Jackson et al. (2001). Further, imagery research in sports science has contributed to cognitive psychological, neuropsychological, neurophysiological, neurorehabilitation, motor learning, motor control, and other fields. Keyword analysis revealed that 97 keywords that occurred >12 times were divided into four clusters, indicating that imagery research in sports science has been conducted in various aspects.

Keywords: sport imagery, motor imagery, mental imagery, bibliometric analysis, co-occurrence analysis

Introduction

Sport psychologists define imagery as a simulation of real experiences that creates or recreates by combining the use of various sensory modalities in the absence of perception to shape relevant information into meaningful images (Cumming & Ramsey, 2008; Weinberg & Gould, 2023). Following the initial hypothesis of imagery proposed by Carpenter in 1894 (cited in Hale, 1982), research has progressed to account for the effect of imagery on various aspects of cognition, affect, and behavior. For example, psychoneuromuscular theory (Carpenter, 1894; Jacobson, 1931; Washburn, 1916), symbolic learning theory (Sackett, 1934) bioinformational theory (Lang, 1977, 1979), triple-code model (Ashen, 1984), and Paivio's (1985) framework have been generated explicitly to explain why imagery may benefit motor performance (for a review, see Martin et al., 1999).

Importantly, imagery resembles genuine experience in terms of neural and behavioral similarities (Cumming & Williams, 2012). According to Holmes and Collins (2001), effective imagery intervention depends on how well the same brain areas are activated. This functional relationship enables researchers to investigate covert motor processes that are critical in everyday life, such as anticipating the effects of an action, planning or intending to move, learning or relearning motor skills, or remembering an action (Jeannerod, 1995).

In sports science, imagery research has focused largely on the role of performance enhancement, where applied domains include sport psychology and neurology-based models (MacIntyre et al., 2018). For example, elite archers' beta waves stabilized and vibration frequency decreased after neurofeedback imagery training (Kim & Chang, 2020). Williams and Cumming (2011) measured individual ability to generate imagery in sports settings, and Jiang et al. (2017) found that small voluntary muscle contractions combined with motor imagery showed greater strength improvements compared with instances without motor imagery. Due to its wide applicability and effects, imagery is considered in sports science to be a cognitive process that is fundamental to motor learning and performance improvement (Williams & Cumming, 2011), and as such, it is involved in numerous aspects of psychological preparation, including skill rehearsal, pre-competition routine, problem solving, strategy development, and dealing with injuries and pain (Ruiz et al., 2019).

To understand the current trends in imagery research, bibliographic analysis (e.g., co-occurrence analysis of research keywords) can be useful. In recent years, bibliometric research has attracted much attention for providing a thorough overview of the published literature as well as identifying research boundaries and future research trends (Liu et al., 2021; Shawahna, 2021; Yu et al., 2021). Bibliometrics analysis enables qualitative and quantitative assessments of particular study fields via the use of mathematical and statistical approaches to comprehend the knowledge structure and investigate development patterns (Bornmann & Leydesdorff, 2014).

This paper focuses on publications that examine imagery from various perspectives in sports science. Bibliographic analysis is applied to provide an in-depth understanding of the research trends, as well as informetrics and scientometrics, which are used for quantitative analysis and mapping of research in scholarly literature to provide systematic and meta-analytic reviews from leading research groups and scientists.

Materials and Methods

Bibliometric Analysis

Bibliometric analysis is a well-known, rigorous technique for analyzing vast quantities of scientific data as it allows researchers to deconstruct the evolutionary nuances of a specific field and shed light on emerging areas of study (Donthu et al., 2021b). It can be used for several purposes, including not only identifying the trends in article and journal performance but also investigating collaboration patterns, research constituents, and the intellectual structure of a specific domain in the existing literature (Donthu et al., 2021a, 2021c; Verma & Gustafsson, 2020). Both performance analysis and science mapping are examples of representative bibliometric analysis techniques. Performance analysis considers the contributions of research constituents such as countries, authors, journals, and institutions, whereas science mapping focuses on the relationships among research constituents such as co-citation analysis, citation analysis, co-word analysis, co-authorship analysis, and bibliographic coupling (Donthu et al., 2021b). Such analyses are useful in presenting the bibliometric and intellectual structure of the research area when combined with network analysis (Baker et al., 2020; Tunger & Eulerich, 2018).

For data analysis, this study used VOSviewer, a software program developed specifically for analyzing and visualizing bibliometric networks. It can be used to create networks of scientific publications, scientific journals, researchers, research organizations, countries, keywords, and terms. The nodes in these networks may be linked via co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation (Van Eck & Waltman, 2022).

Data Sources

Information on publications was collected from the Web of Science (WoS). The WoS is a high-quality digital database that has gained widespread acceptance among researchers globally and has evolved into a common tool for retrieving and evaluating various types of publications (Thelwall, 2008).

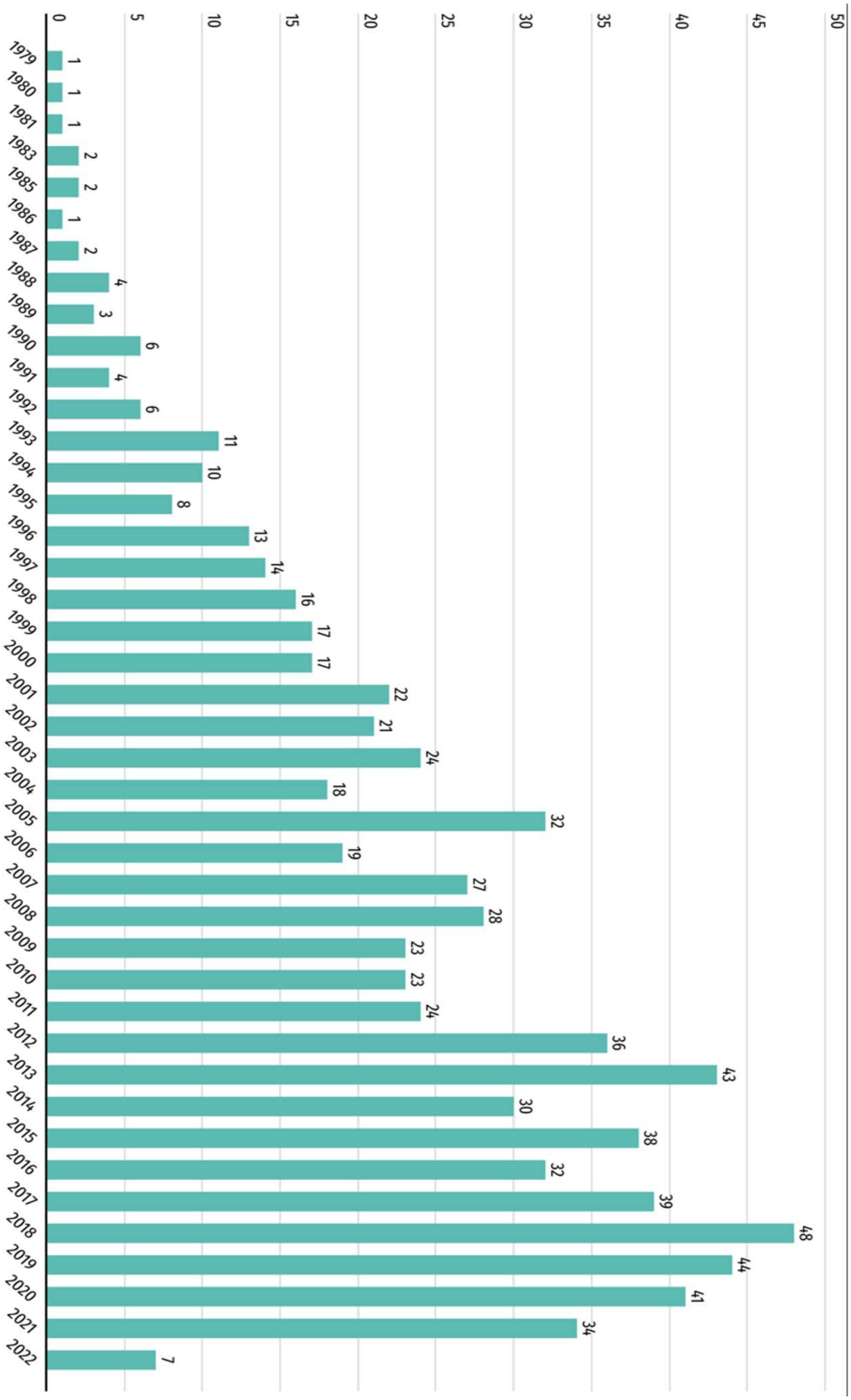
A search for the keyword “imagery” in all fields from inception to May 4, 2022, showed a total of 90,272 publications. These were filtered by “categories = sport sciences,” yielding 1,031 results. Next, the filters “document types = articles or reviews” and “languages = English” were applied, which generated a unique database of 792 publications. The database was analyzed using the built-in tools of WoS and VOSviewer (version 1.6.18).

Results

Trends in Global Publication

Figure 1 shows the distribution of publications by year (1979–2022) obtained using a built-in analysis tool in WoS. In 1993, the number of annual publications exceeded 10. Since then, this number has increased steadily, resulting in a rapid rise in the cumulative number of publications. The number of annual publications surpassed 30 for the first time in 2005, and from 2012 to 2021, more than 30 documents have been published each year. The average number of publications during this decade reached 38.5. The most documents were published in 2018 (48), which is twice as much as in 2003 (24). Overall, the results indicate that interest in imagery research is increasing.

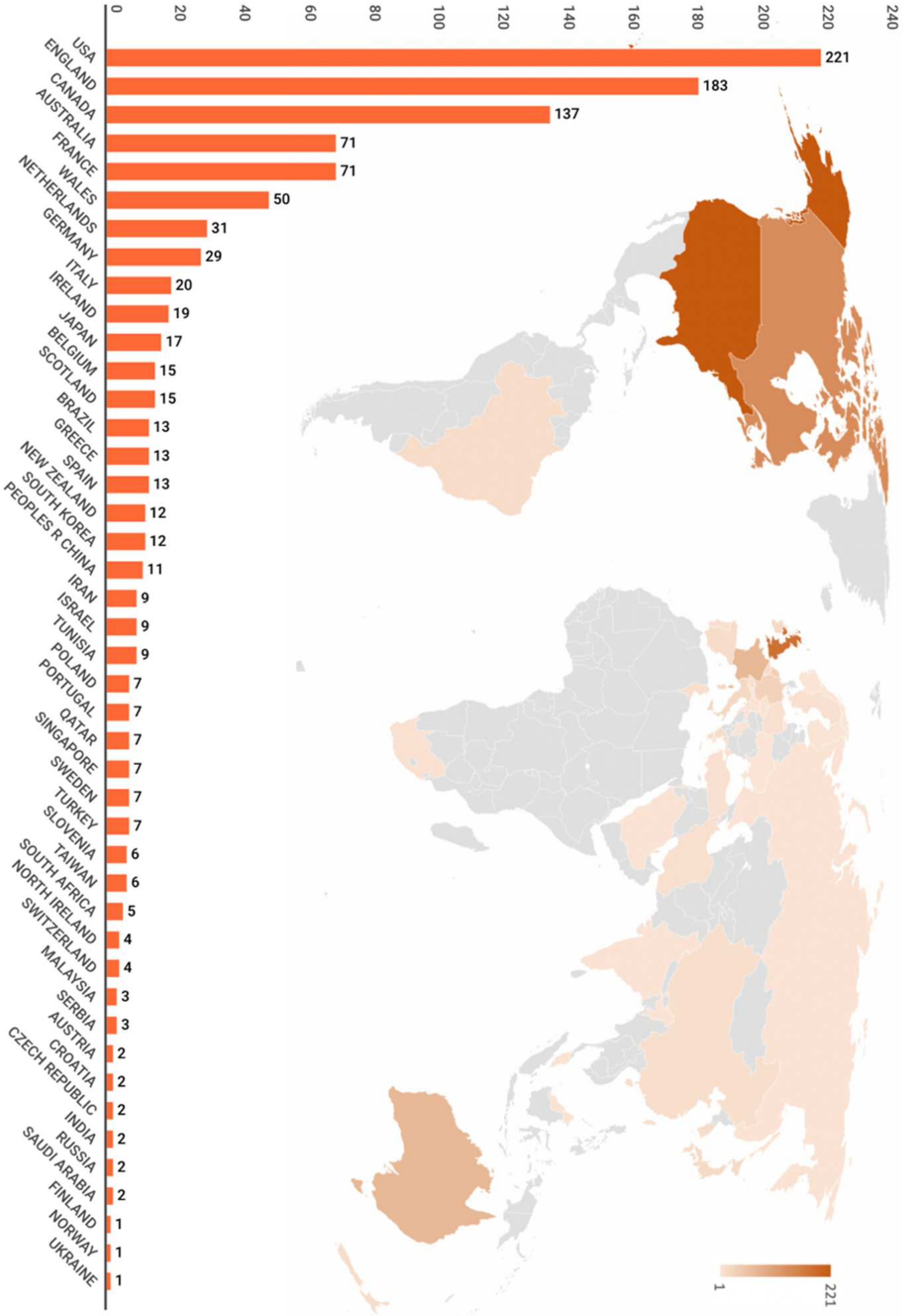
Figure 1. Publication output by year, 1979–2022



Distribution by Country/Region

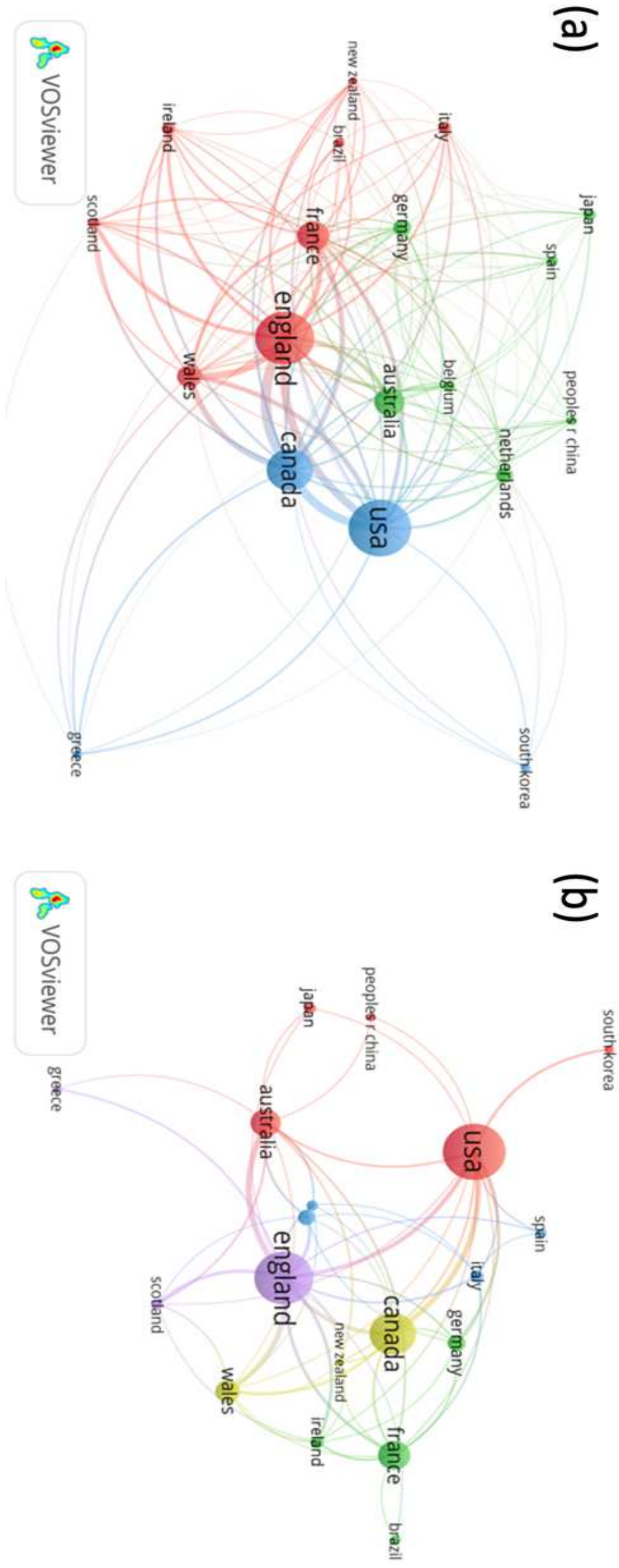
Using WoS, 44 countries or regions that contributed publications in imagery research in sports science were identified, and the distribution is shown in Figure 2. The United States, England, and Canada have published approximately 68% of the global publications, indicating that these three countries are key players in imagery research in sports science. The United States contributed the most publications (221; 27.9% of all publications), followed by England (183; 23.1%) and Canada (137; 17.3%), More than 10 documents were published in the top 19 countries or regions.

Figure 2. A world map based on the number of publications in each country/region



In addition, the VOSviewer revealed that the United States, England, and Canada have a strong citation/cooperation relationship with each other. Figure 3a shows the citation relationship of countries/regions with more than 10 publications from 18 countries (link strength; United States and England = 330, United States and Canada = 386, England and Canada = 499, and total link strength = 3634). Figure 3b shows the co-authorship of countries/regions with more than 10 publications from 18 countries (link strength; United States and England = 16.50, England and Canada = 11.50, United States and Canada = 9.17, and total link strength = 176.00). The closer two countries are in VOSviewer, the better their relationship, and the thicker the line, the stronger the connection between the two countries.

Figure 3. (a) Citation relationships of countries/regions with over 10 publications; **(b)** Co-authorship of countries/regions with over 10 publications



Influential Authors

There were 2,132 authors who contributed 792 publications on imagery research in sports science. Regarding the quantity of publications, Hall C. contributed the most (62 publications), followed by Cumming J. (35), Munroe-Chandler K. (20), Guillot A. (18), and Collet C. (14). Among the top 10 authors, each published at least 10 papers. With respect to the number of citations, Hall C. was cited the most (2,432), followed by Cumming J. (1,006), Hardy I. (842), Callow N. (709), and Collins D. (658).

As for the most influential works, Jackson et al. (2001) has the highest citation count (335), followed by Holmes and Collins (2001) and Fabre (2002) (Table 1). Remarkably, Guillot A. and Hall C. were ranked in all three lists for author by documents, author by citation, and document by citation. Guillot and Collet (2005) discussed the relationship between complex motor skills and motor imagery duration, whereas Hall (1998) suggested measures for the five functions of imagery type.

Table 1. The 10 most influential authors and papers

Rank	Author by documents	Publications
1	Hall C.	62
2	Cumming J.	35
3	Munroe-chandler K.	20
4	Guillot A.	18
5	Collet C.	14
6	Callow N.	13
6	Williams S.E.	13
7	Collins D.	12
8	Hardy L.	10
8	Moseley G.L.	10
Rank	**Author by Citation**	**Citations**
1	Hall C.	2432
2	Cumming J.	1006
3	Hardy I.	842
4	Callow N.	709
5	Collins D.	658
6	Holmes P.	632
7	Malouin F.	616
8	Guillot A.	600
9	Doyon J.	558
10	Collet C.	541
Rank	**Document by citation**	**Citations**
1	Jackson et al. (2001)	335
2	Holmes & Collins (2001)	296
3	Fabre et al. (2002)	281
4	Yavuzer et al. (2008)	275
5	Martin et al. (1999)	248
6	Stevens & Stoykov (2003)	243
7	Abbott & Collins (2004)	226
8	Guillot & Collet (2005)	193
9	Hall et al. (1998)	186
10	Liu et al. (2004)	185

Publication Sources: Journals

The publications appeared in 90 journals. Table 2 lists the top 10 journals ranked in two categories: source by documents (number of publications) and source by citation (number of citations). The Sport Psychologist featured the most publications in imagery research in sports science (80), followed by the Journal of Applied Sport Psychology (71), Psychology of Sport and Exercise (57), and Human Movement Science (45). The source with the most citations was the Archives of Physical Medicine and Rehabilitation, which had 2,953 citations, followed by The Sport Psychologist (2,521), Journal of Applied Sport Psychology (2,096), Journal of Sport and Exercise Psychology (1,469), and Journal of Sports Sciences (1,406).

The aim and scope of each source in Table 2 was searched through SCIMAGOJR (https://www.scimagojr.com) to extract what each source was trying to contribute. A brief description is as follows: The Sport Psychologist (sport psychological support to athletes and coaches), Journal of Applied Sport Psychology (psychological theory and intervention strategies in sport psychology), Psychology of Sport and Exercise (broadly defined psychology of sport and exercise), Human Movement Science (psychological, biomechanical, neurophysiological research on the control, organization, and learning of human movement, and perceptual support of movement and rehabilitation), Archives of Physical Medicine and Rehabilitation (physical medicine and rehabilitation), Journal of Motor Behavior (neurophysiological, biomechanical, electrophysiological, psychological, mathematical and physical, and clinical approaches), Journal of Sports Sciences (physical activity, health and exercise, physiology and nutrition, sport and exercise psychology, sports medicine and biomechanics, and sports performance), International Journal of Sport Psychology (motor learning and control, cognition, health and exercise, social psychology, intervention clinical, and counseling psychology), Journal of Sport and Exercise Psychology (social, clinical, developmental, and experimental psychology, psychobiology and personality, and motor control processes), Research Quarterly for Exercise and Sport (human movement), and Sport Medicine (sports medicine, injury prevention, clinical medicine, rehabilitation, treatment, and physiological and biomechanical principles to specific sports).

Table 2. Top 10 sources by documents and citations ranked for journals

Rank	Source by Documents	Publications
1	*The Sport Psychologist*	80
2	*Journal of Applied Sport Psychology*	71
3	*Psychology of Sport and Exercise*	57
4	*Human Movement Science*	45
5	*Archives of Physical Medicine and Rehabilitation*	42
6	*Journal of Motor Behavior*	42
7	*Journal of Sports Sciences*	41
8	*International Journal of Sport Psychology*	39
9	*Journal of Sport and Exercise Psychology*	35
10	*Research Quarterly for Exercise and Sport*	35
Rank	**Source by Citation**	**Citations**
1	*Archives of Physical Medicine and Rehabilitation*	2953
2	*The Sport Psychologist*	2521
3	*Journal of Applied Sport Psychology*	2096
4	*Journal of Sport and Exercise Psychology*	1469
5	*Journal of Sports Sciences*	1406
6	*Psychology of Sport and Exercise*	1252
7	*Human Movement Science*	1150
8	*Journal of Motor Behavior*	1053
9	*International Journal of Sport Psychology*	682
10	*Sport Medicine*	613

Co-occurrence Analysis of Keywords

The analysis of keywords occurrence concurrently produces a network of subjects and their connections that reflect the intellectual space of a field (Cancino et al., 2017; Martínez-López et al., 2018). The size of the circle indicates the importance of the elements in the graphical display, and the network connections determine the elements that are most closely related; further, the arrangement of circles (nodes) and colors allows the elements to be grouped (Ahmad et al., 2021).

Using VOSviewer, we identified 2,681 keywords in the research publications. To develop a suitable number of clusters, the minimum number of keyword occurrences was set to 12 (Ahmi, 2021), and 97 keywords met this threshold. Four clusters were discovered (Table 3) and in network visualization, each cluster is represented in a different color on the graphical display (Figure 4a). In Figure 4b, the colors in the overlay show the average publication year of the keywords. Figure 4c shows the density visualization displaying the exact keywords identified, mapped by frequency of appearance.

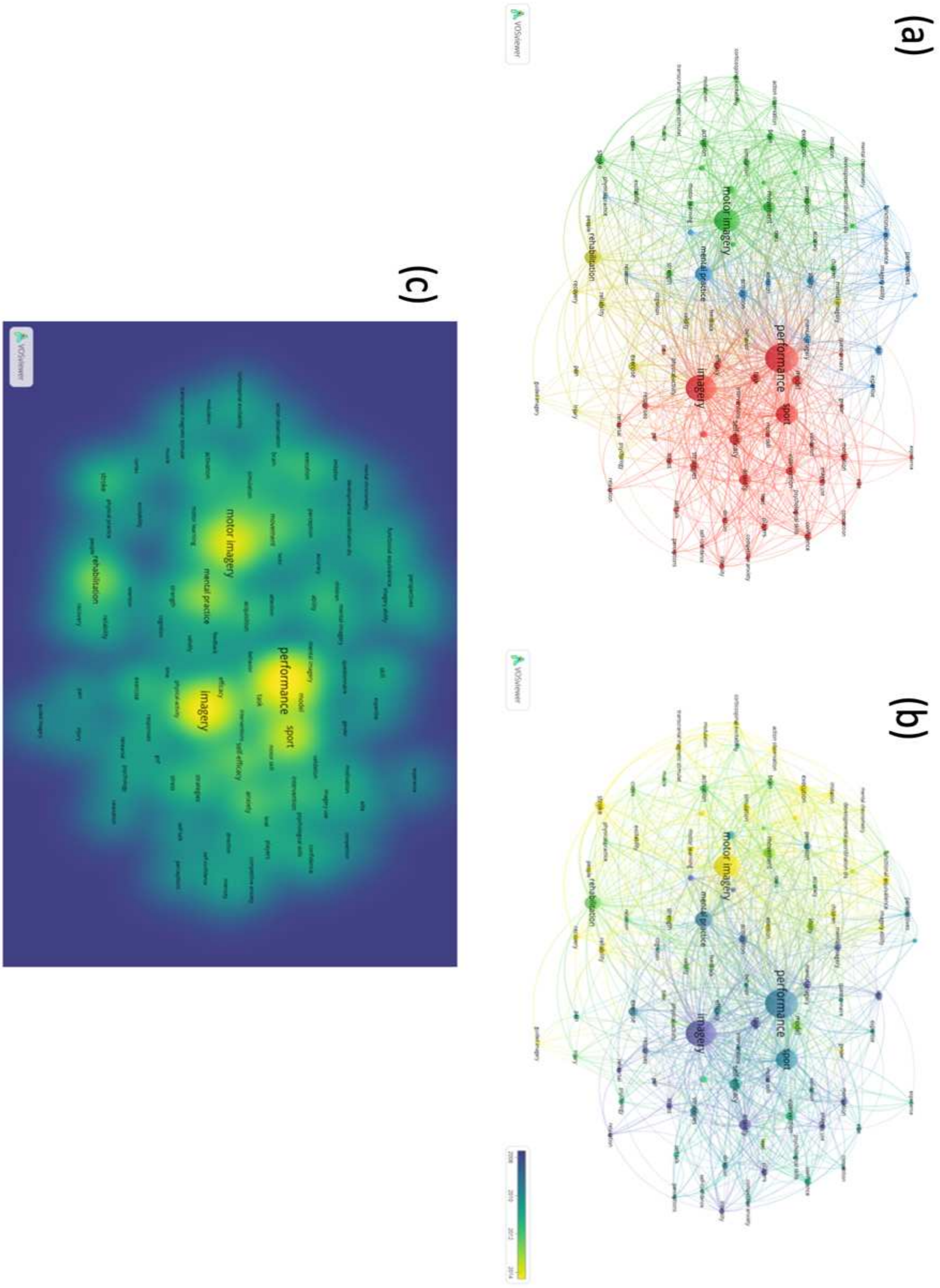
Based on the keyword analysis, the existing imagery research was found to focus on four orientations. Cluster 1 in red (37 items) shows that the most common research keywords were “performance,” “imagery,” and “sports.” This indicates that research has been conducted on revealing the relationship between athletes’ performance and imagery. Then, in Cluster 2 in green (30 items), the most common research keywords were “motor imagery” and “movement.” This cluster contains studies on human movement such as motor learning and development, including approaches that relate to neuropsychology and neurophysiology.

In Cluster 3, represented in blue, “mental practice” was the most common keyword. It is presumed that studies on mental practice were conducted using an imagery approach, that is, imagery training to improve imagery ability. Next, in Cluster 4, shown in yellow, the keyword “rehabilitation” occurred most frequently. This cluster includes clinical and medical studies on injury, pain, and recovery through an imagery approach.

Table 3. Four Clusters of Keywords Identified through Co-occurrence Analysis

Cluster	Keywords	Items
Cluster 1	anxiety, competition, competitive anxiety, confidence, direction, efficacy, elite, experience, gender, golf, imagery, imagery use, intensity, intervention, interventions, level, model, motivation, motor skill, perceptions, performance, players, psychological skills, questionnaire, rehearsal, relaxation, responses, self-confidence, self-efficacy, self-talk, sport, sport psychology, strategies, stress, task, time, validation	37
Cluster 2	accuracy, action observation, activation, brain, children, cortex, corticospinal excitability, developmental coordination disorder, excitability, execution, facilitation, imitation, mechanisms, mental chronometry, mental rotation, modulation, motor, motor imagery, motor learning, movement, movements, muscle, perception, representation, representations, simulation, strength, stroke, tasks, transcranial magnetic	30
Cluster 3	ability, acquisition, attention, expertise, functional equivalence, imagery ability, kinesthetic imagery, memory, mental imagery, mental practice, movement imagery, perspectives, physical practice, retention, skill	15
Cluster 4	behavior, cognition, exercise, feedback, guided imagery, injury, mental imagery, pain, people, physical activity, psychology, recovery, rehabilitation, reliability, validity	15

Figure 4. (a) Network visualization: four clusters of keywords; **(b)** Average publication year of keywords; **(c)** Density visualization: keywords mapped by frequency of appearance



Discussion

This study presents an overview of research trends as well as useful insights into imagery research in sports science area using bibliometric analysis. Imagery research has been steadily increasing over the past 42 years (1979–2022), and more than 30 documents on the topic have been published each year in the past decade. The United States, England, and Canada have published approximately 68% of these publications. To increase global publication and interest, it will be important to facilitate international cooperation between key players and other nations. Regarding these three key players, it would be difficult to conclude that this is because they are all English-speaking countries. Rather, from the beginning, the United States, England, and Canada have been interested in imagery research in sports science. Orlick and Partington (1988) reported that 99% of 235 Canadian athletes in the 1984 Olympics said they had used systematic and planned imagery training. United States athletes who participated in the 1988 Seoul Olympics also reported that they used imagery in their mental training program (Gould et al., 1989). In addition, Biddle (1989) asserted that mental practice/imagery is a popular topic with relevance to both sport psychology and motor learning in the British Association of Sports Sciences in 1983–1987. Thus, the research interest of the three countries is clearly established. Other countries and regions are also seeking to join the conversation on imagery research. For example, researchers from various countries worked on cross-cultural adaptation of the Sports Imagery Ability questionnaire in nine languages of 11 adaptation versions. One of the many advantages of international scientific cooperation is that it facilitates the exchange of knowledge, data, and methods, all of which can help expand current practices. However, most adapted versions were not written in English. Although English-speaking countries are the key players in the field of imagery research, in certain research fields, there are more annual publications in non-English-speaking countries than in English-speaking countries or regions (i.e., Huang et al., 2021; Wang et al., 2021).

Overall, the results indicate an increasing interest in imagery research. In particular, the 10 most cited papers (documents by citation) in Table 1 (Most Influential Authors, Papers) have intensive distribution in the middle of Figure 1, which can be called the mid-term (1995–2008). Jackson et al. (2001) proposed to highlight the importance of motor imagery as a mental practice and to encourage more research on this type of training in the rehabilitation of people with brain-caused motor problems base on similarities between executed and imagined actions. Holmes and Collins (2001) proposed a seven-point checklist based on evidence of imagery delivery. This checklist outlines the minimum requirements for areas where sport psychologists should monitor the equivalence to the physical task to improve the effectiveness of their practice for athletes. Fabre et al. (2002) found that aerobic and mental training both improved cognitive functions, but combined training was more effective than either technique alone. Yavuzer et al. (2008) have proven that in the treatment of hemiparesis with mirror therapy, motor imager has improved hand functioning by providing visual feedback on the performance of imagined actions. Martin et al. (1999) examined athletes' imagery use in an applied model for sport. The model considers sport situation, imagery type, and imagery ability as factors influencing how imagery affects an athlete. Imagery affects skill and strategy learning and performance, cognitive modification, and arousal and anxiety regulation. Stevens and Stoykov (2003) demonstrated the potential for using motor imagery as a cognitive strategy for functional recovery from hemiparesis.

Abbott and Collins (2004) suggested multidimensional talent development guidelines including imagery and adopted effective and controllable imagery to help children with the psychological factors involved in training for a sport. Guillot and Collet (2005) reviewed research on mental movement simulation. In movements that are automatic or repetitive, actual and motor imagery (MI) durations are related. Hall et al. (1998) attempted to measure imagery using the Sport Imagery Questionnaire. Athletes of a higher competitive level displayed greater imagery use and ability compared with those competing at a lower level. Liu et al. (2004) suggested that people who have had an acute stroke can use mental imagery to relearn how to perform daily tasks. As a mid-term research, the abovementioned 10 most cited papers represent imagery research in the field of sports leading to follow-up studies of practical imagery research to present studies. In a broadly defined sport, research subjects were not limited to improving the performance of athletes; they promoted the improvement of functionality in the elderly, children, and those with brain diseases. This underscores the wide applicability of imagery.

Imagery is being studied in numerous fields due to its wide application and ability to highlight underlying mechanisms (Lotze & Halsband, 2006; Munzert et al., 2009; Murphy & Martin, 2002; Williams & Cumming, 2011).

This could be proved by reviewing publication sources. The aim and scope of each source of imagery study has been analyzed from several perspectives and contributes to numerous fields such as cognitive psychological, neuropsychological, neurophysiological, neurorehabilitation, motor learning, motor control, and neurological physical therapy. In addition, the co-occurrence analysis of keywords findings supports that research of imagery is being published in fields in four clusters: Cluster 1 (performance, imagery, and sports), Cluster 2 (MI and movement), Cluster 3 (mental practice), and Cluster 4 (rehabilitation).

A cluster is a group of closely related nodes that each node in a network is assigned to (Van Eck & Waltman, 2022). This finding shows that imagery research in sports fields, conceptualized into four clusters, is dynamically and closely interrelated within each cluster.

In the past 42 years, imagery research in sports has shown an upward trend. Sports science has found benefits for imagery, which is the mental performance of a movement without physical execution, and this research has been undertaken and proved useful in various fields. The works examined in this study were published in various journals.

However, it is regrettable that the main publishing countries were limited. There may be differences between individuals rather than cultural differences in creating imagery. Lee and Horino (2023) argued that there is no cultural difference in how easily athletes generate imagery. Faw (2009) reported that 2.1%–2.7% of 2,500 participants claimed to have no visual imagination. Therefore, imagery as a beneficial technique for use in various domains must be addressed internationally, and cultural and personal differences between each research field should be further proven.

A limitation of this bibliometric analysis is that the database contained only 792 publications from WoS. Although WoS is considered one of the most indispensable indexes in academic publishing, it does not index all sources. Therefore, it is likely that more works have been published on imagery research in sports science; this is an issue for future investigation.

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Appendix II: Original Manuscript

CHAPTER 5: THE SPORT IMAGERY INTERVENTION QUESTIONNAIRE: DEVELOPMENT AND PSYCHOMETRIC EVALUATION

Abstract

This study examined the psychometric properties of the Sport Imagery Intervention Questionnaire (SIIQ), which was created to evaluate athletes' intentional imagery intervention based on Holmes and Collins's physical, environment, task, timing, learning, emotion, and perspective (PETTLEP) model (2001). Specifically, this research investigated the SIIQ's factor structure, gender, subjective performance level, sport type, years of experience, and relation with imagery ability (SIAQ). Although the PETTLEP model contains seven elements, pilot study found 10 exploratory factors—physical, environment, task, timing-real, timing-slow, timing-fast, learning, emotion, third-person perspective, and first-person perspective—which were verified through confirmatory factor analysis in studies 1 and 2 after the removal of problematic items. Overall, the SIIQ showed good factorial validity and temporal reliability and was able to distinguish athletes with different subjective performance ratings. No gender differences were observed in atheletes' SIIQ scores, but some factors had mean differences according to sport type and years of experience. Overall, the SIAQ subscale of all imagery abilities was positively predicted by the SIIQ subscales. These findings highlight the importance of evaluating the 10 imagery intervention factors.

Keywords: imagery, interventions, mental practice, sport psychology

Introduction

Imagery is defined as a simulation of real experiences that are recreated or created through the combination of various sensory modalities in the absence of perception to shape relevant information into a meaningful image (Cumming & Ramsey, 2008; Weinberg & Gould, 2018). It is a fundamental cognitive process in athletic motor learning and performance improvement (Williams & Cumming, 2012) that is involved in many aspects of an athlete's psychological preparation, including skill rehearsal, precompetition routine, problem-solving, strategy development, and managing injuries and pain (Ruiz et al., 2019). Several researchers (e.g., Cumming & Hall, 2002; Hall et al., 1998; Lee & Horino, 2023; Williams & Cumming, 2012) have found that athletes with a higher degree of competitiveness could use imagery more and display greater imagery ability than less competitive athletes. Evidence of the effectiveness of imagery as a performance strategy has led researchers to recommend that sports coaches and athletes incorporate imagery into their training regularly (Lu et al., 2020; Morris et al., 2005).

When delivering imagery intervention during training, trainers must consider the physical, environment, task, timing, learning, emotion, and perspective (PETTLEP) model of imagery intervention (Holmes & Collins, 2001). This model, which was developed to encourage individuals to create conditions for imagery, suggests that seven elements can be integrated into the image so that it can be experienced more effectively (Holmes & Collins, 2001): physical (e.g., body movements and implements used), environment (e.g., surroundings, competitive environment), task (e.g., skill being performed), timing (e.g., task duration), learning (e.g., updating the acquired skill or new information), emotion (e.g., the inclusion of emotions linked to performance and regulation), and perspective (e.g., point of view). Athletes who incorporate all seven components into their mental imagery practice can achieve a more vivid and realistic mental representation of their desired performance, which can positively influence their physical performance. Since Holmes and Collins's (2001) introduction of the PETTLEP model of imagery intervention, its various tenets have received much attention in applied sports psychology literature (e.g., Wakefield & Smith, 2012; Smith & Cantwell, 2008; Wright & Smith, 2007).

The model was derived from a combination of cognitive psychology, sports psychology, and neuroscience research (Smith et al., 2020) and is based on the theoretical premise that imagery and performance have certain related neural activities and that these predicted similarities allow for performance development (Wakefield et al., 2013). Holmes and Collins (2002) argued that effective imagery intervention depends on the extent to which the same brain areas are activated through imagery. This functional equivalence, in which imagery and actual executed movement are presumed to be underpinned by the same neurophysiological processes, is the foundation upon which the PETTLEP imagery model was developed and also pertains to similarities in electromyography patterns (Wakefield et al., 2013). Thus, PETTLEP interventions should be as close as possible to the execution situation and cover all of its relevant elements (Morone et al., 2022).

Functional equivalence can also be demonstrated by improvements in performance brought about by the PETTLEP imagery intervention. Morone et al. (2022) investigated extensive evidence of the application of the PETTLEP imagery intervention in sports performance based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The 12 studies in this PRISMA report observed that the PETTLEP intervention improved performance in both team sports such as soccer, netball, volleyball, field hockey, and cricket as well as individual sports such as gymnastics, table tennis, or golf. However, such interventions have been mainly conducted using "imagery scripts" in which the researcher instructs or encourages the participants to perform imagery interventions contextually and requires them to either read and listen to scripts or watch video content.

However, introducing all seven elements simultaneously may be impractical and cause an athlete to be overwhelmed (Wakefield & Smith, 2012). Hence, such research that uses imagery scripts and involves a large number of participants is considered challenging. Morone et al.’s (2022) PRISMA study reported that the 12 studies had an average of 22.6 participants.

Although PETTLEP imagery models have been proposed more than 20 years ago and have led to well-documented performance improvements until recently, scholars must understand whether such interventions can be quantitatively measured and generalized.

A questionnaire is a highly practical way to collect data from a large population within a short period with interpretable and generalizable results (Jenn, 2006). For example, the Sport Imagery Ability Questionnaire (SIAQ; Williams & Cumming, 2011) and its underlying questionnaire the Sports Imagery Questionnaire (SIQ; Hall et al., 1998) were developed based on Paivio’s (1985) imagery framework and describe the influence of imagery on human motor performance by measuring imagery ability and imagery used, respectively. The usefulness of the SIAQ’s psychometric properties has led to the development of nine language versions of the instrument (Lee & Horino, 2023). In the case of SIQ and SIAQ, Paivio (1985) originally proposed four imagery functions, but a factor analysis identified five factors. Because of the significant theoretical advances that the PETTLEP model has made for more than 20 years, whether well-established PETTLEP imagery intervention models can be developed into an imagery intervention questionnaire is worth investigating.

Holmes and Collins’s (2001) initial proposal for the PETTLEP imagery model consisted of seven elements, while the progress and prospects for studies on the model include potential factors. For example, Holmes and Collins (2001) preferred realistic timing, arguing that imagery and execution must have the same temporal characteristics.

However, O and Hall (2009) reported that athletes use slow-motion, real-time, and fast-motion imagery, which may improve their motor skills. The first-person (1PP) and third-person perspectives (3PP), also known as internal and external visual imagery, respectively, both enhance motor learning and performance depending on the individual's perceptual information (Cumming & Williams, 2012). Just as the SIQ and the SIAQ inherited and extended their theoretical frameworks (Paivio, 1985), PETTLEP-based questionnaires can validate advanced theories on the latter. As such, relevant progress and prospects must be verified to understand whether PETTLEP image intervention can be measured.

Thus, this study sought to empirically examine whether the PETTLEP-based questionnaire called the Sport Imagery Intervention Questionnaire (SIIQ) should contain a factor structure of seven or more.

Anuar et al. (2017) demonstrated the potential for developing a questionnaire based on the PETTLEP model of imagery intervention. To investigate whether imagery ability (SIAQ) is predicted by PETTLEP elements, they designed 10 items under the category "imagery framing" in an attempt to measure the frequency with which physical and environmental elements were used in imaging. Although imagery framing predicted the SIAQ subscale, physical and environmental elements were represented by a unidimensional measure. Other studies have never developed PETTLEP-based items for quantitative research. This suggests that, to achieve our research purpose, all items must be developed from the ground up.

This three-part study aimed to (a) develop the items of the SIIQ and analyze their structure based on constitutive definitions representing each element of the PETTLEP imagery model (Holmes & Collins, 2001) and reviews of sports psychology studies (Cumming & Williams, 2012; Wakefield & Smith, 2012; Wakefield et al., 2013; Anuar et al., 2017); (b) investigate whether the SIIQ can differentiate athletes based on their subjective performance level, gender, sport, and years of experience following the hypothesis that athletes with higher subjectively perceived performance would intentionally use more imagery intervention than those with lower performance because of the positive association between mental imagery and subjective performance (Nicholls et al., 2012); and (c) test the practicality of the SIIQ in the sporting field by determining whether the imagery interventions that it measures can predict sport imagery ability (SIAQ; Williams & Cumming, 2011).

Methods and Materials: Pilot Study – Instrument Development

Pilot study aimed to identify a suitable pool of items to develop the SIIQ, which evaluates the extent to which the imagery elements of PETTLEP intentionally intervene in an individual's sport. To accomplish this, various analytical steps were taken to examine the psychometric properties of the developed items. The primary concerns included (a) the content validation of individual items, (b) item characteristics, (c) factorial validity, and (d) internal consistency.

Procedures

As a first step, an item pool was developed that would form the foundation for the SIIQ, which was conceptualized as an expanded version of imagery framing (Anuar et al., 2017). The development of the initial items, which were based on a thorough literature review and the evaluation of research experts, involved 10 items on imagery framing, which provided useful information on the frequency at which physical and environmental elements were used during imaging. However, imagery framing was designed for only two of the seven PETTLEP elements (i.e., physical: "I make small movements or gestures during the imagery," and environment: "I image in the real training/competition environment"). The items for the remaining elements (i.e., task: "Imagining improving my physical performance," timing: "Imagining performing a movement or skill at roughly the same speed as it would actually be done," learning: "Imagining an acquired skill," emotion: "I control emotions while imagining," and perspective: "Imagining from the perspective of an opponent, an audience, or my coach") were formulated based on constitutive definitions of each of the seven PETTLEP elements (Holmes & Collins, 2001). In total, 38 items were designed to assess the seven types of imagery intervention content.

Ten research experts evaluated the validity of this initial item pool. To determine whether the SIIQ can be used to accurately measure imagery intervention, diagnostic content validation (DCV; Fehring, 1987) was performed at a meeting of experts including four incumbent coaches, four sports psychologists, and two sports science experts with experience in questionnaire development. During DCV, the experts rated the traits of the tested items on a scale of 1–5 (1 = not characteristic or indicator of diagnosis at all, 2 = few characteristics of diagnosis, 3 = somewhat characteristic, 4 = quite characteristic, and 5 = highly characteristic). Next, the weighted ratio for the characteristics of each item was calculated (1 = 0, 2 = 0.25, 3 = 0.50, 4 = 0.75, and 5 = 1). The scores of all 38 items ranged from 0.600 to 0.975, which satisfied our threshold criterion for discarding items (i.e., a weighted ratio of < 0.5).

Participants

In this study, a total of 366 collegiate athletes from 27 sports (180 male, 186 female) accomplished the 38-item SIIQ. Their experience ranged from 1 to 20 years (M = 9.69, SD = 4.60), and their ages ranged from 18 to 24 years (M = 20.1, SD = .85). Ethical approval was obtained, after which random convenience sampling was conducted to recruit participants at the university with which we are affiliated. Those who met the inclusion requirements were athletes who were members of the university's sports club. After being informed that participation was voluntary, they provided their consent to participate and disclosed information about their age, gender, type of sport engaged in, competitive level, and years of experience. In total, 380 questionnaires were returned, and 14 cases were eliminated from the dataset because of missing data, yielding the final sample.

Measures

The SIIQ. All 38 items of the SIIQ items sought to answer the question “In relation to your sport, have you done the following to improve your performance?” The respondents provided ratings based on a Likert-type scale ranging from 1 (not at all) to 7 (often).

Analysis

We used the Statistical Package for the Social Sciences (SPSS version 27, IBM; Chicago, IL) to perform exploratory factor analysis (EFA) and establish the underlying structure of correlations between measures for newly developed items (Frey, 2018). The Kolmogorov–Smirnov test was conducted to determine the null hypothesis that our dataset represented a normal distribution. Skewness and kurtosis calculated for the entire item set showed values ranging from 2.0 to +2.0, indicating normality (George & Mallery, 2010). We also identified the factors and factor loadings of the measured variables by performing EFA with principal axis factoring and direct oblimin rotation (Williams & Cumming, 2011). In addition, we determined the Kaiser–Meyer–Olkin (KMO) value (Cerny & Kaiser, 1977) to evaluate sampling adequacy, ran Bartlett’s test of sphericity to assess relation strength between variables (Bartlett, 1954), and used Cronbach’s (1951) alpha coefficient to calculate the internal consistency (reliability) of the test items within the instrument.

Results and Discussion

Data Screening and Item Characteristics.

The mean scores for all 38 individual items ranged from 3.27 to 5.63. Standard deviation values for each item, which were determined at the beginning stages of development of other imagery measurements (SIQ, Hall et al., 1998; SIAQ, Williams & Cumming, 2011; SIAQ-J, Lee & Horino, 2023) were greater than 1.00 (1.29–1.97), resulting in acceptable response variability. For the entire item set, skewness (−1.340–0.361) and kurtosis (−1.143–1.794) values were within the range of −2.0 to +2.0, indicative of normality (George & Mallery, 2010).

EFA.

Principal axis factoring and Promax rotation were conducted since the Shapiro–Wilk and Kolmogorov–Smirnov tests revealed a non-normal distribution among the majority of responses (Costello & Osborne, 2005); Promax rotation helps obtain factors with simple structures, and the factors were assumed to be correlated a priori (Browne, 2001).

The adequacy of the sampling was evaluated by utilizing the KMO sampling adequacy measures, which suggest that KMO values be close to 1.00 for a satisfactory factor analysis to proceed (Kaiser, 1970; Cerny & Kaiser, 1977; Dziuban & Shirkey, 1974). Meanwhile, Bartlett's sphericity test determined whether factor analysis was sufficient. The results showed that the amount of available data was appropriate for factor analysis to be performed (sampling adequacy = .912, sphericity p = .000).

Using the default option in SPSS, the initial analysis revealed seven factors with eigenvalues greater than 1 (1.18–12.83), which explained 61.93% of the cumulative variance proportion. However, Suhr (2005) suggested retaining the total factors that explain 70%–80% of the variance. In addition, two of the six items under "timing" and all items under "task" and "learning" formed a factor despite being distinctly different concepts (Homes & Collins, 2001). The two "timing" items that formed one factor along with "task" and "learning" were related to real timing, while the other four items under "timing" were separated into two different factors of two items each: slow timing and fast timing.

A more satisfactory solution to these issues is the criterion of a minimum eigenvalue of 0.80 (Aoun, 2010), which yielded 10 factors with eigenvalues ranging from 0.80 to 10.62 and explaining 73.30% of the cumulative variance proportion. For interpretation purposes, Stevens's (1992) criterion of retaining factor loadings was considered, and only those with factor loadings greater than 0.4 on a single factor were included. Three items that did not meet the criteria were discarded, and four items that failed to load onto any factor were dropped from the analysis, which was repeated after each item was removed from the test.

The EFA solution produced 10 factors with factor loadings of 0.404–0.966 and 1–5 items each for a total of 31 items: physical (4), environment (4), task (3), timing-real (2), timing-fast (2), timing-slow (2), learning (4), emotion (5), 3PP (4), and 1PP (1).

Notably, the "timing" and "perspective" elements were separated into three and two factors, respectively. The separation of the "timing" element into three factors may have been unavoidable as athletes have been reported to use slow, fast, and real-time imagery (e.g., O & Munroe-Chandler, 2008; O & Hall, 2009; O & Hall, 2013; Shirazipour et al., 2016; Munroe-Chandler & Guerrero, 2017). Studies have also observed that athletes use both internal and external imagery (e.g., Spittle & Morris, 2007, 2011; Dana & Gozalzadeh, 2017).

However, indicators with only one or two items per factor are considered weak and unstable (Kline, 2005, p. 172; Maclver & Carmines, 1981, p. 15); in this study, these factors were timing-real (two items), timing-fast (two), timing-slow (two), and 1PP (one). The factor solution in pilot study established via EFA is merely preliminary and must be further validated; EFA is often the first step when determining how many factors to use and which of the observed variables are indicators of the latent variables (Brown, 2015). To improve the overall quality of the 10-factor solution established through EFA, we proceeded with further development. Hayduk and Littvay (2012) recommended that a single indicator be carefully considered to encourage a close alignment between the research concept and its structural model. The main goal of EFA is to generate elementary explanatory theories to explain data patterns (Haig, 2005). To facilitate further validation in study 1, we have provided theoretical definitions of each of the 10 identified SIIQ factors. Table 1 shows explanations of these factors and examples of their items.

Table 1. *Description of the 10 SIIQ Factors and Example Items*

Factor	Explanation	Example of item
Phys	Imagining performing physical movements while incorporating physical sensations and perceptions.	I make small movements or gestures during the imagery
Env	Imagining the specific environmental stimuli associated with that competing environment.	I image in the real training/competition environment
Tsk	Imagining performing a specific task or skill that needs to be improved.	Imagining improving my physical performance
T-r	Imaging executing the task or skill with the correct timing and rhythm.	Imagining performing a series of actions at the same speed as in an actual competition
T-s	Imaging executing the task or skills with slower temporal characteristics.	Imagining performing a movement or skill at a slower speed than it would actually be done
T-f	Imaging executing the task or skills with faster temporal characteristics.	Imagining performing a series of actions faster than in an actual competition
Lrn	Imagining performing the newly acquired specific techniques or skills.	Imagining acquired skill
Emo	Imagining experiencing the emotional and psychological responses associated with competition.	I control emotions while imagining
3pp	Imaging performing particular tasks or skills from an external perspective.	Imagining from the perspective of an opponent, an audience, or my coach
1pp	Imaging performing particular tasks or skills from an own perspective.	Imagining from a first-person perspective (as if you see it with your own eyes)

Note. Phys (physical), Env (environment), Tsk (task), Ti-r (timing real), Ti-s (timing slow), Ti-f (timing fast), Lrn (learning), Emo (emotion), 1PP (first-person perspective) and 3PP (third-person perspective)

Internal Consistency and Inter-factor Correlations.

To measure internal consistency, Cronbach's alpha reliability coefficient was computed. The criterion level was established at values between 0.6 and 0.7, which indicate acceptable reliability, and 0.8 and above indicates a high level according to a generally accepted rule (Ursachi et al., 2015). The Cronbach's alpha values were 0.779 for physical, 0.779 for environment, 0.799 for task, 0.804 for timing-slow, 0.828 for timing-fast, 0.661 for timing-real, 0.873 for learning, 0.894 for emotion, and 0.784 for 3PP. For 1PP, limitations were observed regarding reliability calculations associated with a single item; thus, discriminant validity was used to assess each factor's degree of independence.

Bivariate correlations with values ranging from 0.145 to 0.616 ($p < .001$) showed significant small-to-moderate relations between the 10-factor structure. The highest value (0.616) was obtained for learning and task. Because the interfactor correlations did not exceed 0.7 (Maat et al., 2011), the magnitude of these relations suggests that the SIIQ subscales measure related but separate constructs.

Interfactor correlations ranged from 0.145 to 0.485, with 1PP obtaining a correlation value of 0.325 with 3PP, suggesting that they are related but separate concepts.

Study 1: Confirmatory Factor Analysis and Group Differences

After establishing the SIIQ's 10-factor structure via EFA in pilot study, our first aim was to confirm this structure in a new participant sample using confirmatory factor analysis (CFA) (Fabrigar & Wegener, 2012). The second aim was to perform CFAs to compare the 10-factor model with two alternative models and ensure that the latter models do not provide a better data fit. The third aim was to further evaluate the validity of the SIIQ. A series of multivariate analyses of variance (MANOVAs) was performed to determine whether the athlete respondents' gender, competitive level, subjective performance, sport type, and years of experience were associated with imagery intervention.

Procedures

Before specifying the number of factors and the structure of the relation between factors and indicators via CFA, we further developed the overall quality of the 10-factor solution obtained through EFA by eliminating redundant and confusing elements (Johnson & McClure, 2004). We carefully reviewed the separated elements from the EFA in pilot study (e.g., "timing-real," "timing-slow," "timing-fast," "third-person perspective," "first-person perspective") and reworded or added items that were theoretically expected to be loaded onto each factor for a clear theoretical distinction. For the separated elements, we set three items per factor to provide minimum coverage of the construct's theoretical domain (Hair et al., 2010, p. 676).

In addition, task and learning, which showed the highest correlations among all SIIQ factors (r = .615), were modified based on the theoretical conceptualization of the target construct.

A total of 35 items were designed to evaluate the 10 types of imagery interventions: physical (4 items), environment (4), task (3), timing-real (3), timing-fast (3), timing-slow (3), learning (4), emotion (5), 3PP (3), and 1PP (3).

Participants

In study 1, a total of 442 collegiate athletes from 29 sports (231 male, 211 female) answered the 35-item SIIQ. Their experience ranged from 1 to 19 years (M = 8.66, SD = 4.83), and their ages ranged from 18 to 26 years (M = 20.1, SD =1.19). After obtaining ethical approval, this study performed random convenience sampling to recruit participants from five universities in Kanto, a region surrounding Tokyo, Japan. Each respondent, who received consent forms with accompanying information sheets, expressed their consent to participate and were aware of the voluntary nature of their participation. The data they provided included age, gender, sport type, competitive level, subjective performance level, and years of experience. Out of the 450 returned questionnaires, 28 were excluded because of missing data, resulting in a final sample size of 422.

Measures

The SIIQ. We used the 35-item SIIQ.

Subjective Performance Rating. The participants rated the extent to which they subjectively perceive their performance level using a Likert-type scale ranging from 1 (low) to 7 (high).

Data Analysis

The CFA used maximum likelihood estimation to validate the 10-factor structure of the SIIQ identified via EFA in pilot study. We evaluated the model's overall fit using the chi-squared statistic ($\chi 2$), the standardized root mean square residual (SRMR), the Tucker–Lewis index (TLI), and the root mean square error of approximation (RMSEA). We examined convergent and discriminant construct validity using composite reliability (CR), average variance extracted (AVE), maximum reliability (MaxR(H)), maximum shared variance (MSV), and the square root of AVE. Multiple one-way MANOVAs were performed to test the hypothesis that gender, competitive level, subjective performance level, sport type, and years of experience are associated with SIIQ scores.

The variance homogeneity for each analysis was tested using Pillai's trace test. The analyses were conducted using SPSS (version 27) and AMOS (version 27).

Results

Data Screening and Item Characteristics.

For all 38 individual items, the mean scores ranged from 3.27 to 5.63. Response variability was considered acceptable based on analyses of each item's standard deviation values, which were all greater than 1.00 (1.29–1.97), an early strategy in the development of other imagery measurements (SIQ, Hall et al., 1998; SIAQ, Williams & Cumming, 2011; SIAQ-J, Lee & Horino, 2023). For the entire set of items, skewness (−1.340–0.361) and kurtosis (−1.143–1.794) values were within the -2.0 to +2.0 range, indicating normality (George & Mallery, 2010)

Table 2. Convergent and Discriminant Validity Results

	CR	AVE	MSV	MaxR(H)	3pp	Phys	Env	tsk	Ti-r	Ti-s	Ti-f	Lrn	Emo	1pp
3pp	0.795	0.566	0.213	0.811	**0.752**									
Phys	0.816	0.542	0.445	0.903	0.339	**0.736**								
Env	0.813	0.522	0.381	0.820	0.460	0.433	**0.723**							
Tsk	0.807	0.585	0.518	0.822	0.409	0.667	0.485	**0.765**						
Ti-r	0.793	0.562	0.518	0.800	0.461	0.569	0.470	0.720	**0.750**					
Ti-s	0.762	0.527	0.156	0.817	0.285	0.332	0.395	0.343	0.348	**0.726**				
Ti-f	0.812	0.595	0.233	0.851	0.314	0.073	0.379	0.237	0.333	0.318	**0.772**			
Lin	0.884	0.655	0.504	0.885	0.363	0.656	0.401	0.710	0.698	0.346	0.169	**0.809**		
Emo	0.882	0.601	0.381	0.889	0.438	0.287	0.617	0.461	0.517	0.302	0.483	0.394	**0.775**	
1pp	0.911	0.774	0.318	0.913	0.183	0.413	0.325	0.491	0.529	0.330	0.119	0.564	0.404	**0.880**

Note. Boldface indicates the square root of AVE; Phys (physical), Env (environment), Tsk (task), Ti-r (timing real), Ti-s (timing slow), Ti-f (timing fast), Lrn (learning), Emo (emotion), 1pp (first-person perspective), and 3pp (third-person perspective).

CFA.

We followed Kline's (2005) suggestion to assess model fitness by inspecting the CMIN/DF, CFI, TLI, RMSEA, and SRMR using a maximum likelihood estimator; these indices are superior to others because they are the most impervious to sample size issues, parameter estimations, and misleading information.

As presented in Table 2, the overall results showed that the 10-factor model (physical, environment, task, timing-natural, timing-fast, timing-slow, learning, emotion, 3PP, 1PP) yielded a good fit for the data: CMIN/DF = 1.928, CFI = .944, TLI = .933, SRMR = .050, and RMSEA = .046 with a factor loading of 493–906. Tabachnik and Fidell (2007) explained that CMIN/DF should be less than 2; since our results showed a CMIN/DF value of 1.928, it fits the goodness of the measurement model. Also, as suggested by Hu and Bentler (1999), the CFI and TLI values should both be greater than 0.90; our study showed a CFI of 0.944 and a TLI of 0.933, which both meet the goodness-of-fit standard. Furthermore, Steiger (2007) recommended that the RMSEA value less than 0.07 is generally indicative of a good fit to the data; our study obtained an RMSEA value of 0.046. Finally, the SRMR value was significant if it is below 0.08 (Hu & Bentler, 1999); our tests showed an SRMR value of 0.050, indicating goodness of fit.

Convergent and Discriminant Construct Validity.

As shown in Table 2, convergent and discriminant construct validity criteria were satisfied for all indicators. To determine convergent validity, we examined CR, AVE, and MaxR(H). Convergent validity is confirmed when CR exceeds the 0.70 threshold (Hair et al., 1997), AVE exceeds 0.50 (Fornell & Larcker, 1981), and MaxR(H) exceeds the CR value (Fornell & Larcker, 1981; Hair et al., 2014). In our case, all these values met the criteria. Meanwhile, we evaluated discriminant validity using Fornell and Larcker's (1981) criteria, which state that the MSV value should be less than the AVE value and that the square root of the AVE (in bold) should be greater than the interconstruct correlation. Furthermore, according to Kline (2005), discriminant validity is established if the correlations between latent variables are less than 0.85; this was achieved in this study since all values for the MSV, square root of the AVE, and correlations between latent variables were within the standard.

Alternative Models.

Table 3 presents the CFA fit indices for the SIIQ and the alternative models. To verify each item and the correlations between latent variables, we used the alternative CFAs and compared them to the 10-factor model. The first step involved testing the unidimensional model, and the results demonstrated poor model fit (CMIN/DF = 7.834, CFI = 0.519, TLI = 0.491, SRMR = 0.109, RMSEA = 0.124), which supports the idea that the SIIQ is multidimensional.

In the next step, the CFA values of the seven-factor model were examined because the PETTLEP imagery intervention model (Holmes & Collins, 2001) provided an underlying structure for the SIIQ with seven elements (i.e., physical, environment, task, timing, learning, emotion, and perspective).

Because the 10-factor structure of the SIIQ was divided into three and two latent variables under timing and perspective, respectively, we forced the timing-real, timing-fast, and timing-slow items onto a single latent variable under the “timing” subscale and the 3PP and 1PP items onto a single latent variable under the “perspective” subscale. The results showed insufficient values (CMIN/DF = 3.562, CFI = 0.833, TLI = 0.816, SRMR = 0.093, RMSEA = 0.076), falling short of the 10-factor model.

It was not enough that the CFI and TLI values exceeded 90 for the seven-factor model (Hu & Bentler, 1999). An SRMR value below 0.08 is considered significant (Hu & Bentler, 1999), and the CMIN/DF value must be less than 2 (Tabachnik & Fidell, 2007), which suggest that timing is best explained when divided into three components (timing-real, timing-fast, and timing-slow). In addition, 3PP and 1PP, expressed in the perspective scale, are independent measures of a different concept and cannot be explained satisfactorily through forced loading onto a single factor.

Table 3. CFA Fit Indices for the SIIQ and Alternative CFAs

Model	χ^2/df	CFI	TLI	SRMR	RMSEA
Single-factor	7.834	0.519	0.491	0.109	0.124
Seven-factor	3.562	0.833	0.816	0.093	0.076
Ten-factor	1.928	0.944	0.933	0.050	0.046

Group Differences in the SIIQ.

Using five MANOVAs, this study further examined the validity of the SIIQ to determine whether its scores were influenced by (a) gender (231 male, 211 female), (b) competitive level (level 1, international level, n = 74; level 2, top national level, n = 130; level 3, participating in national competitions and winning provincial competitions, n = 114; level 4, participating in provincial competitions and winning local competitions, n = 65; and level 5, no experience participating in regular competitions, n = 59), (c) subjective performance, (d) sport type (254 individual, 188 team), and (e) years of experience (experience 1, 1–5 years, n = 139; experience 2, 6–10 years, n = 130; experience 3, 11–19 years, n = 173). In each analysis, the ten SIIQ subscales served as dependent variables.

For each analysis, Pillai’s trace was selected as the most robust test statistic, and partial eta squared (2partial) was chosen as a measure of the effect size for the univariate F tests (Velotti, 2017).

Gender Differences. One-way MANOVA results revealed that the 10 SIIQ subscales showed no significant differences across genders (Pillai’s trace = .03, F(10, 431) = 1.22, p = .274, η2 = .03, observed power = 63%).

Competitive Level. A one-way MANOVA showed no significant differences across competitive levels with the 10 SIIQ subscales (Pillai’s trace = .120, F(40, 1724) = 1.34, p = .079, η2 = .03, observed power = 99.2%).

Subjective Performance Level. Athletes with higher subjective performance levels were hypothesized to exhibit more imagery intervention than lower-level athletes (Nicholls et al., 2012).

Pillai’s trace values showed that subjective performance ratings were significantly different across SIIQ scores (Pillai’s trace = .21, F(60, 2586) = 1.54, p = .005, η2 = .034, observed power = 100%). To determine the impact of each effect on individual-dependent variables, we conducted a univariate F test with an alpha threshold of.05 and found that subjective performance had a significant effect on nine dependent variables (physical, environment, task, timing-real, timing-fast, learning, emotion, 3PP, and 1PP; timing-slow was excluded).

A comparison of the mean ratings for subjective performance on each SIIQ subscale using Tukey’s honest significant difference test (HSD) showed that subjective performance ratings had a significant mean difference on physical, environment, task, timing-normal, timing-fast, learning, emotion, and 3PP.

The overall results showed that athletes with higher subjective performance showed higher SIIQ scores than those with lower ratings on each subscale.

The relation between subjective performance level and each SIIQ subscale revealed a similar pattern of differences between highly perceived subjective performance and lowly perceived subjective performance, which supports the claim that subjective performance positively predicts imagery (Nicholls et al., 2012).

Table 4 shows the results for subjective performance level differences in the SIIQ.

Sport Type. Pillai's trace F was used to estimate the F-statistics (Pillai's trace = .047, F(10, 431) = 2.140, p = .021, η2 = .047, observed power = 90.7%). To investigate the impact of each effect on individual-dependent variables, we performed a one-way MANOVA with an alpha level of.05 and found a significant effect of sport type on the SIIQ subscale timing-slow.

Mean SIIQ scores were higher for team sports (M = 4.51, SD = 1.33) than individual sports (M = 4.10, SD = 1.41). In terms of the effect for the other nine subscales, no significant differences were observed.

Years of Experience. Another one-way MANOVA revealed that SIIQ scores differed with years of experience (Pillai's trace = .072, F(20, 862) = 1.616, p = .043, η2 = .036, observed power = 95.8%). After conducting a univariate F test with an alpha level of.05 to investigate the impact of each effect on the individual-dependent variables, we found that years of experience had a significant effect on the emotion subscale of the SIIQ, and the results of Tukey's HSD showed that years of experience 1 (M = 4.25, SD = 1.44) had lower mean SIIQ scores than years of experience 3 (M = 5.63, SD = 1.11) (p-value = 0.008). No significant differences in terms of effect were found in the other nine subscales.

Table 4. Results of Subjective Performance Level Differences in the SIIQ

	Subjective performance level								
	1 (N=14)	2 (N=14)	3 (N=121)	4 (N=128)	5 (N=85)	6 (N=58)	7 (N=22)	ANOVA	Multiple Comparisons
	High						Low		
	M (SD)							*f*	Tukey's HSD
Phys	5.61 (1.38)	5.11 (1.27)	5.85 (1.06)	5.17 (1.33)	5.16 (1.14)	4.92 (1.27)	5.05 (1.20)	2.72*	3 > 6
Env	5.27 (1.26)	3.50 (1.87)	4.49 (1.36)	4.18 (1.42)	3.92 (1.25)	3.82 (1.29)	3.72 (1.25)	4.75***	1 > 2,5,6,7 3 > 6
Tsk	5.67 (1.18)	4.98 (1.20)	5.36 (1.03)	5.15 (1.12)	4.85 (1.03)	4.74 (1.27)	5.24 (0.99)	3.65**	3 > 5,6
Ti-r	5.40 (1.51)	5.00 (1.03)	5.36 (1.01)	4.98 (1.15)	4.69 (0.97)	4.70 (1.35)	4.83 (1.09)	4.34***	3 > 5,6
Ti-s	4.79 (1.71)	4.29 (1.46)	4.29 (1.44)	4.29 (1.42)	4.10 (1.25)	4.36 (1.41)	4.29 (1.19)	0.57	
Ti-f	4.62 (1.40)	3.40 (1.77)	3.52 (1.43)	3.58 (1.50)	3.26(1.27)	3.15 (1.27)	3.58 (1.45)	2.54*	1 > 5,6
Lrn	5.82 (1.39)	5.66 (1.05)	5.75 (0.97)	5.57 (1.10)	5.38 (1.03)	5.14 (1.35)	5.39 (1.16)	2.57*	3 > 6
Emo	5.14 (1.67)	3.76 (1.79)	4.82 (1.24)	4.61 (1.33)	4.20 (1.20)	4.04 (1.29)	3.82 (1.41)	5.55***	3 > 5,6,7
1PP	5.69 (1.40)	4.55 (1.64)	4.70 (1.30)	4.64 (1.38)	4.48 (1.33)	4.20 (1.45)	4.56 (1.46)	2.46*	
3PP	5.74 (1.30)	5.38 (1.70)	5.73 (1.29)	5.34 (1.47)	5.16 (1.34)	5.28 (1.52)	4.88 (1.36)	2.46*	1 > 5,6

*p < .05, **p < .01, ***p < .001.

Note. Phys (physical), Env (environment), Tsk (task), Ti-r (timing real), Ti-s (timing slow), Ti-f (timing fast), Lrn (learning), Emo (emotion), 1PP (first-person perspective), and 3PP (third-person perspective).

Study 2: CFA and Relation with Imagery Ability

In study 2, a new group of participants was recruited to confirm the 10-factor model fit of the 35-item SIIQ to first conduct a further assessment of the instrument’s validity and reliability. The second goal was to determine whether the questionnaire matches its intended purpose; to this end, we assessed the relation between the SIIQ and the presence or absence of imagery intervention experience. The third purpose was to investigate the relation between the SIIQ and the SIAQ (Williams & Cumming, 2011), which both use a seven-point Likert scale to evaluate sports-specific imagery, to establish the former’s concurrent validity. The main concern with concurrent validity is that one instrument must be distinguishable from the other (Taherdoost, 2016). Investigating the correlation between the SIIQ and the SIAQ allows the SIIQ subscale’s degree of relation to be evaluated with other measures for sport-specific imagery. In addition, regression analysis was performed with the SIIQ and the SIAQ to suggest how the former can be applied in the sporting field. The final purpose was to assess test–retest reliability, which was obtained by administering the questionnaire on two separate occasions over two months.

Participants and Procedure

In study 2, a total of 378 collegiate athletes from 18 sports (242 male, 136 female) responded to the 35-item SIIQ. Their experience ranged from 1 to 20 years (M = 10.97, SD = 4.16), and their ages ranged from 18 to 24 years (M = 19.72, SD = 1.36). After ethical approval was obtained, participants were recruited via random convenience sampling. Those who met the inclusion criteria were athletes who were members of the university’s sports club. Each participant provided informed consent and understood that participation was entirely voluntary. They also furnished information including their age, gender, sports played, and years of experience. We then used a separate group of 39 athletes who agreed to participate in the test–retest reliability procedure and complete the SIIQ twice at a two-month interval under the same conditions.

Measures

The SIIQ. We used the same 35-item SIIQ in studies 2 and 3.

The SIAQ. We used the SIAQ (Williams & Cumming, 2011), specifically its Japanese translation (SIAQ-J; Lee & Horino, 2023), to test concurrent validity and perform regression analysis. The 15 items of this instrument are rated on a seven-point Likert-type scale, with responses ranging from 1 (very hard to image) to 7 (very easy to image), to assess the ease of generating imagery.

Result

Data Screening and Item Characteristics.

The mean scores for all 35 items ranged from 3.53 to 5.58, and standard deviations ranged from 1.21 to 1.71.

The skewness and kurtosis values for all items were distributed within the tolerance levels of normality assumptions (George & Mallery, 2010).

CFA.

We followed the same CFA procedure in study 1 for the 10-factor structure with a new sample, and the results showed a factor structure that is identical to that in study 1 (CMIN/DF = 1.934, CFI = 0.945, TLI = 0.935, SRMR = 0.048, and RMSEA = 0.050, with a factor loading of 551–948). The goodness-of-fit criteria also showed adequate values (Hu & Bentler, 1999; Steiger, 2007), with some values slightly increasing from the CFA results in study 1 (e.g., an increase of 0.002 for CFI and 0.003 for TLI), because data collected from different samples may vary in response distribution and response variability level.

Table 5. SIIQ Items and Construct Validation, Study 2

Item	CR	AVE	MaxR(H)
Physical	.863	.619	.893
1. I make small movements or gestures during the imagery			
2. I image while holding or touching kit related to my sport			
3. I perform the movement for real just before I image it			
4. I image while adopting a position similar to what I am imaging			
Environment	.803	.509	.823
1. I image the competition site and surroundings			
2. I image in the real training/competition environment			
3. I image the reactions of the audience and situations that could occur in the stadium			
4. I try to image the same senses (e.g., sight, sound, smell, taste, touch) that I would experience in the real-life situation			
Task	.876	.702	.877
1. Imagining specific skills that I need to improvement			
2. I image what I am working on to improve my performance			
3. Imagining improving my physical performance			
Timing-real	.758	.511	.764
1. Imagining performing a movement or skill at roughly the same speed as it would actually be done			
2. Imagining performing a series of actions at the same speed as in an actual competition			
3. Imagining at a normal speed			
Timing-slow	.803	.579	.825
1. Imagining performing a movement or skill at a slower speed than it would actually be done			
2. Imagining performing a series of actions more slowly than in an actual competition			
3. Imagining in slow motion			
Timing-fast	.808	.593	.863
1. Imagining performing a movement or skill at a faster speed than it would actually be done			
2. Imagining performing a series of actions faster than in an actual competition			
3. Imagining at a speed faster than normal			
Learning	.927	.764	.935
1. Imagining recently learned skills			
2. I image a well-executed performance as expected			
3. I image being able to do something new			
4. Imagining acquired skill			
Emotion	.892	.623	.900
1. I image specific emotions felt at a particular moment during a competition			
2. I control emotions while imagining			
3. I feel similar emotions as during the actual competition while imagining			
4. I generate all the necessary emotions while imagining			
5. I evoke emotional changes based on the content of image			
Third-person perspective	.757	.509	.7573
1. Imagining from a third-person perspective (as if observing yourself from the outside)			
2. Imagining seeing myself on video.			
3. Imagining from the perspective of an opponent, an audience, or my coach			
First-person perspective	.909	.769	.935
1. Imagining from a first-person perspective (as if you see it with your own eyes)			
2. Imagining a scene as I would see it			
3. Imagining things from my own line of sight			

Convergent Validity.

Table 5 shows all convergent validity values for the SIIQ, including CR (0.757 to 0.927), AVE (0.509 to 0.769), and MaxR(H) (0.757 to 0.935), which all indicated adequate convergent validity (Fornell & Larcker, 1981; Hair et al., 1997, 2014).

Imagery Intervention Status.

Discriminant function analysis (Wilks' lambda = .802, $p < .001$) showed significant discriminant function differences for all 10 SIIQ subscales and imagery intervention status. The structural matrix revealed that imagery intervention status can be predicted by task (0.787), learning (0.738), physical (0.670), emotion (0.667), 1PP (0.603), environment (0.600) timing-fast (0.488), timing-real (0.485), 3PP (0.464), and timing-slow (0.236). Overall, 78% were revealed to be correctly classified.

Because athletes who are experienced in implementing imagery intervention showed higher scores than those who are not, this result confirms the appropriateness of the questionnaire responses.

Test–Retest Reliability.

The correlation coefficient was used to calculate the consistency of the measures test, and two month elapsed between each test session. Results for each item showed the following values: 0.710 (physical), 0.691 (environment), 0.752 (task), 0.658 (timing-real), 0.801 (timing-slow), 0.668 (timing-fast), 0.815 (learning), 0.844 (emotion), 0.683 (3PP), and 0.793 (1PP). According to Cicchetti (1994), test–retest reliability coefficients within the range of 0.60–0.74 are considered good, while 0.75 and higher are deemed excellent. The results showed that the SIIQ has two months of temporal reliability.

Table 6. Bivariate Correlations between the SIIQ and SIAQ Subscales

SIIQ	SIAQ				
	Skill	Strategy	Goal	Affect	Mastery
Physical	.218	.177	.251	.289	.208
Environment	.146	.214	.216	.223	.269
Task	.337	.187	.315	.370	.294
Timing-real	.282	.207	.266	.318	.311
Timing-slow	.318	.171	.187	.246	.311
Timing-fast	.173	.302	.225	.136	.322
Learning	.324	.241	.329	.439	.289
Emotion	.281	.252	.384	.308	.270
Third-person perspective	.202	.192	.238	.323	.332
First-person perspective	.282	.194	.343	.289	.255

Note. All coefficients are significantly lower than $p \leq .01$.

Concurrent Validity.

Table 6 summarizes all correlations between the SIIQ and the SIAQ. To establish concurrent validity, this study investigated the correlation between the SIIQ and the SIAQ, which are both questionnaires on sports imagery contents. Both instruments assess sport-specific imagery on a seven-point Likert-type scale. The small to moderate size of these correlations, from.136 to.439 ($p \leq .01$), suggests that despite the relation between the questionnaires, imagery intervention and sports imagery ability are not the same traits. The SIIQ is concerned with the extent to which imagery intervention has been used intentionally to enhance performance. SIAQ taps the ease of generating imagery.

Regression.

Further validation was performed using stepwise regression to determine whether the SIIQ positively predicts imagery ability and suggest how the tool could be applied in practice in sports. The primary validation of the SIIQ for regression with another questionnaire used stepwise regression, a technique for selecting predictor variables in a multiple regression model; note that it can be useful in situations that involve a large number of potential predictor variables, and it can be useful when it is not clear which ones should be included in the model (Montgomery, 2021; Tabachnick & Fidell, 2001). In each analysis, the 10 SIIQ subscales were selected as independent variables, and one of the five SIAQ subscales was chosen as a dependent variable.

Stepping criteria were used for 0.15 and 0.20 as the entry and removal p-levels, respectively, following Hosmer and Lemeshow’s (2000) recommendations. For all SIAQ subscales, Cronbach’s alpha coefficients indicated adequate internal reliability (skill = .865, strategy = .863, goal = .797, affect = .866, mastery = .866).

Based on the results of each final step of the stepwise linear regression, skill imagery ability $[F(2,375) = 32.73, p < .001]$ was predicted by task ($\beta = 0.243, p \leq .001$) and timing-slow ($\beta = 0.209, p \leq .001$), which constitute 14.9% of the explained variation. Strategy for imagery ability $[F(2,375) = 24.42, p < .001]$ was predicted by timing-fast ($\beta = 0.251, p < .001$) and learning ($\beta = 0.164, p = .001$), accounting for 11.5% of the explained variation. Goal imagery ability $[F(2,375) = 40.62, p < .001]$ was predicted by emotion ($\beta = 0.284, p < .001$) and 1PP ($\beta = 0.201, p < .001$), which together represent 17.8% of the explained variation. Affect imagery ability $[F(2,375) = 48.96, p < .001]$ was predicted by learning ($\beta = 0.370, p < .001$) and 3PP ($\beta = 0.138, p < .010$), which all constitute 20.7% of the explained variation. Mastery imagery ability $[F(3,374) = 24.74, p < .001]$ was predicted by 3PP ($\beta = 0.193, p < .001$), timing-fast ($\beta = 0.200, p < .001$), and 1PP ($\beta = 0.145, p = .004$), which represent 16.6% of the explained variation. Meanwhile, physical, environmental, and timing-real did not predict any imagery ability.

Discussion of All Three Studies

This three-part study developed an SIIQ with 10 structures (i.e., physical, environment, task, timing-real, timing-fast, timing-slow, learning, emotion, 3PP, and 1PP). The SIIQ itself aims to assess one’s use of intentional imagery interventions; to do so, we obtained the validity and reliability figures of the developed SIIQ to ensure its accuracy and consistency. Overall, the SIIQ demonstrated good reliability and validity. Moreover, we provided preliminary psychometric support for this newly developed questionnaire, such as differences in gender, competitive level, subjective performance, sport type, and years of experience. We found that the SIIQ functions as a comprehensive tool for evaluating 10 types of imagery interventions in sports.

Holmes and Collins (2001) proposed the PETTLEP framework to effectively execute imagery interventions using seven specific elements (i.e., physical, environment, task, timing, learning, emotion, and perspective); this model has been widely used and studied in sport psychology, with a well-documented effectiveness in improving sports performance (Wakefield & Smith, 2012).

The present findings suggest that this framework, through the SIIQ, can help in the evaluation of imagery interventions. Furthermore, timing was divided into three factors (real, slow, and fast), and perspective was divided into two factors (3PP and 1PP). Although we developed the initial items based on constitutive definitions for each of the seven elements of the PETTLEP model, the EFA in pilot study identified 10 factors, and through the application of CFA and the participation of new samples in studies 2 and 3, these results were confirmed. A cross-validation of the findings demonstrated a good fit between the 10-factor model and the data. Because of the initial items in Holmes and Collins's (2001) framework, the 7-factor model, in which the timing-real, timing-slow, and timing-fast items were forced onto a timing subscale and 3PP and 1PP items were forced onto a perspective subscale, was compared with the 10-factor model to ensure that the 7-factor model does not provide a better fit to the data. However, the 7-factor model was revealed to be a poorer fit than the 10-factor model, indicating that the timing-real, timing-slow, and timing-fast and 3PP and 1PP scales are independent measures of different contents and cannot be explained through forced loading onto timing or perspective factors, respectively.

These findings support studies that have reported the impact of various speeds of imagery and perspective on athletic performance. For instance, O and Hall (2009) found that athletes use slow-motion, real-time, and fast-moving images according to their imagery function and learning stage, and Morris and Spittle (2012) suggested that the two main imagery perspectives, or the viewpoints adopted by an athlete while using imagery, are crucial factors in determining the effectiveness of the imagery.

Overall, the SIIQ demonstrated acceptable convergent and discriminant construct validity. The reliability coefficient was satisfactory as well, and interconstruct correlation indicated that the 10 SIIQ subscales were linked but clearly independent. A further validity test of the SIIQ via MANOVA demonstrated the instrument's ability to distinguish athletes of different groups.

Study 1, which examined group differences, found no significant differences in SIIQ mean scores for gender and competitive level. However, significant differences in mean scores were observed for subjective performance, experience duration, and sport type (i.e., team or individual) in the SIIQ subscales.

The SIIQ was also found to predict athletes' subjectively perceived performance levels. A significant mean difference was observed between most subscales and subjective performance (i.e., physical, environment, task, timing-fast, timing-slow, learning, emotion, 3PP, and 1PP). That is, athletes with higher subjectively perceived performance levels intentionally use more imagery intervention than those with lower ratings. In the context of overall athletic performance, subjective performance is considered an important aspect (Levy et al., 2011) because of its impact on an individual's motivation, engagement, and satisfaction with their athletic pursuits.

In addition, a significant mean difference was found in the emotion subscale of the SIIQ, with the imagery intervention of emotion increasing with years of experience. Imagery itself can be developed through time and effort (Hall, 2001). This result implies that the intentional imagery intervention of emotion undergoes a particularly time-consuming developmental process because emotional regulation requires alterations to phylogenetically ingrained affect systems with psychologically complex control mechanisms, which is laborious from a psychological standpoint (Thompson, 1991). The nine remaining subscales (i.e., physical, environment, task, timing-real, timing-slow, timing-fast, learning, 3PP, and 1PP) were unaffected by years of experience. Athletes were engaged in intentional attempts at such interventions regardless of their experience.

A significant mean difference was observed in the SIIQ's timing-slow subscale between team and individual sports. Specifically, team sports had a significantly higher mean score for timing-slow than individual sports, which may be because team sports require players to pay attention to more things. While individual sports rely on individual performance and abilities, team sports require players to engage in collaboration, communication, and teamwork to achieve a common goal.

Study 2 examined the relations between the SIIQ and the SIAQ. To establish concurrent validity, correlation analysis was performed. The small to moderate size of the correlation between SIIQ and SIAQ subscales suggests that while both questionnaires measure sport-specific imagery, they do not assess the same trait. The SIIQ evaluates the use of intentional imagery interventions, which are associated with subjective performance, while the SIAQ specializes in measuring the ease of generating imagery and is linked to objective performance (e.g., high-competition-level athletes display greater imagery ability; Williams & Cumming, 2011).

This study also performed regression analysis with the SIIQ and the SIAQ to suggest ways to apply the former in the sporting field. Skill imagery ability was predicted by task and timing-slow, strategy imagery ability by timing-fast and learning, goal imagery ability by emotion and 1PP, affect imagery ability by learning and 3PP, and mastery imagery ability by 3PP, timing-fast, and 1PP.

The majority of SIIQ subscales (i.e., task, timing-fast, timing-slow, learning, emotion, 3PP, and 1PP) positively predicted imagery ability (SIAQ), which supports the finding that physical and environmental factors do not respond to imagery ability (Anuar et al., 2017) because the physical and environment subscales of the SIIQ were based on imagery framing (Anuar et al., 2017). In imagery framing, imagery ability (SIAQ) was positively predicted when physical and environmental factors were forced into a single factor. The speed of imagery has also been reported to significantly affect performance accuracy (O & Hall, 2009); timing-slow and timing-fast influenced imagery ability. The current results suggest that the SIIQ's timing subscale is useful in providing more detailed information about imagery interventions. As emphasized by Holmes and Collins (2017), further research must be conducted to determine the optimal speed of mental imagery, which could lead to a more effective and efficient use of imagery interventions in sports performance.

These results sufficiently demonstrate how the SIIQ will be applied in the sporting field. Notably, measures of subjective performance–linked traits (SIIQ) can predict those of objective performance–associated traits (SIAQ). This regression analysis was performed during initial development; hence, to strengthen the effectiveness of the SIIQ, researchers must also validate the questionnaire by exploring other characteristics that could shape sporting performance. In addition, demonstrating the predictive validity of the SIIQ for outcomes associated with imagery intervention would establish its efficacy as an assessment tool for athletes.

Our study evaluated the effectiveness of the SIIQ as a comprehensive tool for assessing 10 elements of sport-specific imagery interventions. The SIIQ, which was designed to assess athletes' intentional use of imagery interventions, proved to be a suitable instrument for thoroughly examining these interventions in sports. Our results showed that the SIIQ had good temporal reliability as evidenced by its test–retest reliability over two months. In study 2, discriminant function analysis results confirmed that the SIIQ could accurately distinguish athletes who had intentionally used imagery interventions from those who had not. These findings suggest that the SIIQ responses are appropriate for the questionnaire’s intended purpose. Overall, our study highlights the SIIQ’s utility as a valuable tool for evaluating the effectiveness of sport-specific imagery interventions in enhancing athletic performance.

Limitations and Directions for Further Research

Notably, this study had population limitations. Specifically, our participant sample consisted of only Japanese collegiate athletes, which may limit the generalization of these results to other populations. Hence, future investigators may examine athletes from different cultures and in other age groups and consider their occupations and careers.

Conclusion

Our preliminarily developed and verified SIIQ showed good psychometric properties for evaluating imagery intervention. The 10 newly identified structures for the SIIQ must be highlighted. This questionnaire of 10 different imagery interventions will strengthen further research on athletes. For example, the SIIQ can help researchers develop the most effective image training programs or psychological intervention methods for athletes to enhance their performance. Scholars can also expand their research on various causal relations by evaluating imagery intervention alongside other measurements.

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Appendix 1: Sport Imagery Ability Questionnaire (Williams & Cumming, 2011)-Japanese Version (Chapter 4 and Chapter 5-Study 2)

アスリートがイメージを浮かべる能力について質問します。それぞれの質問項目ついて**目を閉じた状態でイメージを浮かべてください。**そして、以下のイメージを浮かべるのがどの程度簡単なのかを評価してください(1=非常に難しい、4=どちらとも言えない、7=非常に簡単)。

例えば、あるサッカー選手がボールを蹴ることをイージする時、簡単でも難しくもない場合④を選択します。質問項目ついて適切な回答をしていただくために、できるだけ時間をかけてください。答えに合っている、間違っているということはありません。

自分の専門競技に関して、 以下のことをイメージするのがどの程度簡単なのか…	とても難しい	難しい	やや難しい	どちらとも言えない	やや簡単	簡単	とても簡単
1. 頭の中で新しいプランや戦略を練（ね）るイメージ	1	2	3	4	5	6	7
2. うまくいかない時でも最善を尽くすイメージ	1	2	3	4	5	6	7
3. スキルを改善するイメージ	1	2	3	4	5	6	7
4. 試合や練習中にポジティブな感情を持つイメージ	1	2	3	4	5	6	7
5. メダルを獲得（かくとく）するイメージ	1	2	3	4	5	6	7
6. 別のプランや戦術を作り出すイメージ	1	2	3	4	5	6	7
7. プレーに対する情熱と期待感を思い浮かべるイメージ	1	2	3	4	5	6	7
8. 特定のスキルを向上させるイメージ	1	2	3	4	5	6	7
9. 勝者としてインタビューを受けるイメージ	1	2	3	4	5	6	7
10. 失敗した後でも前向きでいるイメージ	1	2	3	4	5	6	7
11. パフォーマンスに対するワクワク感を思い浮かべるイメージ	1	2	3	4	5	6	7
12. スキルやフォームを調整するイメージ	1	2	3	4	5	6	7
13. 新しいゲームプランを立てるイメージ	1	2	3	4	5	6	7
14. 勝利するイメージ	1	2	3	4	5	6	7
15. 困難な状況でも自信を持つイメージ	1	2	3	4	5	6	7

Appendix 2: - Goal Clarity Scale (Kwan et al., 2013; Nishioka 2023) (Chapter 4 - Study 2)

自分がスポーツに取り組む上での目標や、そのスポーツに取り組んでいる場面について思い浮かべてください。 次の文章が自分自身にあてはまるかどうか、１ ～ ５ のうちからひとつ選び、番号に〇をつけてください。	あてはまらない		どちらとも言えない		あてはまる
1. 自分のプレーが周りの人からどのように評価されているか理解している	1	2	3	4	5
2. 監督・コーチ・キャプテンは、自分の課題が何であるかをわかりやすく教えてくれる	1	2	3	4	5
3. スポーツに取り組む上で、自分がどんなことをするべきかを正しく理解している	1	2	3	4	5
4. スポーツに取り組む上で、自分には目指すべき具体的ではっきりとした目標がある	1	2	3	4	5
5. スポーツでの目標がいくつかある場合、どの目標から達成するべきかわかっている	1	2	3	4	5
6. スポーツに取り組む上で、自分の目標が何なのか、はっきりとしている	1	2	3	4	5

Appendix 3: 38 Version of Sport Imagery Intervention Questionnaire (Chapter 5- Pilot Study)

あなたが競技力向上のために**イメージに関して以下を実施したことがあるか思い出してください。**そしてその程度を選んでください。（1=まったくない、4=どちらとも言えない、7=非常によくある）質問項目ついて適切な回答をしていただくために、できるだけ時間をかけてください。答えに合っている、間違っているということはありません。

専門競技を始めてからあなたは競技力を向上させるために 以下のことを実施したことがありますか?	まったくない			どちらとも言えない			非常によくあ
1. 試合で起こり得る場面をイメージし小さくジェスチャーする	1	2	3	4	5	6	7
2. トレーニングウェアやユニフォームを着てイメージする	1	2	3	4	5	6	7
3. スポーツ器具を持ってイメージをする （サッカーボール、ゴルフクラブなど）	1	2	3	4	5	6	7
4. イメージしながら体を動かす	1	2	3	4	5	6	7
5. 軽く体を動かしながら、類似のフォームをとりイメージする	1	2	3	4	5	6	7
6. 競技場と周辺環境をイメージする。 （天気、競技場のコンディション、グラウンド状態、雰囲気など）	1	2	3	4	5	6	7
7. 実際のトレーニング環境や競技場でイメージする	1	2	3	4	5	6	7
8. 観客の反応や競技場で発生し得る状況をイメージする	1	2	3	4	5	6	7
9. 試合の動画などの視線覚的手掛かりを用いてイメージする	1	2	3	4	5	6	7
10. 実際の状況で経験できる感覚をイメージする （例:視覚、音、嗅覚、味、触覚）	1	2	3	4	5	6	7
11. 改善すべき特定のスキルをイメージする	1	2	3	4	5	6	7
12. 指導されたことをイメージする	1	2	3	4	5	6	7
13. 実力向上の為に学んでいることをイメージする	1	2	3	4	5	6	7
14. 身体的機能を調整するイメージをする	1	2	3	4	5	6	7
15. 実力向上のために最近気になっているスキルや動作をイメージする	1	2	3	4	5	6	7
16. 次に起こることについてイメージする	1	2	3	4	5	6	7
17. 実際の動作やスキルにかかる時間とほぼ同じ速度でイメージする	1	2	3	4	5	6	7

18. 実際の動作やスキルにかかる時間より遅い速度でイメージする	1	2	3	4	5	6	7
19. 実際の動作やスキルにかかる時間より速いスピードでイメージする	1	2	3	4	5	6	7
20. 実際の試合スピードに合わせて一連のパフォーマンスをイメージする	1	2	3	4	5	6	7
21. 一連のパフォーマンスを実際の試合スピードより遅くイメージする	1	2	3	4	5	6	7
22. 一連のパフォーマンスを実際の試合スピードより早くイメージする	1	2	3	4	5	6	7
23. 最近新しく身につけたスキルをイメージする	1	2	3	4	5	6	7
24. 思った通りうまくできたパフォーマンスをイメージする	1	2	3	4	5	6	7
25. 試合で学んだことをイメージする	1	2	3	4	5	6	7
26. 新しくできるようになったことをイメージする	1	2	3	4	5	6	7
27. 最近獲得（かくとく）したスキルをイメージする	1	2	3	4	5	6	7
28. 試合中、ある瞬間に感じ得る特定の感情をイメージする	1	2	3	4	5	6	7
29. イメージをしながら感情をコントロールする	1	2	3	4	5	6	7
30. イメージをしながら試合の時と似た感情を感じる	1	2	3	4	5	6	7
31. イメージをしながら必要なすべての感情を思い浮かべる	1	2	3	4	5	6	7
32. イメージの内容によって感情が多様に変える	1	2	3	4	5	6	7
33. 一人称視点でイメージする（自分の眼で見るように）	1	2	3	4	5	6	7
34. 三人称観察者視点でイメージする（外側から見るように）	1	2	3	4	5	6	7
35. 鏡で自分を見るようにイメージする	1	2	3	4	5	6	7
36. 全知的視点でイメージする（すべてのことがわかるように）	1	2	3	4	5	6	7
37. 必要に応じて自由に多様な視点でイメージする	1	2	3	4	5	6	7
38. 相手、観客、コーチの視点でイメージする	1	2	3	4	5	6	7

Appendix 4: 35 Version of Sport Imagery Intervention Questionnaire (Chapter 5-Study 1, Study 2)

ここでは、あなたが競技力向上のために**イメージに関して以下を実施したことがあるか思い出してください。**そしてその程度を選んでください。(1=まったくない、4=どちらとも言えない、7=非常によくある)質問項目ついて適切な回答をしていただくために、できるだけ時間をかけてください。

専門競技を始めてからあなたは競技力を向上させるために 以下のことを実施したことがありますか?	まったくない			どちらとも言えない			非常によくあ
1. 試合で起こり得る場面をイメージし小さくジェスチャーする	1	2	3	4	5	6	7
2. スポーツ器具を持ってイメージをする（サッカーボール、ゴルフクラブなど）	1	2	3	4	5	6	7
3. イメージしながら体を動かす	1	2	3	4	5	6	7
4. 軽く体を動かしながら、類似のフォームをとりイメージする	1	2	3	4	5	6	7
5. 競技場と周辺環境をイメージする。（天気、競技場のコンディション、グラウンド状態、雰囲気など）	1	2	3	4	5	6	7
6. 実際のトレーニング環境や競技場に行ってイメージする	1	2	3	4	5	6	7
7. 観客の反応や競技場で発生し得る状況をイメージする	1	2	3	4	5	6	7
8. 実際の状況で経験できる感覚をイメージする（例:視覚、音、嗅覚、味、触覚）	1	2	3	4	5	6	7
9. 改善すべき特定のスキルをイメージする	1	2	3	4	5	6	7
10. 実力向上の為に取り組んでいることをイメージする	1	2	3	4	5	6	7
11. 身体的機能を向上させるイメージをする	1	2	3	4	5	6	7
12. 実際の動作やスキルにかかる時間とほぼ同じ速度でイメージする	1	2	3	4	5	6	7
13. 実際の動作やスキルにかかる時間より遅い速度でイメージする	1	2	3	4	5	6	7
14. 実際の動作やスキルにかかる時間より速いスピードでイメージする	1	2	3	4	5	6	7
15. 実際の試合スピードに合わせて一連のパフォーマンスをイメージする	1	2	3	4	5	6	7
16. 一連のパフォーマンスを実際の試合スピードより遅くイメージする	1	2	3	4	5	6	7
17. 一連のパフォーマンスを実際の試合スピードより早くイメージする	1	2	3	4	5	6	7

18. 最近新しく身につけたスキルをイメージする	1	2	3	4	5	6	7
19. 思った通りうまくできたパフォーマンスをイメージする	1	2	3	4	5	6	7
20. 新しくできるようになったことをイメージする	1	2	3	4	5	6	7
21. 獲得（かくとく）されたスキルをイメージする	1	2	3	4	5	6	7
22. 試合中、ある瞬間に感じ得る特定の感情をイメージする	1	2	3	4	5	6	7
23. イメージをしながら感情をコントロールする	1	2	3	4	5	6	7
24. イメージをしながら試合の時と似た感情を感じる	1	2	3	4	5	6	7
25. イメージをしながら必要なすべての感情を思い浮かべる	1	2	3	4	5	6	7
26. イメージの内容によって感情が多様に変える	1	2	3	4	5	6	7
27. 動画で自分を見るようにイメージする	1	2	3	4	5	6	7
28. スローモーションでイメージする。	1	2	3	4	5	6	7
29. 早送りでイメージする。	1	2	3	4	5	6	7
30. 普通のスピードでイメージする。	1	2	3	4	5	6	7
31. 相手、観客、コーチの視点でイメージする	1	2	3	4	5	6	7
32. 三人称観察者視点でイメージする（外側から見るように）	1	2	3	4	5	6	7
33. 自分の目線でイメージする	1	2	3	4	5	6	7
34. 自分から見た景色でイメージする	1	2	3	4	5	6	7
35. 一人称視点でイメージする（自分の眼で見るように）	1	2	3	4	5	6	7

Appendix 5: Subjective Performance Rating (Chapter 5-Study 1)

自分が思う自分の競技力 あてはまる番号に０をつけてください。

(Low) 1　2　3　4　5　6　7 (High)

Appendix 6: Imagery Intervention Status (Chapter 5-Study 2)

競技力を向上させるためにイメージトレーニングをしたり、
専門競技に関して何かをイメージしたりしたことがありますか？

あてはまる番号に○をつけてください。

1. あまりない　2. ない　3. ある　4. かなりある