

Institution: Manchester Metropolitan University		
Unit of Assessment: C24 Sport and Exercise Sciences, Leisure and Tourism		
Title of case study: The PETTLEP model for motor imagery: international application in sport psychology training and practice		
Period when the underpinning research was undertaken: 2000 – 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Paul Holmes	Senior Lecturer to Professor	1995 - present
David Smith	Lecturer, Senior Lecturer	1997 - 2000; 2008 - present
David Wright	Lecturer, Senior Lecturer	2013-present
Period when the claimed impact occurred: 1 August 2013 – 31 December 2020		
Is this case study continued from a case study submitted in 2014? No		
<p>1. Summary of the impact</p> <p>First described in 2001, the PETTLEP model has become one of the most prevalent methods to guide imagery interventions in sport. In the UK, it is now effectively part of the sport psychology 'national curriculum' – taught across all undergraduate- and postgraduate-taught sport psychology degree programmes, and most sport and exercise sciences courses (over 85,000 students in the UK alone since 2013/14). It is also taught at top-ranked universities worldwide. We estimate over half of active sport psychology practitioners worldwide regularly draw on PETTLEP to guide imagery interventions across more than 40 sports, especially at national level or higher. Self-reports from practitioners, and research studies, provide evidence that PETTLEP enhances confidence, reduces anxiety, and improves personal performance, supporting personal bests and Olympic qualification.</p>		
<p>2. Underpinning research</p> <p>In the late 1990s, research in neuroscience and cognitive psychology was uncovering the likely mechanisms underpinning imagery's contribution to motor performance, but the work was fragmented and lacked any overarching theoretical framework or application to sport. Holmes and Collins (Manchester Metropolitan, later University of Edinburgh) brought together this body of evidence to create the first theoretically- and empirically-based model to guide motor imagery interventions in sport [1]. This paper was published in the <i>Journal of Applied Sport Psychology</i>, a world-leading journal for applied sport psychology research. Nineteen years since its publication, the article remains the second most-cited article published in the 32-year history of this journal (see Section 3).</p> <p>The original research describes a rigorous conceptual framework based on empirical data and theory from psychology, neuroscience and cognitive science. The PETTLEP acronym is derived from seven behavioural elements, linked to the cognitive neuroscience of motor performance, which should be considered when designing imagery interventions: Physical, Environment, Task, Timing, Learning, Emotion and Perspective.</p> <p>The model was the first in sport psychology to advocate the use of highly-individualised imagery interventions, a significant break away from the typical group-based psychology approaches at the time. A key aspect of the model is the association of the image with the physical characteristics and experiences of the task, involving a multisensory approach, use of environmental cues, and incorporation of relevant sports clothing and implements. Holmes and Collins argued, (based on neuroscientific evidence), that PETTLEP imagery would engage and strengthen some of the shared neural networks involved in the execution of the imagined movement, terming this '<i>functional equivalence</i>'. Although this term had been used previously in the neuroscience literature, Holmes and Collins were the first researchers to establish and report the potential of this concept to optimise imagery practice in sport.</p> <p>Having published the PETTLEP approach, the research team then focused on validating the model through empirical research, with over 20 PETTLEP-related papers published to date by the team. For example, Smith (then at University of Liverpool) and Holmes showed that PETTLEP-based imagery significantly improved the putting accuracy of county-level golfers by 29% [2]. Following his move to Manchester Metropolitan, Smith also showed that the use of PETTLEP-based imagery in combination with physical practice improved golf bunker shot performance of national-level golfers by 22%, compared to an improvement of only 13% through physical practice alone [3]. Concurrently, Holmes was applying the findings, using PETTLEP for</p>		

the first time with England Golf and European Tour professionals as well as work with British Shooting.

Subsequent research focused on refining optimal delivery of PETTLEP interventions, with a focus on the dose-response relationship. For example, the team validated the model for improving performance in strength-based tasks [4], hence extending applications of PETTLEP beyond target-based sport skills. Smith demonstrated that a PETTLEP intervention improved one repetition maximum bicep strength, with increases of over 50% in novice weightlifters following a four-month intervention period, and greatest effects as the imagery dose increased.

The team also validated the underlying neurophysiological predictions of the model regarding functional equivalence (funded by the French Ministry of Sport and UK Sport). Working with national-level rifle shooters, Holmes and sport psychologist colleagues from Manchester Metropolitan demonstrated that a PETTLEP-informed intervention evoked cortical activity that was more similar to cortical activity recorded during movement execution than did non-PETTLEP-informed conditions [5]. Qualitative data indicated that the shooters found the PETTLEP-informed intervention to be the most engaging. These findings informed subsequent use of PETTLEP imagery by sport psychologists working with British Olympic shooters (see Section 4) and French Olympic Gymnasts.

In an extension of this research, the team currently focuses on integrating PETTLEP with simultaneous action observation. For example, Smith and Wright recently demonstrated that PETTLEP imagery, both with and without video observation, enhanced strength over an eight-week intervention period [6]. These findings are informing the applied use of PETTLEP in conjunction with action observation in elite sport settings and ensure that PETTLEP remains integral to current applied sport psychology practice.

3. References to the research

1. **Holmes** PS, Collins DJ, (2001). The PETTLEP approach to motor imagery: A functional equivalence model for sport psychologists. *J. Appl. Sport Psychol.* 13(1):60-83. DOI: 10.1080/10413200109339004.
2. **Smith** D, Holmes P, (2004). The effect of imagery modality on golf putting performance. *J. Sport Exerc. Psychol.* 26(3):385-395. DOI: 10.1123/jsep.26.3.385.
3. **Smith** D, Wright CJ, Cantwell C, (2008). Beating the bunker: The effect of PETTLEP imagery on golf bunker shot performance. *Res. Q. Exerc. Sport* 79(3):385-391. DOI: 10.1080/02701367.2008.10599502.
4. Wakefield C, **Smith** D, (2011). From strength to strength: A single-case design study of PETTLEP imagery frequency. *Sport Psychol.* 25(3):305-320. DOI: 10.1123/tsp.25.3.305.
5. **Holmes** PS, Collins DJ, Calmels C, (2006). Electroencephalographic functional equivalence during observation of action. *J. Sports Sci.*, 24(6): 605-616. DOI: 10.1080/02640410500244507.
6. **Smith** D, Romano-Smith S, **Wright** DJ, Deller-Rust B, Wakefield CJ, (2020). The effects of combining PETTLEP imagery and action observation on bicep strength: A single-case design. *J. Appl. Sport Psychol.* 32(4):377-391. DOI: 10.1080/10413200.2018.1560372.

Additional indicators of quality

- Reference [1] established a theoretical and empirically-supported framework for a new area of academic psychology research now described universally as 'functional equivalence'. The paper has garnered 250 citations compared to Journal Expected Citations of just 66.95 (WoS, accessed 16 December 2020).
- Reference [1] is included as key reading on 63% of relevant UK sport psychology/sport and exercise sciences courses in the UK; the current editions of popular key sport psychology texts (e.g. *Foundations of Sport and Exercise Psychology* by Weinberg & Gould) include sections detailing PETTLEP (see Section 4).
- In their 2010 book, *The Neurophysiological Foundations of Mental and Motor Imagery*, authors Guillot and Collet state: "...no model comparable to PETTLEP currently exists for creating more functionally equivalent observation interventions."

Grants and Funding

- Examination of the neurophysiological processes during simulated motor acts. French Ministry of Sport. 2003-2008. Three projects, total awards value EUR39,000 (01-2003). Manchester Metropolitan project lead: Holmes (named UK project consultant and author for all published outputs in English with Calmels, INSEP, France).

- Research and development of international coach education material. International Shooting Sport Federation. 2009-2011. Total award: EUR26,000 (01-2009). PI: Holmes.

4. Details of the impact

Until Holmes and Collins published the PETTLEP model (reference [1]), no structured guidelines existed for the development of motor imagery interventions in sport. Nineteen years on, PETTLEP has become an essential component of sport psychology, and sport and exercise sciences teaching and training around the globe. It is the gold standard for imagery interventions; we estimate over half of practitioners worldwide regularly utilise PETTLEP for their imagery interventions, working with athletes across many sports, from Olympians to amateurs.

A standard element of sport psychology teaching

Analysis of data from all UK universities offering sport and exercise sciences or sport psychology degree programmes has revealed that PETTLEP is embedded in the curriculum across these subjects. All undergraduate and taught postgraduate sport psychology programmes in the UK include PETTLEP in their course content [A]. Significant numbers of students are also exposed to the model as part of sport and exercise sciences (SES) programmes: 89% of undergraduate and 90% of postgraduate taught SES programmes cover PETTLEP [A]. Using Higher Education Statistics Agency (HESA) student record data, we estimate that approximately 11,000 students learn about PETTLEP annually as part of sport psychology and SES courses. We, therefore, estimate that over 85,000 students in the UK (academic years 2013/14 to 2020/21) have encountered the model during their studies [A,B].

Although focused on the UK, our survey indicates that PETTLEP is also taught outside of the UK, based on responses from universities in 17 countries. These institutions include the University of Copenhagen and the University of Queensland, ranked first and fifth in the Shanghai World Sport and Exercise Science Department rankings (2018), respectively [A]. Even universities placed outside of the top 1,000 in the Times Higher Education World University Rankings 2020 reported that they included the model in their teaching; this indicates PETTLEP is integrated into higher education teaching across institutions of differing sizes, prestige, and teaching and research focus [A,B]. As Morris, lead author of the textbook *Imagery in Sport: The Mental Approach to Sport*, states: "...the model [is] ubiquitously taught in universities" [C].

The original Holmes and Collins PETTLEP paper features on course reading lists at over half of providers in the UK and internationally; more significantly, textbooks that feature PETTLEP are recommended to students by all providers [A]. All the key international English language textbooks in the field of sport and exercise psychology now reference the PETTLEP model and advocate it as an evidence-based way of structuring and delivering motor imagery interventions. Weinberg and Gould's *Foundations of Sport and Exercise Psychology* cites numerous studies supporting the model; it focuses on PETTLEP when explaining how to develop an imagery training programme, with detailed evidence-based instructions based on its components [D]. According to the publisher, PETTLEP has been included in all editions of *Foundations of Sport and Exercise Psychology* since 2003; this is the most popular sport psychology textbook worldwide and 134,000 copies have been sold worldwide since its first edition [E]. The textbook is used by 63% of UK undergraduate Sport Psychology or Sport and Exercise Sciences courses [A]. Other leading sport and exercise psychology textbooks covering PETTLEP include Moran's *Sport and Exercise Psychology: A Critical Introduction*, and Lane's *Sport and Exercise Psychology (Topics in Applied Psychology)* [D].

This evidence base shows that the model is regarded as significant for sport psychology practice and is effectively part of the 'national curriculum' taught to the next generation of sport psychologists and sport scientists throughout the UK and worldwide.

PETTLEP in practice: used by over half of sport psychologists worldwide

Analysis of submissions to an open online survey on the use of PETTLEP suggests that it has been applied to structure effective imagery for performance athletes in most sports. Of 78 active practitioners from 13 countries who responded, 63% reported using PETTLEP in their applied work with athletes [F]. Within this group, 90% of practitioners said the model substantially informed their work (i.e. at least half of interventions). Despite the small sample, the data suggest that more than half of active imagery practitioners worldwide may regularly use PETTLEP [F]. These survey data are complemented by the views of experts in the field: for example, Morris states: "PETTLEP is certainly the most widely used model in guiding imagery training and has become the dominant model for structuring imagery interventions in sport" [C].

Since 2014, PETTLEP has been used with participants across at least 43 different sports (athletics, swimming and golf as the top three disciplines mentioned in the survey); our survey suggests over 40% of interventions are with topflight (national and international) athletes. PETTLEP has been used with elite soccer players (English Premier League), professional rugby league teams, professional snooker players, NFL footballers, Major League baseball players, professional golfers, world championship level dancers, and Olympic athletes in various sports in the UK, US, Ireland and New Zealand [F].

Building on the impacts in teaching and practice reported above, we describe how the model is deeply embedded across two sports – shooting and canoeing – to illustrate both the reach and significance of the impact. PETTLEP was championed from early on by British Shooting's former Performance Director, who recognised its direct relevance to target sports. Now Rifle and Pistol Manager (Olympic), he states: *"Almost all the psychologists who work with athletes in British Shooting's World Class, Podium and Podium Potential Programmes adopt the key principles of PETTLEP... all athletes will experience some PETTLEP intervention points during their development. One of the reasons why PETTLEP has been so successful and widely adopted as a model in sport psychology is the framework it provides for psychologists and coaches to adopt and adjust their interventions to individual athletes"* [G]. The current Lead Psychologist at British Shooting describes the impact of video-based PETTLEP sessions for Olympic shooters during the coronavirus lockdown. *"Coaches agreed to adopt the model into their coaching as they could see how PETTLEP could provide a rich experience in the absence of a "real world" shooting experience... The best feedback is the commitment of athletes to the sessions. These are elite athletes and they won't spend time on things that they don't feel support their performance. So certainly, the athletes think this imagery-based approach has been significant for them... The coaches also want to continue using PETTLEP. They now understand and appreciate the benefit of this model as part of an elite coaching environment"* [G].

British Canoeing advocated PETTLEP in its Coaching Handbook back in 2006 and the model is now firmly embedded in the discipline's psychology support and practice at all levels, including younger paddlers. For example, the model is included in core support curriculum for young people on the prestigious national Talent Programme (10% will eventually make a GB team); their parents receive parallel education about PETTLEP through the Talent Parent Programme, which launched in 2019 [H].

The benefits of PETTLEP: enhancing athlete performance

In our survey, almost half (47%) of respondents said that PETTLEP's main benefit was to enhance the performance of athletes, although nearly a third noted improved athlete buy-in/enjoyment of imagery, 16% reported enhanced confidence and 16% better anxiety management/arousal regulation [F].

A psychologist working with an Olympic swimmer prior to Rio 2016 noted that when integrated with video-guided imagery *"PETTLEP made a significant contribution to his technique and performance."* The swimmer broke the national record and achieved a personal best at the Olympic Games. A US practitioner also testifies: *"PETTLEP imagery helps [baseball] athletes modify/improve their movements, specifically their movement mechanics."* A psychologist who supported the five-medal-winning England Shooting team at the Glasgow Commonwealth Games in 2014 says: *"PETTLEP helps and increases confidence in those I work with, and leads to marginal gains, which in performance sport can have a great impact."* Practitioners also reported using PETTLEP with injured athletes to overcome performance anxiety; they said it contributes to recovery from injury, improves athlete self-efficacy and mind set, and has supported memorable medal wins [I]. In relation to the overall benefits of applying the PETTLEP model, one practitioner claims: *"I can confidently say that the improvements I have observed following imagery training and practice among my athletes have been largely driven by the PETTLEP-based framework I use to construct their imagery program"* [I].

British Shooting's Rifle and Pistol Manager (Olympic) describes how PETTLEP has helped a GB shooter hoping to qualify for the Tokyo Olympic Games: *"...he has observed how the imagery has made him more confident and has correlated with his rapid improvement in his competition World and European rankings... His resulting ability of analysis and combining dry fire and mental imagery in real time have enabled him to better understand and manage his emotional state towards developing an optimal state for high performance. This has been corroborated by live firing after the long initial [COVID-19] lockdown period"* [G].

PETTLEP use outside of sport

PETTLEP is now applied in other fields of physical performance. Speaking about her dance teacher students, the Head of Learning and Teaching the London Dance Studio (formerly at the Royal Academy of Dance) , remarks: *“It was clear that the use of PETTLEP imagery helped to improve their dance technique. I have now embedded PETTLEP imagery into my practical dance classes for student teachers... PETTLEP is having a significant impact on both professional dance teaching practice, and hence, on dance itself” [I]*.

PETTLEP imagery is emerging across a variety of physical practices, including music performance and surgeon training. Raison *et al.* (2018) tested the efficacy of PETTLEP imagery training on the performance of robotic surgery tasks in novice surgeons, and found significant improvements in surgical task performance in the PETTLEP group compared to the group that received only standard training, pointing to its future integration into surgeon training [J].

5. Sources to corroborate the impact

- A. Evaluation report ‘The teaching of PETTLEP imagery on undergraduate and postgraduate sport psychology-related courses’ *provides evidence on the inclusion of PETTLEP as part of sport and exercise sciences, sport psychology and sport coaching programmes in the UK and overseas.* Data from the Shanghai World Rankings for Sport and Exercise Science Departments (2018) and the Times Higher Education World University Rankings 2020 gives *evidence of global rankings of these institutions.*
- B. An analysis using HESA Student record data *provides estimates of student numbers encountering the PETTLEP model during studies since the start of academic year 2013/14.*
- C. Testimonial from author of *Imagery in Sport: The Mental Approach to Sport* provides *evidence that PETTLEP is the most widely-used model for imagery interventions.*
- D. Extracts about PETTLEP taken from the popular textbooks *provide evidence of its ubiquitous international acceptance within sport psychology teaching and practitioner training.*
- E. Statement from Human Kinetics, publisher of Gould and Weinberg’s *Foundations of Sport and Exercise Psychology* provides *evidence of international sales figures.*
- F. Survey evaluation report ‘The use of PETTLEP imagery by sport psychology practitioners’ *provides evidence on the reach and significance of the application of PETTLEP in sport psychology practice and athlete benefits worldwide.*
- G. Statements from Rifle and Pistol Manager (Olympic) and current Head of Culture and Lead Psychologist at British Shooting *give evidence that PETTLEP is embedded into elite psychology support in the discipline.*
- H. Webpage for British Canoeing’s Talent Parent Programme *includes materials and a video about using the PETTLEP model to help athletes cope with nerves. The video has been watched 104 times (YouTube, accessed 30 November 2020).*
- I. Testimonials from active practitioners (three sport psychologists and one dance teacher) *describe the performance improvements they attribute to PETTLEP-based interventions.*
- J. Raison N, *et al.* (2018). Cognitive training for technical and non-technical skills in robotic surgery: a randomised controlled trial. *BJU Int* 122:1075-1081. doi:10.1111/bju.14376.