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Practical Proprioception: An Examination of a Core Physiological Foundation for Physical Performance Training.

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An Examination of a Core Physiological Foundation for Physical Performance Training.

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PRACTICAL PROPRIOCEPTION:

An Exploration of a Core Foundation for Physical Performance Training.

Contents

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Abstract:

Proprioception is both the means by which people naturally have a pre-reflective awareness of their bodies, and the mechanism by which performers (and others) can develop advanced levels of bodily awareness in the service of physical skill and psychophysical fluency. These two qualities are amongst the most important for contemporary performers, and this thesis demonstrates how an understanding of proprioception and its enhancement provides a strong foundation for performance training.

The original contribution to knowledge in this thesis is to cross epistemological boundaries and bring the scientific research, theory and discourse to the field of actor training, where previously this has not been done. This thesis synthesises theories and definitions of proprioception to provide a clear and comprehensive overview, establishes the functions that proprioception performs, maps relationships between proprioception and related terms and concepts, and argues that proprioception provides a comprehensive model for a core physiological foundation for physical performance training.

The research questions under investigation are ‘Can proprioception in physical performers be improved and if so, how will increased proprioception be of benefit to the performer?’ Two research studies are carried out to investigate whether proprioception could be improved in physical performers after targeted proprioceptive training. The studies also explore what benefits the performers accrued during the training and how improved proprioception manifested in their levels of performance. The studies show that proprioception can be improved in performers after participating in proprioceptive training, and demonstrate, explore and evidence that this improvement brings an enhancement in physical performance. Methodologically, an approach is proposed to evaluate training practices which is based in a practice led research paradigm. This research is of interest to actors who use their bodies for specialist skilled movement in training and performance and who undertake a physical approach to their work, and particularly pertinent to actor trainers, providing a rationale to inform, support and enhance training methodologies.

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Chapter 1.

1.1 Introduction.

Proprioception is both the means by which people naturally have a pre-reflective awareness of their bodies, and the mechanism by which performers (and others) can develop advanced levels of bodily awareness in the service of physical skill and psychophysical fluency. These two qualities are amongst the most important for contemporary performers, and the thesis will demonstrate how an understanding of proprioception and its enhancement can provide a strong foundation for performance training.

My background as a trained physiotherapist and physical performer has put me in a privileged position to see firsthand how useful proprioception can be to those training to improve their physical performance capabilities. Proprioception came to my attention during my physiotherapy training and has informed all my work to date, with both disabled and non-disabled performers. Working with disabled performers has provided me with particular insight into what happens when the proprioceptive system isn't working as well as it should, and the consequent challenges performers face. This work has in turn informed my work with non-disabled performers by showing me that physical training can be accelerated and advanced by training proprioception and that many benefits, such as improved performance and increased performance lifespan, occur as a result of this training.

Combining my respective science and arts training, this thesis will seek to discover how proprioception can be enhanced, and will pursue this investigation in the context of training actors in the performance training studio. This thesis will bring my physiotherapeutic knowledge and physiological and anatomical understanding to impact on my performance training and my movement work with actors in a rigorous and evidenced manner. This research is pertinent to actors who use their bodies for specialist skilled movement in training and performance and who undertake a physical approach to their work, (hereby referred to as 'physical performers') and is intended to support those practitioners who train physical performers by giving them a rationale and a foundation for physical performance training.

The domain of the physical performer.

Throughout this thesis, I will make reference to the term ‘physical performer’. As a movement director, I acknowledge that all actors need to use their physicality on stage, and appreciate that ‘all theatre/performance cannot but be physical’ (Zarrilli, 2010, 175), but for the purposes of this thesis, I am making a distinction between what we might think of as text-based character actors and those performers whose work necessarily involves significant physical challenges. The benefits to training that this thesis offers are primarily within a physical domain and involve working towards achieving corporeal fluency and physical expressiveness.

I intend the term ‘physical performer’ to include individuals engaged in a broad range of performance activities - from the development of character physicality to the realisation of dance theatre choreographies. It encompasses performers who work with highly physical acrobatic skill, such as those found in companies like DV8 and Frantic Assembly, those who work with clowning, masks (both physical and archetypal), and those who embrace movement training as a necessary part of their development as an actor.[1]

Examples of physical demands on the performer.

As mentioned above, theatre practice places many physical demands on the performer, and the need for a commitment to physical training has been underlined by many practitioners, including Grotowski, Barba, Meyerhold and Lecoq (Wolford in Hodge, 2000, Watson in Hodge, 2000:209; Potter, 2002:4, Murray and Keefe, 2007:9).

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[1] I acknowledge the availability of the term ‘physical theatre’, but as Zarrilli underlines, ‘The term ‘physical theatre is problematic and awkward’ (Zarrilli, 2010:175). I prefer the term ‘physical performer’, which unlike ‘physical theatre’, doesn’t suggest a genre, but rather emphasises the important inherent

The Polish theatre director Jerzy Grotowski (1933 – 1999) has been 'arguably one of the most influential figures in the development of experimental theatre and actor training techniques' in the twentieth century (Wolford in Hodge, 2000:191). His career included various phases[2], and within the Theatre of Productions phase, the group (formally known as the Theatre of 13 Rows), changed its name to the Laboratory Theatre Research Institute of Acting Method, marking the group's interests in pursuing research aims and disseminating their findings concerning actor training techniques (Slowiak and Cuesta, 2007:24). Exercises practised by his actors in the Laboratory Theatre were very 'physically demanding and could be interpreted as athletic or even acrobatic' (Wolford in Hodge, 2000:200). The training served not only to develop important physical capacities such as 'strength, agility, stamina, flexibility and gestural articulation', but also worked towards more subtle levels of increasing the actor's receptivity[3] to themselves and others (Wolford in Hodge, 2000:205).

Eugenio Barba, the Italian born director of the Odin Teatret (founded in 1964), spent time in Poland in the early 1960s observing the work of Jerzy Grotowski. He has been described as 'one of those rare theatre people who combines the creativity of an artist with the more reflective skills of a researcher, theorist and teacher (Watson in Hodge, 2000:209). He conducts his research under his International School of Theatre Anthropology (ISTA) and has produced '*A Dictionary of Theatre Anthropology'* (Savarese and Barba, 2005), which is a resource book for actors, scholars and practitioners, documenting some of the work of the ISTA. In the *Dictionary*, are 'cumulative bits of 'good advice' for the 'actor's work on himself' which focus on… such phenomena and performative circumstances as the actor's 'anatomy', 'balance', 'dilation', energy' or 'rhythm' (Zarrilli, 2002:88). Training has been a major factor in Barba's approach to theatre since Odin was formed, and is physically demanding in form. Barba's training with his Odin actors went through many phases over the years, but at times involved his actors participating in physical explorations of balance and weight distribution. They did this by attending to principles of opposition (where opposing body tensions are employed to create a

[2] These phases were: Theatre of Productions, Theatre of Participation (or Paratheatre), Theatre of Sources, Objective Drama, and Art as a Vehicle. For more on all these phases of Grotowski's work, see Slowiak and Cuesta (2007).
[3] The Laboratory Theatre's training of receptivity involved enhancing the actor's receptivity to impulse, which is defined in more detail in Chapter 5:1.

dynamic on stage), and by the use of distorted equilibrium to alter muscular tensions during performance (Watson in Hodge, 2000:216).

Vsevolod Meyerhold was an early pioneer in the development of Western actor training methods (Hodge, 2000:1). He was a former actor with Stanislavsky at the Moscow Art Theatre, who went on to develop his own, distinct working methods (Hodge, 2000:5). He wrote in 1914 that ‘Movement is the most powerful means of theatrical expression’ and that ‘the role of movement is more important than that of any other theatrical element’ (Meyerhold in Leach, 1993:48). Meyerhold detailed the desire for his actors to develop a variety of physical skills to provide solid awareness of balance, control and expressiveness in their bodies (Meyerhold in Potter, 2002:4). A foundation of Meyerhold’s training was his Biomechanics:

> Meyerhold’s biomechanical *etudes,* the key-stone of his actor training, were an inspired fusion of both Taylor and Pavlov’s respective systems. From Taylor’s ‘work cycle’ Meyerhold took the idea of a smoothly executed, rhythmically efficient action, punctuated with rest periods or pauses. From Pavlov, he borrowed the concept of a chain of reflex responses, described in *Conditioned Reflexes* as ‘the foundation of the nervous activities of both men and of animals’ (Pavlov, 1921:11). Together they formed Meyerhold’s notion of the ‘acting cycle’.[4]
>
> Pitches, 2005:112

His ‘Biomechanics’ require of the actor, and concurrently train, the following physical demands: ‘(1) balance (physical control); (2) rhythmic awareness, both spatial and temporal; and (3) responsiveness to the partner, to the audience, to other external stimuli, especially through the ability to observe, to listen and to react’ (Leach in Hodge, 2000:43).

Jacques Lecoq (1921-1999) was an actor and teacher who founded his Paris based school for trainee actors in 1956. He is notable in the history of twentieth century movement training as ‘the only significant theatre pedagogue with professional experience in sports and sports therapy’ (Evans, 2012:168). The pedagogy of Lecoq’s school is shaped around a ‘total physical engagement with the creative challenges facing the actor’ (Evans, 2012:168), in particular encouraging the

[4] For more detail on Meyerhold’s Biomechanics and the work of Taylor and Pavlov, please see Pitches (2005) and Gordon in Zarrilli, (2002).

‘athleticism, agility and physical awareness of the creative actor’ (Evans, 2012:164). For Lecoq, ‘movement, as manifested in the human body, is our permanent guide in this journey from life to theatre’ (Lecoq, 2002:160), and so his training involves human movement analysis as a starting point for creating work, including character. Lecoq was clear that the analysis of physical action is not just an academic exercise, but is rather about ‘acquiring physical awareness which will form an indispensible basis for acting’ (Lecoq in Evans, 2012:171). In the following quotation, we can see some of the many aspects of movement that Lecoq wanted his performers to understand and to be able to manipulate in practice,

> Movement is more than just a matter of covering the distance between points A and B. The important thing is *how* the distance is covered. The laws of movement have to be understood on the basis of the human body in motion: balance, imbalance, opposition, alternation, compensation, action and reaction.
>
> Lecoq, 2002:17

These ‘laws of movement,’ for Lecoq, are what enable an actor to have a better control and utilisation of her body. Proprioception underlies such ‘laws of movement’; it is a physiological basis for all action and for the ability to react physically to any stimuli. Balance and imbalance rely directly on proprioception, as do the muscular fine-tunings involved in opposition, alternation and compensation, all of which arise from the ability to feel opposing muscle groups and sense the position of body parts in relation to each other, and the tension at which they are working. The resultant physical awareness that Lecoq states above as ‘an indispensable basis for acting’ (Lecoq in Evans, 2012:171) is made possible by proprioception. This mechanism of proprioception will be explored in more detail in Chapter 3.

Since the practice of Russian actor and theatre director Stanislavsky (1863 – 1938) came to prominence, there has also been a concern for actors to work ‘psychophysically’; that is, operating out of a unified mind and body. Director and internationally renowned actor trainer Phillip Zarrilli, best known for training his actors through Asian martial arts and yoga, has provided a body of work dedicated to exploring how psychophysical training can benefit the contemporary actor (2009). He charts the use of the term ‘psychophysical’ and provides a historical overview from Stanislavsky’s first usage of the term to how it is used today. Zarrilli argues for the benefits of Eastern practices (such as the martial art form Kalarippayattu) in the work of cultivating body-mind unity within actor training techniques (Zarrilli, 2009). Zarrilli's own approach to psychophysical acting does not begin with psychology or emotion, but rather with work ‘preparing the actor’s body, mind, sensory awareness/perception and energy for the expressive work of the actor’ (Zarrilli, 2009:8). Indeed, for Zarrilli, one of the key ways in which an actor can bring together body and mind is as a function of raised 'sensory awareness/perception', achieved through working with the breath. Here, too, proprioception will be seen to be the key mechanism being enhanced as trainees extend their sensory awareness and develop greater degrees of psychophysical integration.

As Nicolás Núñez[5], a Mexican theatre practitioner, says when discussing what it means to be a performer:

> It is someone who ‘accepts the commitment of learning, in as much depth as possible, about his psychophysical instrument.
>
> Núñez, 1997:66

He concludes that ‘if he discovers it in its entirety, he becomes a performer’ (Núñez, 1997:66). Lorna Marshall[6], a theatre practitioner specializing in the movement of the actor, suggests that most teachers or practitioners would share this objective. Her aspiration for performers, expressed as ‘fully owning the body’ (Marshall, 2001), implies that performers should take responsibility for their bodies through developing a practical knowledge of how it works and an advanced capacity for utilising all of their psychophysical potentials. Actors and performers are often encouraged to have a deeper awareness of, and better engagement with, their psychophysical mechanism and its movement potentials. Physical performers and actors are advised to take an active interest and delight in their body’s mechanics and

[5] The work of Núñez can be explored in more detail in the work of Middleton (2009). ‘The work of Nicolas Núñez and his collaborators at the *Taller de Investigacion Teatral* (Theatre Research Workshop/TRW) in Mexcio City offers an activity that responds to both ritual and theatrical imperatives and that integrates religious sources as transferable psycho-physical practices’ (Middleton, 2009:41).

[6] Lorna Marshall has taught physical acting at the Royal Academy of Dramatic Art in London, and has worked internationally as a director and performance consultant.

workings, since the ‘key site of performance is the human body’ (Marshall in Murray and Keefe, 2007b:159). Proprioception is the sense through which we are able to pay this active attention to our bodies, and is the physiological basis for the enhanced awareness desired by so many theatre practitioners.

Awareness.

Body awareness is, at its simplest, the bringing of attention to the body and its felt experience. Zarrilli describes the use of Asian martial arts and yoga to help “attune” the body and mind in order to work psychophysically, and he notes the role of body awareness in achieving this (Zarrilli, 2009: 31). Developing the ability to place and sustain attention and awareness on the body can be seen as a key concern within a range of performance training processes. As Zarrilli underlines, ‘Intensive body training must first awaken in the participant an awareness of the body which has been missing from his or her experience and understanding of the acting process’ (Zarrilli, 2009:31). That bodily awareness is possible because of the neurophysiological mechanism of proprioception. It is because of proprioception that we are able to generate an intrinsic awareness of our bodies at all, and it is through developing proprioceptive acuity that performers are able to attain the heightened awareness of which Zarrilli speaks, as well as advanced levels of skills such as balance and better control over how our nervous system communicates with our muscular system to produce movement. In other words, improving proprioception helps performers to develop detailed bodily awareness and improve their neuromuscular control.

Rebecca Loukes, a theatre practitioner who trained with Zarrilli, and whose research interests lie in the area of body awareness practices, highlights the importance of performers being ready to react and respond appropriately to stimuli around them. She explains how actors need to be able to carry out specific actions, reactions and responses to stimuli (Loukes, 2006:395), such as physical gestures, choreography and undertaking a physical score as demanded by a rehearsal process.

Proprioception allows us to carry out such actions, reactions and responses with appropriate placement, force and sensitivity to the environment.

Despite the importance of proprioception in bodily awareness and in enabling all our bodily movements, it is a term that is rarely used within theatre discourse. Within a theatre context, Zarrilli briefly discusses this core concept of proprioception in relation to modes of perception, and the word 'proprioceptor' is included in the glossary of the 2007 Murray and Keefe book, '*Physical Theatres: A Critical Introduction',* where it is defined as a sensory receptor which receives stimuli from within the body, and one that particularly responds to position and movement' (Murray and Keefe, 2007:211). There is no further mention from the authors as to what proprioception is or how it is a useful concept for actors or physical performers. In a scholarly context, Professor Nicole Potter[7] also uses the term 'proprioceptive awareness' when discussing the work of Director Erika Batdorf[8], although here, the term appears in brackets with no further explanation or expansion of the term and why it is used (Potter, 2002:231). These are some of the rare usages of the term proprioception that can be found within the theatre field. Although the term fares slightly better in literature on dance, where it is beginning to generate interest, here too, mentions of proprioception lack full and clear definition of what the term entails. In the cases where there is mention of proprioception, we lack a full and clear definition of what the term entails. This thesis will serve to conduct a thorough multidisciplinary literature review of research and theory relating to proprioception and closely related concepts and terms.

This thesis will explore the fullest definitions of proprioception, and will provide a detailed understanding of how proprioception (and related neurological factors) relate to performance training. Those terms which are closely related to proprioception and used within theatre, dance, philosophy and other fields will be explored in depth as part of the literature review later in this thesis, and the relationships between them mapped. Understanding more about proprioception and other closely related philosophical and neuroscientific concepts, such as 'body maps', 'body schema' and 'body image' may well support actors, physical

[7] Potter has produced the book 'Movement for Actors' (2002), detailing different approaches to movement training for actors.
[8] Batdorf is an artist practicing internationally, who has written about, created, performed, directed and choreographed original movement theatre since 1983.

performers, and those who train them to engage with a physical and psychophysical approach to actor training and help illuminate their journey into enhanced body awareness. In particular, I will argue that an understanding of proprioception provides a context and a language through which we can better understand and manipulate body awareness in the service of performance skill. The following hypothesis: **Proprioception in physical performers can be improved with specialised and focussed proprioceptive training**; will also be investigated in a practice led research paradigm, with an exploration into how improved proprioception can benefit levels of performance and provide an approach to evaluating efficacy of practice for theatre training methodologies.

Evaluating Practice and Methodologies.

The fields of sports and athletics have been evaluating the efficacy of their training for many years, bringing together sports science, medicine and performance. These evaluative practices often include studies undertaken by researchers, sports scientists, physiotherapists amongst others, to demonstrate that certain training can enhance performance and/or lead to fewer injuries. Techniques developed in the fields of biomechanics and sports science have been responsible for working with athletes to enhance many different facets of their performance from accuracy of swing for golfers, foot placement for sprinters and hand and arm coordination in tennis players to analyse and improve their serve. These partnerships between the athletes, trainers and the fields of sports science, physiotherapy and biomechanics have contributed to athletes' performances being enhanced, in measurable ways such as increased stamina and fitness, reduction in injury and improved balance, limb position, speed, reactions and muscular control (Lee and Lin, 2008, Toledo *et al*, 2004, Muiadi *et al*, 2009). This interaction between the science field and the sports field has generated many positive results and the ability to tailor training to better serve the athlete.

The dance world is also embracing the crossing of epistemological boundaries and as a result has seen the emergence of organisations like IADMS (International

Association for Dance Medicine and Science), which was formed in 1990 by a group of dance medicine practitioners, dance educators, dance scientists and dancers. The purposes and objectives of IADMS are as follows:

> IADMS enhances the health, well-being, training and performance of dancers by cultivating educational, medical and scientific excellence.
>
> IADMS website: www.iadms.org

The organisation runs large conferences which bring together the dance world and the science fields to disseminate examples of good practice, health news and advances in training and performance. The result has been significant changes in training and dance education to better improve outcomes for dancers. The website and accompanying journal has a wealth of resources outlining how research can support dancers and dance educators striving towards better performance, health and longevity of performing life.

Recent funding from the Legacy Trust and the Cultural Olympiad has supported projects that have attempted to bridge the gaps between the arts and science fields. 'IMove' is a programme of events in Yorkshire which has supported collaborations between scientists and artists to address 'how we feel in our moving bodies', by 'celebrating and exploring human movement' (IMove mission statement, www.imoveand.com). One of the collaborations brought together artists (including myself) and sports scientists in Sheffield Hallam's Motion Capture laboratory to explore what the scientists could offer the artists in terms of enhancing performance and providing a different perspective on the examination and analysis of human movement. One of the results of the project was the ability to use the high-speed cameras in the Motion Capture laboratory to analyse movement in more depth than the human eye can see. The cameras take up to 200 frames per second to allow each flicker of movement to be seen passing through the body. It allowed us to see proprioception in action and close up. Some clips from the high-speed camera will be explored in more depth later in this thesis.

Although steps are starting to be made, particularly in the approach to the Olympics, it is still rare to see scientists working alongside physical performers working within a theatre context. Despite the physical demands placed on physical performers in their training, such as the capacity to be able to move fully and freely with precision, to be able to perform detailed physical scores and choreography, to have a solid awareness of balance, control and expressiveness in their bodies and to have an advanced understanding and capacity for movement generally, there is very little research demonstrating the efficacy of training modalities or methodologies. As Professor Mark Evans, who has written in depth about the movement training of actors and performers describes:

> Movement training for actors stands in interesting relation to other subjects such as sport, gymnastics, industry, education and medicine in so far as it represents a field of body practice which has been subject to very little in terms of either quantitative or qualitative research.
>
> Evans, 2009:2

This thesis aims to address this gap in the field and quantitatively and qualitatively evaluate the efficacy of a proprioceptive training methodology. It will do so by framing the research undertaken in a practice led paradigm, as 'Practice As Research'.

Practice as Research and Practice led Research.

This research can be located within a 'Practice as Research' (PaR) paradigm, identifying as 'Practice led research'. Practice as Research (PaR) is becoming an established form of research activity, particularly for those working within the creative fields. This can be seen in the field of actor training, to which this thesis relates. As Professor Jonathan Pitches[9] notes: 'Research into the processes of performer training has enjoyed an explosion of activity in recent years' (Pitches in Kershaw and Nicholson, 2011:137).

PaR is a contested notion, with many differing definitions and viewpoints on what actually constitutes PaR. As academic Dr. Angela Piccini notes, Practice as research (PaR) remains a troubling term that 'resists close definition' (Piccini, 2004: 192). Senior Theatre Lecturer, Melissa Trimingham, after attending the 2001 PARIP

[9] Jonathan Pitches is a Professor of Theatre and Performance at the University of Leeds, where he is Director of Research and Leader of the Practitioner Processes Group.

(Practice as Research in Performance) conference, noted that 'everything concerning PaR is at present still in a state of flux' (Trimingham, 2002:54). In the ten years that have passed since that conference, there is still no conclusive definition of PaR, although many have attempted to more clearly define the terrain.

There are a number of terms affiliated with PaR: Performance as Research, practice based, practice led, and practice through research (Smith and Dean, 2009), many of which are used interchangeably. In their 2012 report on PaR for the Higher Education Academy, Boyce-Tillman *et al* (2012), split PaR into two types: practice based and practice led (Boyce-Tillman *et al*, 2012:10). In practice based research, the creative work produced acts as the form of research whereas practice led research is about practice leading to research insights (Smith and Dean, 2009:5). Boyce-Tillman *et al* go on to explain that 'practice led research concerns the nature of practice and is concerned with originality in the understanding of practice in a particular area' (Boyce-Tillman *et al*, 2012:10). This thesis is located within a practice led paradigm as it doesn't produce creative work as the form of research (as found within practice based research) and instead is concerned with the nature of practice, and understanding physical performer training practice within the newly explored contexts of neuroscience and physiology.

Trimingham suggests that PaR is 'doing itself no favours by claiming that 'all practice is research' (Trimingham, 2002:54). She takes a firmer line, suggesting that 'all practice is relevant to research but does not necessarily contribute to research until it is subject to analysis and commentary, using a language that aims to be as clear and unambiguous as possible' (Trimingham, 2002:54). Trimingham underlines the need for research findings to be clearly articulated and disseminated and the need not to be wary of more traditional research demands such as a clear methodology. She goes on to state that 'methodology underpins research and gives credibility to research outcomes' (Trimingham, 2002:55).

Some PaR practitioners don't see the need for a clear methodology. In Kershaw and Nicholson's[10] recent book on research methods in theatre and performance, they

[10] Baz Kershaw was Professorial Research Fellow in Performance at Warwick University and led the PARIP project. Helen Nicholson is Professor of Drama and Theatre at Royal Holloway, University of London.

look at more creative approaches to research practice. They structure the book with writing from a wide community of scholars working and researching within theatre and performance:

> The authors' creative approaches to research practices offer an implicit challenge to outmoded perceptions that the terms 'method' and 'methodology' imply an attempt to capture, codify and categorise knowledge.
>
> Kershaw and Nicholson, 2011:1

Kershaw goes one step further, stating, 'What are methods for, but to ruin our experiments?' (Kershaw in Smith and Dean, 2009:115). He acknowledges the importance of admitting that what we don't know can be a major source of inspiration and give quality outcomes to the research:

> So from the *multi - /inter- / transdisciplinary* perspectives of drama, theatre and performance research *not* to know where your project is heading exactly, or even a*voiding* a methodological tactic in favour of more risky ones, can produce fruitful failures.
>
> Kershaw and Nicholson, 2011:9

Whilst acknowledging the unpredictability of research, this thesis aligns itself more with Trimingham's model than Kershaw's. This is because the thesis begins by starting from a hypothesis, which through practice, it attempts to address. Due to my background in physiology, anatomy and physiotherapy, and my previous experience in scientific models of research, I have adopted the approach of articulating a hypothesis based on previous research in a different field and constructing a methodology through which to explore it in an original medium – theatre training.

The thesis uses a hypothesis, defines a line of enquiry, outlines a clear, repeatable methodology for testing proprioception in trainee performers and then develops proprioceptive practice informed by theory and previous practice. The thesis includes results produced within the traditional rational-scientific paradigm, and also shares results and insights of the experiences of the participants.

Director of Research at Central School of Speech and Drama, Robin Nelson underlines:

> PaR is not precluded from "hard" knowledge production within the traditional rational-scientific paradigm, it is perhaps most disposed to insights of relational understandings produced through experience.
>
> Nelson, 2006:19

The research undertaken both produces quantitative data and also pursues the 'insights of relational understandings produced through experience' (Nelson, 2006:19). The methodology includes witnesses or external observers, used to comment on the work seen and share the more subjective discoveries. These discoveries include any improvements in proprioception in the trainees and how these improvements manifest, comments on the training and how the training impacts on the trainee's levels of precision, balance, reaction time observed when undertaking movement tasks.

This practice led research thesis uses theories from neuroscience, physiotherapy and other scientific studies to inform the creative practice in the studio. As Nelson states:

> One way in which creative practice becomes innovative is by being informed by theoretical perspectives, either new in themselves, or perhaps newly explored in a given medium.
>
> Nelson, 2006b:114

The creative practice described in this thesis is the proprioceptive training undertaken by participants and the exploration of the benefits that improved proprioception can give in performative contexts such as contact improvisation, movement improvisation and other actor training exercises (described in detail later in the thesis).

The research aims to provide clear written dissemination of results, alongside photographic evidence and video clips to show examples of the practice. The thesis also looks for ways to share these more subjective, qualitative results about participant experience explored through questionnaires, participant testimony, observer testimony and a discussion of all findings. For as Trimingham explains, 'we cannot afford to dispense with the most basic (and moral) of research intentions: put simply, it must be for the benefit of others apart from the researchers themselves' (Trimingham, 2002:54). In other words, the results should be able to be disseminated in order to share the knowledge the studies have generated. As Nelson acknowledges, when discussing more traditional forms of research which set out to find out knowledge with a set of 'testable and falsifiable propositions' (Nelson, 2006:5):

> Some PaR projects may locate themselves in this tradition and aim to produce factual knowledge and, where they do, they are unproblematic in the established academy. Some inquiries might follow the scientific laboratory model and write up their findings from the experiments undertaken.
>
> Nelson, 2006: 5

This research identifies as PaR, and is practice led, as the creative practice undertaken is informed by theoretical perspectives and scientific research, and by drawing from fields of neuroscience and physiotherapy to inform actor training methodologies, it explores actor training in a new context. The Arts and Humanities Research Council state in their funding guidelines for practice led research that they are looking for:

> Research where practice is an integral component and/or where it theorises contemporary practice in order to then inform your own individual practice.
>
> AHRC, 2013

The theory and the practice in this practice led research are entwined, and taken together provide an explanation of the physiological mechanics at work during proprioceptive training. The theory and practice can also highlight ways in which the training can improve performative levels in the performer, in order to improve knowledge and understanding.

Statement of Aims:

In summary, this thesis will cover the following:

- The multidisciplinary literature review will introduce, explore and synthesise theories and definitions of proprioception to provide a clear and comprehensive overview. It will outline a definition for exploration throughout this thesis and reconcile conflicting terminologies and confusion surrounding the term.
- The thesis will establish in detail the functions that proprioception performs in both daily use and in cases where specialist, skilled movement, and therefore advanced proprioceptive acuity, is required.
- The thesis will map relationships between proprioception and related terms and concepts, arguing that proprioception provides a fundamental, comprehensive and accurate model for a core physiological foundation for physical performance training.
- The thesis will test and demonstrate that proprioception can be both trained and enhanced, and propose a methodology for training proprioception in physical performers.
- The thesis will explore and evidence the benefits, accruing to the performer, of enhanced proprioception.
- The accompanying DVD will demonstrate visual examples of the training practice, and how improvements in proprioception manifest in performers.

Whilst performers themselves could benefit from directly engaging with the material presented throughout this thesis, the findings are more likely to be of interest to practitioners developing physical actor training methodologies. The understandings presented here would enable practitioners to incorporate proprioceptive training practices within their actor training regimes, and/or provide a rationale for supporting the efficacy of existing training practices.

1.2 Proprioception

‘However neglected or understated, proprioception is a corporeal matter of fact’.

Sheets-Johnstone, 1999:62.

Proprioception is the sense that gives us information about the location, movement and posture of our bodies in space. The term ‘Proprioception’ is derived from the Latin word *proprius*, meaning "one's own," and *perception*. As Cognitive Science Professor Shaun Gallagher writes, proprioception is the ‘bodily sense that allows us to know how our body and limbs are positioned... If a person with normal proprioception is asked to sit, close his eyes and point to his knee, it is proprioception that allows him to successfully guide his hand and find his knee’ (Gallagher, 2005:43). Proprioception allows us to know where our limbs are *in relation* to each other and the space around us without us having to look specifically at them. It is the capacity that allows someone to walk in complete darkness without losing balance as they can sense and ‘feel’ where their body is in space and therefore proprioception affects our lives in every moment of every day. It allows us to carry out simple and complex movement tasks and to be able to move ourselves around and to interact with the world around us. Proprioception is vital for our movement as human beings and is fundamental to our functioning because without proprioception we wouldn’t be able to perform any motor activity without watching what we were doing.

Considering how important proprioception is to our moving bodies, it is surprising that the term isn’t better known, and is not utilised in performance training vocabularies. Proprioception as a term is more familiar within the medical, physiotherapy and sports science worlds, where it is commonly found. Despite this, existing definitions of proprioception are wide ranging, and this thesis will seek to highlight the discrepancies, clarify the concept, and demonstrate the significance of the term to the physical actor. The initial hypothesis explored in this thesis is that proprioception is a core sense for a physical performer and that it can be manipulated and enhanced to improve the performer's level of physical performance, and further serve physical training.

What is Proprioception?

At the beginning of the 20th Century, the term proprioception was introduced by Charles Sherrington, an English neurophysiologist who won the Nobel Prize in Physiology and Medicine in 1932 for his work exploring the human nervous system. He defined proprioception as a 'system for the maintenance of body position and coordination of movement and the means whereby one is conscious of body position' (Sherrington, 1907:467). It is the mechanism by which we are able to be aware of the position of our bodies and our limbs, and how our limbs interact to produce coordinated movement. Researchers Fremeney *et al*, (2000) agree, explaining that proprioception gives us information about movement (kinaesthesia) and position (position sense), and they extend the definition by outlining proprioception's importance in muscular control and accuracy of muscular action. (Fremeney *et al*, 2000:816). Along with assisting us to have more control and accuracy in our movement, proprioception also plays an important role in letting us know how much effort and energy we need to be able to carry out a particular movement. It is the sense that indicates to us whether the 'body is moving with required effort, as well as where the various parts of the body are located in relation to each other.' (Surhone *et al*, 2010:1) All facets of human movement from limb positioning, co-ordinated movement, using appropriate force and effort, to limbs moving efficiently in relation to each other rely upon the general underlying capacity of proprioception.

Stillman, a physiotherapist, in his thorough article about proprioception (2002), provides more detail about how proprioception can protect against injury. His definition of proprioception explains that the concept includes sensory functions and that these sensory functions involve awareness of 'spatial and mechanical status of the musculoskeletal framework' (Stillman, 2002:669). They include the senses of position, movement and balance and therefore also have a vital role in reflex protection of joints against potentially harmful forces and protection of the body against falls (Stillman, 2002:670). Stillman here provides us with more information on why those working in medical and physiotherapy contexts are interested in proprioception, outlining its role in injury prevention. He also outlines the link between proprioception and balance. Balance is achieved using information available through the proprioceptive system, along with sight, hearing and vestibular information.

A useful way to look at the importance of proprioception is to look at those rare cases where it is missing; for example, in the well documented case of Ian Waterman, who lost his proprioceptive sense at the age of 19 after contracting a rare neurological disease. Ian was still capable of movement and could experience hot, cold, pain and muscle fatigue but his illness left him with no proprioceptive sense. The result of this, post illness, was loss of all postural and motor control. 'He could not sit up or stand or move his limbs in any controllable way' (Gallagher, 2005:43). Ian could see his body but not feel any movement and without looking would not have known if he was moving or not. Science writers Blakeslee and Blakeslee report that 'Gradually, he taught himself to move again by watching and guiding his actions visually. But the second he closes his eyes, he collapses in a heap' (2007:33). Whilst Ian was, to some extent, able to replace his proprioceptive sense with visual information, his unique case clearly demonstrates the importance of proprioception to normal functioning.

Given the role of proprioception in muscle control, postural control, balance and accuracy of movement, it is likely that proprioception and the proprioceptive sense play a significant role in the training of actors, dancers and physical performers. Without the appropriate integration of proprioceptive input, a dancer would not be able to move across the stage and an actor would not be aware of exactly where her body was in relation to others and the space without looking at it. As demonstrated in a study by Ho-Li *et al*, proprioception is vital for skill-demanding movement, even more so than for daily movements, because of its importance in motor control (Ho-Lin *et al*, 2006:218) and is therefore of high import for the physical actor. A recent article by IADMS (International Association of Dance Medicine and Science) describes how dancers often demonstrate higher proprioceptive acuity than untrained individuals (IADMS.org, 2009:2). As an article on a website for physiotherapists states, 'Proprioception is important in all everyday movements but especially so in complicated sporting movements, where precise coordination is essential. This coordinated movement is a result of the normal functioning of the proprioceptive system' (www.physioroom.com). Muiadi *et al* (2009) support this claim, stating in their 2009 study that 'high levels of proprioceptive acuity may be more critical for skilled tasks such as accurate ball placement in soccer than for activities of daily living (Barrack *et al*., 1983; Barrack *et al*., 1984a, b; Lephart *et al*., 1996). They go on to undertake a study into levels of proprioceptive acuity in athletes and conclude post study that, 'the current findings suggest that elite soccer players have better proprioceptive acuity' in all tests and a 'higher level of functional performance than the non-athletic control group' (Muiadi *et al*, 2009:109). Soccer players are a group engaging in specialist skilled movement. Whilst acknowledging that some of the skills required by a soccer player are specialised to the sport, broad comparisons can be made between the specialist skilled movement of the athlete and that of the physical performer. As physical performers can also engage in highly physical practice, and specialist skilled movement, they could also benefit from improvements in some of the same physical attributes as soccer players. They both require flexibility, precision, co-ordination and motor control, and physical performers may benefit from strength and speed of reactions as well. It could be inferred therefore, that these studies could provide rationale for proprioception being of high importance to the physical performer, as there is a correlation between high levels of proprioceptive acuity and highly specialised movement skills.

Despite being vital, to us all, for daily and specialist skilled movement, proprioception is widely misunderstood, and, where utilised, the term is deployed in various ways:

> While people from different backgrounds may legitimately assign different meanings to the same word, it is desirable for communication and comprehension purposes if all who use 'proprioception', 'kinaesthesia' and related terms reach a general consensus as to their most appropriate meaning.
>
> Stillman, 2002:667

Stillman, in his essay about proprioception, attempts to define the term in a manner that has 'validity and relevance for a broad spectrum of readers' (Stillman, 2002:667). The literature review undertaken for this thesis confirmed Stillman's need to find a more standardised definition. In comparing and contrasting some of the different definitions for proprioception, we see that the term could benefit from a more consistent description. Scientists Snijders *et al* (2007) define proprioception simply as the information coming from muscle and joint receptors. Blakeslee and Blakeslee (2007) develop their definition further by explaining that proprioception is the inherent sense of body position and body's motion in space. Scientists Van Hedel and Dietz (2004) state that proprioceptive information provides the basis for a conscious and unconscious representation of our body in its surroundings. This definition extends even further than the previous ones by making claims with regard to the question of whether or not proprioception happens unconsciously or consciously, and how it can interact with our immediate surroundings. The consequences of this statement by Van Hedel and Dietz will be explored later in this thesis when we look in more depth at consciousness.

A more standardised definition of proprioception is certainly needed in the field of science, but how does the term fare within performing arts literature? In fact, awareness of proprioception isn't common at all within theatre and performance writing and practice. As we have seen, the term is more prevalent in the fields of enhancing sports performance, as more sports scientists and physiotherapists are working within these fields to enhance performance. There is however, evidence of a growing interest in proprioception within the dance world. Discussions around proprioception and awareness of its existence are slowly being filtered into dance performance training, particularly through dance science's interest in helping dancers achieve longer performance lives, maintenance of a healthy performative body and enhanced performance.

Sklar, an associate professor of dance, discusses proprioception in *Unearthing Kinaesthesia,* defining it as the 'perception of one's own sensations' (Sklar in Banes and Lepecki, 2007:38). Franklin, the originator of the 'Franklin method', which is taught at elite dance institutions around the world, states that it is the sense of one's own body position (Franklin, 1996:50). These definitions, whilst not going far enough to highlight proprioception's core use in motor control or balance, do indicate that the dance world is aware of the significance of proprioception for skilled movement. Further adding to the information available to the dance field, a resource paper produced by IADMS (2008) states that ‘practising and refining the proprioceptive sense means greater speed, accuracy, and quality of movement as well as expressiveness’ (Batson, 2008:1).

1:3 Concepts related to proprioception.

It is important to consider, in the literature review, other examples of proprioception, and closely related concepts from across a range of fields of research. As we shall see, there is significant overlap in terminologies relating to proprioception, perhaps because precise meaning is still in the process of emerging. The range of examples of terms which address one or more aspects of proprioception's function demonstrates the significance of the mechanism, and the relevance of this research. In what follows, I attempt to clarify the various terminologies and map the ways in which concepts relate to one another (see table 1).

Table 1: Key terms relating to proprioception and the fields in which they are discussed.

Key terms	Meaning	Writer	Context
Kinaesthesia	Sense of movement	Fraleigh	Dance Research
		Laban	Dance Research and teaching methodology
		Sheets-Johnstone	Interdisciplinary – including anthropology, dance and philosophy
Kinetic Body Feeling	Bodily feelings based on movement, and the ability to make	Sheets-Johnstone	Interdisciplinary – including

	distinctions between different feelings in motion.	Foster	anthropology, dance and philosophy Dance
Tactile Kinaesthetic Sense	Movement and touch sense which has a central role in organizing perception as a whole (Sheets-Johnstone, 1999).	Sheets-Johnstone O'Donovan Anderson	As above Philosophy
Somatics	'The art and science of the inter-relational process between awareness, biological function and the environment, all three factors being understood as a synergetic whole' (Hanna, 1986:39).	Hanna	Somatic Practice Dance Body work therapies
Laban's Art of Movement	'Becoming aware of the body in relationship to space, others and the changing nature of time and dynamics, and provides underlying movement concepts and language' (Kail, 2007:94).	Laban	Dance Education Dance Research
'Felt Sense'	'Every person has a continuous on-going flow of bodily lived experience. A felt sense is formed when we deliberately pay attention to that flow of experience in relation to some situation or issue or problem' (Hendricks, 2007:43).	Gendlin	Philosophy and Psychotherapy

Somatic Markers	Feelings about the body that are associated with emotion.	Damasio	Neuroscience
Body Schema (Somatic Scheme)	'One's body is known to one by means of a body schema. The body schema is an organizing structure contained in one's body that presents one with a unified understanding of one's body, which is experienced as a unified whole' (Brey, 2000:7).	Merleau-Ponty	Philosophy
Kinaesthetic Conscious-Ness	What we can experience in movement.	Sheets-Johnstone	Philosophy
Circuit of kinaesthesis	The interplay between the sensory and motor systems, primarily concerned with motion.	Yuasa	Philosophy

Kinaesthesia, a term used frequently within the field of dance, was defined by pathologist Henry Bastian around 1880 as the sensations which arise from movement (Stillman, 2002:667). Therefore kinaesthesia is often used to mean the 'feeling of movement', which is much narrower in meaning than proprioception. Despite this, the term kinaesthesia is often used in place of proprioception by writers such as Fraleigh (1987) in dance research.

Stillman suggests that it is not useful to have, within one field of enquiry, two terms that are used to identify the same concept (Stillman, 2002:668). The terms need to be clearly defined, and in this thesis, the term kinaesthesia is used solely to describe the sense of movement, whereas proprioception as a term includes wider meaning, which encompasses kinaesthesia and also includes position sense, balance and the other facets of proprioception outlined in this thesis. Proprioception is a more comprehensive term, especially when its meaning is clearly understood, which this thesis will address.

Sheets-Johnstone (1999) and Foster (1997), when talking about the experience of dancers, make use of the term 'kinetic bodily feeling', with which they describe how bodily knowledge enables people to make distinctions between feelings in motion. 'They can distinguish kinetic bodily feelings as smoothness and clumsiness, swiftness and slowness, brusqueness and gentleness; they make bodily felt distinctions' (Sheets-Johnstone, 1999:57). Foster and Sheets-Johnstone are describing being aware of certain different qualities of movement. Proprioception gives the information which allows those distinctions about movement to be made.

Sheets-Johnstone and Philosopher O'Donovan-Anderson also discuss bodily experience using the term 'tactile-kinaesthetic sense', which is described as having a 'central organising role for perceptions as a whole' (O'Donovan-Anderson 1997, Sheets-Johnstone, 1999). Sheets-Johnstone explains that this sense of bodily experience is developed by listening to our own movement and learning by moving, which is the basis of bodily awareness (Parviainen, 2002:13). The tactile – kinaesthetic sense described is a very similar concept to proprioception, and seems to encompass the information derived by touch as well as movement sense which are both information sources provided by proprioception. With this knowledge, provided by proprioception, dancers are able to manipulate the knowledge to become more expressive, sensitive and aware performers (Parviainen, 2002:23). Sheets-Johnstone is an advocate of the merits of discussing proprioception, kinaesthesia and the use of terms such as tactile-kinaesthetic sense (Sheets-Johnstone, 1999). This thesis will work towards providing evidence for the use of these terms, and provide a more rigorous analysis of the physiological mechanism which she claims is responsible for increased expressivity and freedom of movement.

The term ‘somatics’ was initially used by the late Thomas Hanna, a Feldenkrais practitioner and philosopher, and was defined as ‘the art and science of the inter-relational process between awareness, biological function and the environment, all three factors being understood as a synergetic whole’ (Hanna, 1986:39). Somatic practices include methods that teach participants to attend to bodily experience and can include meditation practices, yoga, the Feldenkrais technique, bodily orientated psychotherapies and the Alexander Technique (Hanna, 1986:39). Hanna saw somatics as a holistic, person centred approach to body awareness, which he understood as bringing a much needed additional point of view to the fields of scientific medicine and physiology:

> The somatic viewpoint must be added to the objective bodily viewpoint if we are to understand exactly what happens to human beings as they age... The somatic viewpoint complements and completes the scientific view of the human being, making it possible to have an authentic science that recognises the whole human: the self-aware, self-responsible side as well as the externally observable ‘bodily’ side. Together, these two viewpoints of human beings make possible an authentic human science.
>
> Hanna, 1988:21

Hanna’s wish, to bring together the two sides of ‘bodily experience’, involves acknowledging that alongside the external view of the body held by others, we also have our own experiential viewpoint, which is capable of self-awareness, self – learning and has the capacity to change. Proprioception isn’t mentioned in Hanna’s book on somatics and would have made a useful addition to his explanations, as it is the information on which to reflect on body experience and body awareness, as will be demonstrated throughout this thesis. Batson, a physiotherapist and writer for IADMS, and Schwartz, a professor of dance, do however recognise proprioception’s role in somatics, and its role in awareness of sensory input:

> Somatics tends to more readily embrace the use of ...proprioceptive experience in defining form. Focussed attention to proprioceptive input may augment and refine sensory feedback as the major means of learning smooth, coordinated movement.
>
> Batson and Schwartz, 2007:48

Batson and Schwartz go on to explain that to achieve improved awareness, movements are often slowed down in somatic practices, explaining that ‘in somatics, slowing movement down and reducing muscular effort is done in order to refine...

proprioceptive awareness for better coordination of motor action, particularly in the initial stages of learning' (Batson and Schwartz, 2007:48). They note that slowing movement down isn't the only way to achieve this refinement of awareness. The goal of somatics, as described here, is similar to the work explored in this thesis (and applied to the physical performer).

Laban's 'Art of Movement' is a system that relies heavily on proprioception, despite not utilising the term directly in the relevant literature. Laban was a movement theorist whose work impacted heavily on dance training and has also found its way into the training of actors. 'Laban's 'Art of Movement' involved becoming aware of the body in relationship to space, others and the changing nature of time and dynamics, and provided underlying movement concepts and language' (Kail, 2007:94) through training and exercises. To better assist the understanding of movement, Laban created four categories in which to discuss 'the art of movement: body, effort, shape and space':

> In Laban's Art of Movement classes on the other hand, the student is introduced to certain basic movement principles to which all living matter conforms... Once we know WHERE we are going in space, we must observe and analyse HOW we are going and WHAT KIND OF MOVEMENT ENERGY we use. Our choice of the type of the muscular energy, or from now on, EFFORT, which determines how we carry out an action, is the result of previously experienced inner impulses. Coupled with our chosen spatial direction it produces a definitive expressive movement quality'.
>
> Newlove, 1993:13

Proprioception is directly linked to all these concepts in Laban's 'Art of Movement': proprioception gives the information by which one can become aware of the body in relation to space and others, and provides information allowing appropriate judgements to be made in regards to force and effort. Laban's work influenced choreographers such as Jooss, Wigman and Bausch (Newlove, 1993:13), and has been embraced in drama conservatoires and drama departments at universities to become an accepted part of actor training. It could be said that the 'Art of Movement' is founded on, and reliant upon, the effective functioning of proprioception.

'Felt sense' is a term used by psychotherapist and philosopher Eugene Gendlin, particularly when he is discussing his work on 'focusing'. Focusing is a process that was developed in 1978 by Gendlin 'in response to his theoretical concerns with the notion of the 'felt sense' or the idea that there is something more than the five senses and more than can be explained by the terms feeling and emotion' (Bacon, 2007:17). Bacon goes on to draw parallels between Gendlin's work and the work on neuroscientist Antonio Damasio on somatic markers. Somatic markers refer to the unpleasant 'gut feeling' that appears when a bad outcome connected with a given response option comes into mind. 'Because the feeling is about the body, I have called the phenomenon the technical term 'somatic state' and because it 'marks' an image, I have called it a 'marker' (Damasio, 1994:173). Bacon describes how Damasio's 'somatic markers' mirror Gendlin's own definition of the felt sense:

> which 'he describes as the 'aha' sensation or feeling we get prior to the understanding of what it is about. In other words, I see someone who looks familiar. I don't know who you are but I get a feeling inside that I know who you are. After a moments of this bodily response, I get an 'aha, oh yes, I know who you are' as the thinking function is taken into the body and processed. It is the fleeting experience in the body that occurs prior to something making sense. Focusing concentrates our attention on how to get in touch with the 'felt sense' or 'somatic markers.
>
> Bacon, 2007:19

The focus on raising awareness and tuning attention to certain body parts and experiences is a useful one, which will be explored in this thesis in relation to Baar's 'spotlight of attention' (Baars,1997:43). However, this description of the 'felt sense', which sounds similar to proprioception on first reading, seems to be referring more to the link between 'gut feeling' and resulting emotion, which isn't the same thing. In fact, both Gendlin's 'felt sense' and Damasio's 'somatic markers' are more closely related to interoception than proprioception. Interoception refers to the sense of the physiological condition of the body and can include sensations from the visceral feelings of vaso-motor activity, hunger, thirst, and other internal sensations (Craig, 2003:500). Zarrilli mentions interoception alongside proprioception and defines it physiologically as our 'experience of our internal viscera and organs (Zarrilli, 2004:658). Zarrilli goes on to explain that sensations received from interoceptors are 'vague and anonymous' (Zarrilli, 2004:660), which resonates with Gendlin's description of the 'aha' moment or the 'gut feeling'. Damasio goes as far as to make the direct link between 'somatic markers' and interoception (Damasio in Craig, 2003:504). This area of exploration is beyond the scope of this thesis, but useful to note the distinction between the interoceptive aspect of 'felt sense' and proprioception.

References to the 'felt sense' with respect to the 'focusing' technique Gendlin advocates, are usually found in the context of psychotherapy. Gendlin's work has influenced the field of focusing orientated therapy. Executive Director of the 'Focusing Institute', Mary Hendricks, describes the 'felt sense' more broadly:

> Every person has a continuous on-going flow of bodily lived experience. A felt sense is formed when we deliberately pay attention to that flow of experience in relation to some situation or issue or problem.
>
> Hendricks, 2007:43

Gendlin develops this 'continuous on-going flow of bodily lived experience' from Hendricks and explains that our bodies are always in interaction with the environment and that the bodily felt sense is a direct sense of this interaction (Gendlin, 1997). As Hendricks explains further this concept of bodily felt sense, the link to proprioception becomes clearer, and more relevant:

> We experience our situations bodily and so our bodies 'know' our situations. This knowing is not just an 'inner' feeling, but is a sense of a whole complex situation that includes more than could ever be specified completely.
>
> Hendricks, 2007:43

This 'whole complex situation that includes more than could ever be specified completely', that Hendricks describes above would include proprioceptive input, as well as interoceptive input.

French Philosopher Merleau- Ponty, much referenced by dance theorists, talks about body schema, or *schema corporel.* His definition of body schema is similar to the one used in this thesis, although he doesn't make the differentiation between body image and body schema that is unpacked later. This could be due to the translation, with Gallagher explaining that the term '*schema corporel'* was 'rendered 'body image' in the English translation of his work *The Phenomenology of Perception* (1962)' (Gallagher, 2005:20). This is despite the description of the term pertaining to body schema. Merleau-Ponty defines body schema as the ‘organising structure contained in one’s body that presents one with a unified understanding of one’s body, which is experienced as a unified whole or ‘Gestalt’. The body schema moreover provides one with a pre-reflective, immediate knowledge of the position of one’s body parts’ (Brey, 2000:7). In fact, proprioception is the capacity through which we can have this immediate knowledge of the position of one’s body parts, and, as will be shown later, proprioception is very closely linked to body schema.

Sheets-Johnstone discusses kinaesthetic consciousness and notes that ‘in order to reapproach this kinaesthetic consciousness, we can (re)discover what it is like to learn one’s body by being in it’ (Sheets-Johnstone, 1999:360). What we experience through movement and resultant kinaesthetic consciousness is brought about by proprioception.

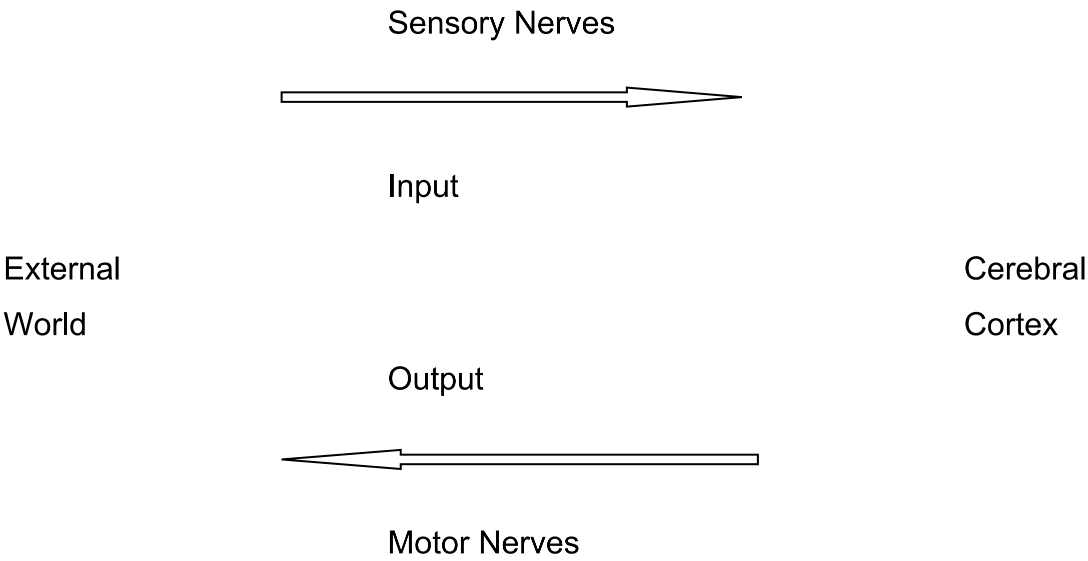
Of the philosophical models which address proprioceptive function, that of Japanese Philosopher Yuasa Yasuo is particularly pertinent. Both Zarrilli (2009) and Deborah Middleton (2012) draw on Yuasa to inform their theorisation of psychophysical actor training. Yuasa has a detailed model of mind and body which has many parallels with the model explored in this thesis. Yuasa’s model is, in turn, built on writings by Philosophers Merleau-Ponty (Yuasa, 1987:167) and Bergson (Yuasa, 1987:161).

Yuasa’s model posits layers of ‘bright’ and ‘dark consciousness’ and ‘relates the self to the world through the bright consciousness accompanying the sensory-motor circuit’ (Yuasa, 1987:186). He presents Merleau-Ponty’s ‘somatic scheme’, (mentioned above as ‘scheme corporel’) and his own model of the ‘sensory-motor circuit’, neither of which make use of the term proprioception, but each of which imply both proprioception and body schema. Yuasa’s explanations of the information systems of the body are the most detailed found in this literature review, outside of the scientific writing, and bear further discussion.

The first information system Yuasa presents is the ‘external sensory – motor circuit’ (Yuasa, 1993:44), shown below in figure 1.

Figure 1: Yuasa's model of the external sensory –motor circuit.

(From Yuasa, 1993:44)



Yuasa explains this model, stating:

> The stimuli received through the sensory organs from outside.. are information inputs to the computer, which is the brain, of data concerning situations in the external world. The computer, that is, the cerebral cortex, reads off data to give a response, and sends a command to the motor organs through the circuit of motor nerves thereby initiating an action.
>
> Yuasa, 1993:44

The stimuli received from the sensory organs can include proprioceptive information, which is processed through the sensory nerves. This model is described in more detail in Chapter 2. Crucially, Yuasa believes that the external sensory-motor circuit can be trained and adapted to better serve the individual. In fact, he explains that the 'training of bodily capabilities is to enhance the potential capacity of the sensory motor circuit, that is, to develop the capacity to respond more swiftly to stimuli from outside' (Yuasa, 1993:44). In other words, speed of reaction to stimuli, is improved by improving proprioception through bodily training practices.

Yuasa goes on to explain a second information system of the body, which he refers to as ‘an internal information apparatus about the condition of the body itself’ (Yuasa, 1993:45). This refers to information concerned with motion. He explains that the muscles and tendons are equipped with sensory motor nerves which inform the brain of their condition (Yuasa, 1993:45). The description he uses for this system is somewhat simplistic but effective. Proprioceptors are sensory nerve endings and are missing from Yuasa’s descriptions. The information they provide gives rise to our sense of proprioception, which Yuasa is clearly discussing, without implicitly using the term. He goes on to underline why this system is of interest to actors and performers:

> Those who excel in sports or in the performing arts have the capacity of this circuit well developed: The information carrying the conditions of the hands and legs is rapidly conveyed to the centre of the brain through the sensory motor nerves, and the centre, in turn, immediately sends commands responding to the conditions to the distal organs of hands and legs. In virtue of this circuit, they are capable of performing well’. This is the body’s ‘circuit of kinaesthesis’ and is the information system which supports the first external sensory-motor circuit.
>
> Yuasa, 1993:45

There are some physiological and anatomical errors in this presentation. Proprioceptive information comes from the entire body, not just distal body extremities and there is, in fact, no central place in the brain to process information (Damasio, 2004:95). That said, the ‘circuit of kinaesthesis’ is a useful model for performers and Yuasa uses it as the basis of an explanation of cultivation practices, means by which to enhance physical performance.

This thesis will provide the physiological background for how the proprioceptive system works, its place within the model of body schema and awareness, and explain and explore how enhanced proprioception can improve performance potentials of physical performers. As mentioned earlier, Zarrilli draws on Yuasa in his writings, and he is one of the few practitioners working within theatre to mention proprioception. Other theatre practitioners advocate skills and desirable qualities in performers that are directly related to proprioception, but the term hasn’t yet filtered into research on actor training, apart from the very few examples listed above. Nevertheless, it is possible to identify evidence of an interest in the functions proprioception performs, and in the qualities and capacities in which it manifests.

The literature review will now turn towards key examples of such in the writings of practitioners working in theatre.

Theatre literature review concerning concepts related to proprioception.

There are many examples of theatre practitioners discussing concerns and methodologies that rely on, or are similar to, proprioception; there are also a number of related practices, used in training, which directly address proprioceptive skill, such as that of Moshe Feldenkrais. Although the term proprioception is not mentioned in these practices, it is highly pertinent to the work. The following discussion is further rationale for the importance of bringing proprioception to the attention of the theatre world. See table 2 for examples of key terms, concepts or training methodologies used to train physical performers that are closely related to proprioception. Their link to proprioception will be discussed below the table.

Table 2: Table listing key practitioners whose work is related to proprioception.

Practitioner	Key concepts in their work	Explanation
Feldenkrais	'Awareness through Movement'	Lessons developed by Feldenkrais and used as actors (amongst others) as a modality to enhance body awareness.
Batdorf	Physical Awareness	'The brain's ability to go to a specific part of the body and feel it internally' (Potter, 2002:231).

Pagneux	Attention	'For Pagneux, attention is about a finely tuned and deep listening, looking, feeling, sensing, and knowing' (Laing, 2002:174).
Grotowksi	Kinaesthetic Learning	Claimed by Lendra to be the most important aspect of the learning process in Grotowksi's training (Lendra in Zarrilli, 2002:158).
Loui	Kinetic Awareness	Body and spatial awareness.
Overlie Bogart and Landau	Kinaesthetic Awareness - Within Viewpoints	Viewpoints is a method of training and developing performance, based around Space, Story, Time, Emotion, Movement and Space (Climenhaga in Hodge, 2010:295).
Meyerhold	Biomechanics	Biomechanics requires of the actor, and trains, (1) balance (physical control), (2) rhythmic awareness, both spatial and temporal, and (3) responsiveness (Leach in Hodge, 2010:32).

Feldenkrais developed 'Awareness Through Movement' lessons, which are often used by actors as a modality to enhance body awareness. There are many lessons, taught by trained teachers, or taken from his books, 'each with an emphasis on reducing effort and developing awareness' (Potter, 2002:54). The student's attention is guided to areas where they don't usually pay focussed attention, and results of the method are listed as 'improved breathing, increased range of motion, reduction of pain, a greater sense of well being and feeling more connected with oneself' (Potter, 2002:54). As we have already noted, proprioception is the mechanism by which we have awareness of the body, and which enables one to feel 'connected with oneself'.

Director and teacher Erika Batdorf attempts to delineate the main physical skills for the actor, and cites ‘physical awareness’ as the first one, defining it as ‘the brain’s ability to go to a specific part of the body and feel it internally (proprioceptive awareness)’ (Potter, 2002:231). This is a rare mention of proprioception in a theatre book, however the use of ‘proprioceptive awareness’ appears in this context with no further explanation of what the term means, or how it is useful. It also simplifies the processes at work, but the underlying link from physical awareness to proprioception is a useful one nonetheless.

Monica Pagneux is a movement director whose work has been influenced by her work with Feldenkrais, Wigman and Lecoq (Murray in Hodge, 2010:219). Laing (2007) explains that ‘attention’ is the principle that encapsulates Pagneux’s teaching practice and pedagogy:

> This attention is to oneself, to others and to the material world. In the language of other theatre teachers it might be called ‘being present’ or ‘being in the moment’, but it is richer and more complex than this... For Pagneux, attention is about a finely tuned and deep listening, looking, feeling, sensing, and knowing.
>
> Laing in Murray and Keefe,2007:153

The attention that Pagneux demands in her students is dependent on proprioceptive information. The finely tuned and deep listening, looking, feeling and sensing are all dependent on proprioception.

Stephen Wangh (director, teacher), when describing Grotowski’s work, outlines the actors ability to activate all the parts of their bodies, to be able to move fully and freely and precisely as skills to be developed during physical actor training (Wangh, 2000:xli). Here too, awareness plays a primary role:

> When I began to teach this work I came to understand that the essence of what I had learned with Grotowski lay not in the particular exercises but in an awareness of the connections between the body, the mind, and the emotions, an awareness that can be reawakened, and strengthened every day as part of the warm up process.
>
> Wangh, 2000:8

Wangh describes Grotowski's work in developing 'inner awareness to initiate clear, physical actions' (Wangh, 2000:9), another clear example of a practitioner prioritising capabilities that proprioception serves. Barba outlined a principle of Grotowski's training to be learning control of the body, and directing this control with confidence (Barba and Savarese, 2005:281). The awareness, and kinaesthetic learning outlined in table 2 above by Lendra (in Zarrilli, 2002:158), are made possible by proprioception.

Wangh (2000), Barba and Savarese (2005) and Lendra (in Zarrilli, 2002), are all identifying an aspect of Grotowski's work which has been of key importance to a range of practitioners. Here, director and choreographer Annie Loui underlines the importance of awareness in her work:

> In order to arrive at our goal of the compelling, capable physical actor we first look at the actor's body, developing it through daily warm-up into a strong, flexible and aligned instrument. Physical awareness of self in space, and self within a group is honed through exercises in spatial awareness and mime studies promote fine motor control and a certain physical-intellectual connection. Partnering skills develop physical receptivity, heighten coordination and sustained motion, and create an active physical responsiveness to the "other".
>
> Loui, 2009:3

Loui is describing the link from enhanced awareness to responsivity and receptivity, principles of performance desired by many practitioners (Lecoq, 2000, Barba and Savarese, 2005, Zarrilli, 2002, Mitter and Shevtsova, 2005). In order to be responsive, actors need to be open, available and receptive. The links between proprioception, awareness and enhanced responsiveness will be explored in more detail in chapter 5:2 of this thesis.

Viewpoints is a method of training and developing performance, first identified by choreographer, teacher and performer, Mary Overlie, based around six fundamentals aspects of dance practice that she called the Viewpoints of Space, Story, Time, Emotion, Movement and Shape (Climenhaga in Hodge, 2010:295). Rather than using fixed and structured exercises, the training here 'consists of awakening a consciousness of specific qualities of presence in time and space and being responsive to them, usually in a more improvisatory way' (Climenhaga in Hodge, 2010:295). Directors Anne Bogart and Tina Landau developed Overlie's work, within the frame of time and space, to engage with detail in 'shape, spatial relationships, floor pattern, architecture, repetition, gesture, tempo, duration and kinaesthetic response' (Mitter and Shevtsova, 2005:221). Central to the method for both Overlie and the developments by Bogart and Landau is a focus on their term, for one of the viewpoints, 'kinaesthetic awareness':

> The first thing you notice in initial work with Viewpoints training is the degree to which you are forced to let go of preparatory thinking in order to simply react. You work to juggle multiple awareness, leaving you to experience the connections you create with others in the room as you create them.
>
> Climenhaga in Hodge, 2010:296

This awareness is made possible by proprioception, and brings about desirable qualities for working in performance, particularly in the example above, which describes being able to react and respond in the moment, without pre-planning. Proprioception allows us to respond physically to stimuli and with appropriate force. Proprioception enables us to have kinaesthetic awareness, outlined as one of the viewpoints by Bogart and Landau above, which Climenhaga expands upon here:

> This is the main component of the Viewpoint of kinaesthetic response – an awakening of physical and visceral connection where you feel the appropriate action to take and respond before you have the chance to intellectualise the consequence of your action.
>
> Climenhaga in Hodge, 2010:296

Climenhaga continues by underlining this level of response as the engine that drives viewpoints (Climenhaga in Hodge, 2010:296). This level of kinaesthetic response, and consequent ability to react without pre-meditated planning, is made possible by proprioception.

Meyerhold was one of the few practitioners to combine science and kinesiology with his method for actor training, as Potter underlines:

> Meyerhold trained his company of actors in a variety of physical skills to provide a solid awareness of balance, control and expressiveness in their

> bodies... Influenced by science, technology and kinesiology, he established an entire system based on the creation of efficient and effortless stage movement.
>
> Potter, 2002:4

Potter's description of Meyerhold's 'system', biomechanics, as creating efficient and effortless stage movement, certainly doesn't sound 'effortless' when reading Leach's descriptions of the same system, although he too underlines the importance of awareness and control. Leach goes into more depth with his explanation of Meyerhold's work, saying 'Biomechanics requires of the actor, and trains: (1) balance (physical control); (2) rhythmic awareness, both spatial and temporal; and (3) responsiveness to the partner, to the audience, to other external stimuli, especially through the ability to observe, to listen and to react' (Leach in Hodge, 2010:32). The balance that biomechanics trains and requires of its actors relies upon proprioception, (along with vestibular and visual inputs), and proprioception also has an integral role to play in physical control as it allows us motor control and postural control, as well as contributing to coordination and accurate movement. It plays a part in rhythmic awareness, both spatially and temporally as it allows us to know where and how limbs are moving in relation to each other. Proprioception also gives us the information we need to be able to respond and react, with appropriate force and effort to stimuli around us, demonstrating its link to the responsiveness required of the actor described above by Leach.

A specific example given by Jonathan Pitches, when describing his experience of working on one of Meyerhold's etudes, gives us an opportunity to explore exactly how proprioception is deployed within Meyerhold's biomechanics:

> it developed the solidity of the physical base by introducing falls, jumps, and exaggerated body positions and demanded the same movement away from the centre of gravity before finding the centre anew. The etude required a constant shifting of weight from left to right and, at one moment, from the lower body to the upper body. As the hieroglyphic body shape was adopted for the etude, one's balance was further tested, particularly by the jumps included in the exercise.
>
> Pitches in Leach in Hodge, 2010:33

Proprioception allows us to explore falls, jumps and exaggerated body positions as it gives us the information we need to balance and therefore inhabit positions that compromise our base of support as described here by Pitches. Maintaining balance whilst jumping and landing is due to our ability to know where our limbs are in space and in relation to each other, which is an integral role of proprioception.

The ranges of terms explored above are all closely related to proprioception and awareness. The variety of differing terminology and its importance across so many fields makes the claim for proprioception to be more widely known within the theatre field. The many different terms used, from 'awareness through movement' (Feldenkrais in Potter, 2002), 'kinetic awareness' (Loui, 2009), 'physical awareness' (Batdorf in Potter, 2002) all pertain directly to proprioception. The detail of proprioception improves upon and finesses and synthesises many of the terms above into a more comprehensive mechanism. Proprioception is also a term and concept that can be measured, evaluated and analysed unlike many of the other terms explored throughout this literature review.

One of the very few theatre practitioners to mention the term 'proprioception' in his writing is Phillip Zarrilli. In his 2004 article, '*Towards a Phenomenological Model of the Actor's Embodied Modes of Experience',* he states that proprioception is 'the sense of balance, position and muscular tension, provided by receptors in muscles, joints, tendons and the inner ear' (Zarrilli, 2004:658). This is the most detailed definition available to the theatre world to date and does encompass the multi-faceted nature of proprioception. Zarrilli has realised and underlined the importance of proprioception for the physical performer. However, his use of the term and resulting definition does not go so far as to include proprioception's role in motor learning. In his writings, although he mentions proprioception, he doesn't really go into depth as to how and why the term is useful for physical performers – an area which this thesis attempts to address. Thus, whilst its function and effects are highly and widely sought after, the concept of proprioception is little known and only partially understood. In order to argue for the importance of proprioception in theatre training, it is important to arrive at a more conclusive definition.

1:4 Key points about proprioception.

The key points about proprioception discussed in this thesis are derived from Barry Stillman's useful essay, where he acknowledged the confusion arising from misuse of the term and sought to define the term clearly. As Stillman undertook a comprehensive literature review, he identified the problems and wrote an article that went into greater depth than most, acknowledging the multi-faceted nature of the term. From Stillman, we can derive the following comprehensive key points about proprioception:

- The proprioceptive system is that ...part of the nervous system which provides for sense of the spatial and mechanical status of the musculoskeletal framework.
- Proprioception serves motor control, and facilitates reflex defence of individual joints against injury and the whole body against falls.
- A proprioceptor is any receptor which transmits information about the spatial and mechanical status of the musculoskeletal framework to the central nervous system. This information may reach consciousness, but often does not.
- Proprioception .. is that category of sensations representing the spatial and mechanical status of the musculoskeletal framework.
- Proprioception serves body image, and the development of motor control when learning new skills.

Stillman, 2002:676

This definition is much more detailed than others in the field, and makes clear the breadth of information that proprioception provides for the physical performer. Each point shall be explained and elaborated on in turn:

- The proprioceptive system is that ...part of the nervous system which provides for sense of the spatial and mechanical status of the musculoskeletal framework.

The nervous system contains cells called neurons which co-ordinate the actions of a human being and transmit information between different body parts. These neurons transmit signals which allow us to know where our bodies are in space, and where our limbs are in relation to each other, and this provides us with a sense of the spatial and mechanical status of the musculoskeletal framework. Proprioception allows us to have a detailed sense of position even with our eyes closed.

- Proprioception serves motor control, and facilitates reflex defence of individual joints against injury and the whole body against falls.

This means that proprioceptive information enables us to control our motor systems: the part of the central nervous system concerned with movement. It simply means we can control our movement. 'Reflex defence of individual joints' against, for example, falls, refers to our 'saving mechanism' against injury, seen most acutely when our ankles make appropriate adjustments after encountering an unexpected obstacle when walking. The wobble, reflex defence and consequent adjustment in limb position are what protects the body against falls and injury and proprioceptive information serves these mechanisms directly. Proprioception's role in injury prevention is well documented both in medical and physiotherapeutic literature and scientific studies, and is highly pertinent to physical performers interested in prolonging their performing life spans and staying as efficient and healthy as possible, hence its inclusion in this definition.

- A proprioceptor is any receptor which transmits information about the spatial and mechanical status of the musculoskeletal framework to the central nervous system. This information may reach consciousness, but often does not.

This point is referring to the fact that mostly the proprioceptive system works without us knowing about it but at times the information that the proprioceptive system provides may reach consciousness. This point will be explored in more detail in Chapter 2.

- Proprioception.. is that category of sensations representing the spatial and mechanical status of the musculoskeletal framework.

This point underlines the fact that proprioceptive sensations are those that pertain to where we are in space and how our limbs are working in relation to each other to allow us build a spatial and mechanical status representation of our muscles and our skeleton.

- Proprioception serves body image, and the development of motor control when learning new skills.

Proprioception provides information which serves body image, which is an important point for actors in particular and which will be explored in detail in Chapter 4. Proprioception also allows us to make judgements about our movement capabilities and how we interact with other elements sharing our space, such as other performers. By serving motor control, proprioception allows us to learn and develop new motor skills. This area and its particular relevance to physical performers will also be explored later in the thesis. This comprehensive definition of proprioception shall be adopted throughout this thesis, and the various component parts and functions related specifically to their application in theatre training contexts.

1.5 Proprioception can be improved.

Proprioception is most often written about and discussed in its role of injury prevention. After injury, proprioception is often affected adversely, leaving the individual at a higher risk of re-injury, and therefore making proprioception a very important consideration when devising treatment plans for injured patients. A rehabilitation programme would typically involve improving proprioception at the site of injury to improve stability and decrease risk of re-injury. This programme would be dependent on the injury, the person and the level of function they hoped to return to, but would involve the objective assessment of proprioception so that improvement could be monitored throughout rehabilitation. Some of the proprioceptive training tools used by physiotherapists in musculoskeletal outpatient practice include wobble boards, trampolines and specific exercises. These modalities are also used within sports medicine to treat dancers and sportspeople.

When proprioception is adversely affected after injury, co-ordination and stability when moving are affected. In a study on proprioception of the knee by Barlett and Warren, it was shown that injury to the knee joint resulted in a poorer sense of joint position. This put the patient at increased risk of re-injury due to loss of proprioceptive input as well as decreased mechanical stability (Bartlett and Warren, 2002:132). The treatment in this case would involve stabilizing the injured joint and treatment of associated symptoms, including swelling and pain. The swelling, which causes pressure on the joint and associated structures, can also cause diminished proprioception. It is the impaired proprioception and resultant instability that it causes that make people prone to re-injury. The rehabilitation programme would, therefore, involve improving proprioception at the site of injury to improve stability and decrease this risk of re-injury. As it is trained during rehabilitation, improved proprioception manifests in movement in quicker reaction time (where your body can react quickly to stimuli around it) and more appropriate reactions to stimuli (eg if your foot encounters uneven ground without you expecting it, improved proprioception can help you make the adjustments at the ankle to proceed without falling). Improved proprioception also manifests in more accuracy in movement (ie foot or limb placement) as it gives information about each body part in relation to each other.

Importantly, proprioception can also be improved in the absence of injury or illness and it is this fact that is particularly pertinent to those who participate in highly skilled movement work or sport like physical performers and dancers. Studies by Chong *et al* (2001) and Hoffman and Payne (1995), both demonstrate improvements in proprioception in healthy individual subjects after proprioceptive training. Toledo *et al,* writing about proprioception for dancers, explain that the training of proprioception can enhance neuromuscular control and contribute to more efficient movement (Toledo *et al,* 2004:75). Proprioceptive sense can be sharpened through a number of disciplines. Activities that require balance, co-ordination, agility, power and movements that challenge the body's normal range of motion are good ways to cross-train for proprioceptive adaptation. Any skill or practice that stresses our balance and ensures sensorimotor control will help improve proprioception. The sensorimotor system refers to the relationship and interplay between the sensory system and the motor system. The sensorimotor system describes the 'sensory, motor, and central integration and processing components involved in maintaining joint homeostasis during bodily movements' (Reimann and Lephart, 2002:72). This means that the sensorimotor system is concerned with maintaining functional joint stability (homeostasis in this quote refers to maintaining stability). Sensorimotor function can be improved by emphasising sensory inputs such as proprioception training and balance exercises (Ahmed, 2011:305). Therefore, any activity that ensures that functional joint stability is maintained whilst moving (and therefore stressing balance concurrently) will utilise and improve levels of proprioception.

Tai Chi is an activity which utilises the sensorimotor system and relies on functional joint stability. Tai Chi has been practiced for centuries in China by the young and elderly alike to attain agility, balance and postural control (Xu *et al*, 2004:50). It involves moving from a standing position through a series of postures like a choreographed dance. The series of postures are performed very slowly in a sequence and are known as forms (Field, 2011:141). Tai Chi is slower than other martial arts such as karate and judo, and demands the participant place concentrated attention on how their body is moving to adopt the forms accurately. Significant time is required to master the forms, which is true of other martial arts using form work, such as Kalarippayattu, an Indian martial art of which Zarrilli is a master. Zarrilli uses Kalarippayattu to train his acting students psychophysically and explains why practices such as yoga and Kalarippayattu are psychophysical in nature:

> The practice of yoga, kalarippayattu, and taiqiquan is one means by which the primary empirical, material elements of the psychophysical actor's art are discovered and then attuned. The psychophysical exercises begin with the body and move both inward toward subtle realms of experience and feeling, and outward to meet the environment.
>
> Zarrilli, 2007:63

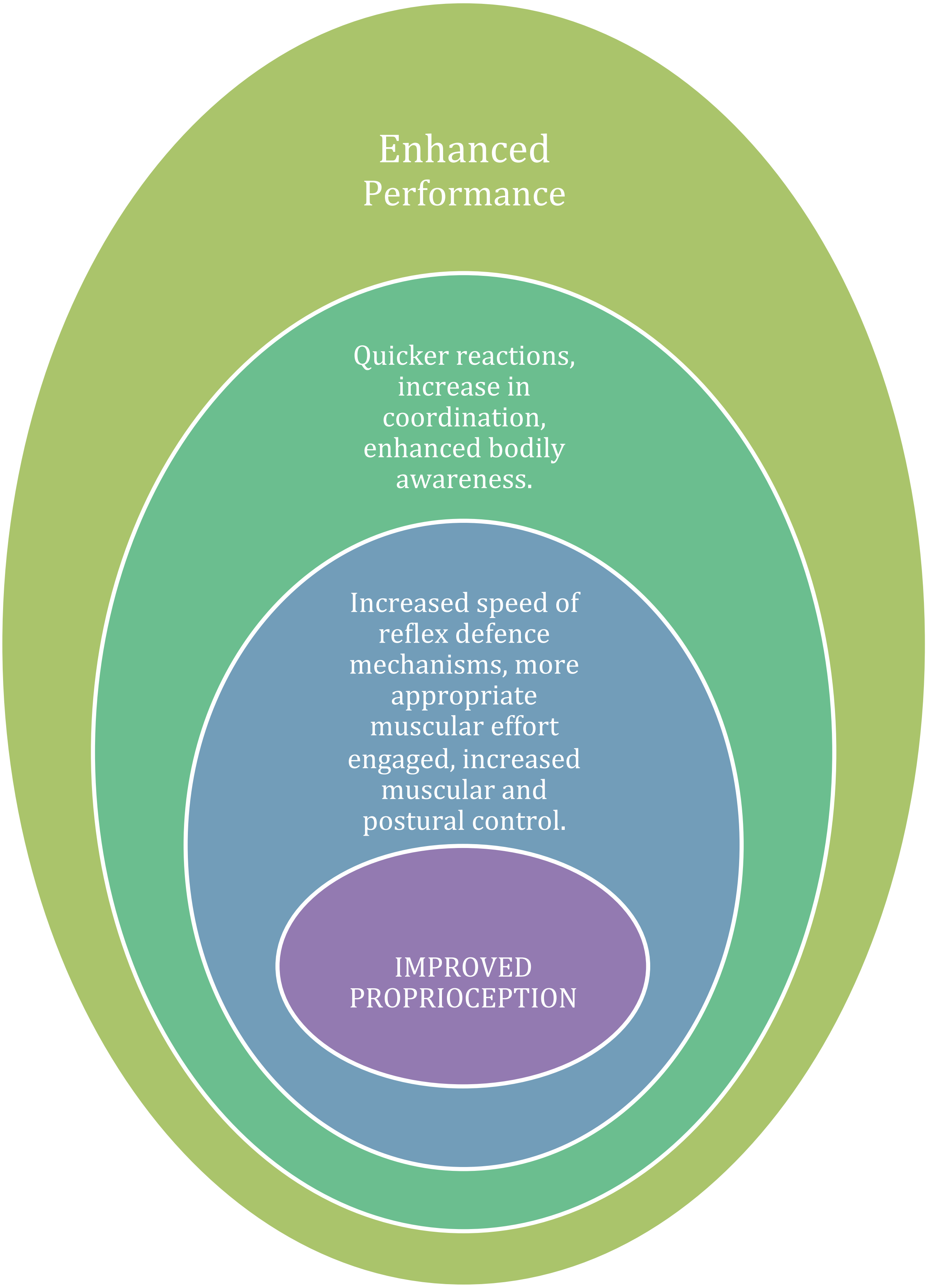
The practices encourage the trainee or participant to work psychophysically: out of a unified body and mind in order to master the poses and forms. One of the key ways in which a participant can work out of a unified body and mind is to employ enhanced awareness on the body's experience whilst working through each pose and form. Proprioception allows this awareness to be placed and ensures accurate limb positioning in relation to other body parts and fine discrimination of limb placement.

The study by Xu *et al* (2004) demonstrated that Martial Arts, such as Tai Chi, help to improve proprioception. Tai Chi's benefits to health have been well documented and the improvement and maintenance of balance enjoyed by those who practice Tai Chi is now drawing increasing attention from scientific researchers. The study by Xu *et al,* demonstrated that long term Tai Chi practitioners had stronger proprioception of the ankle and knee joints than the sedentary control subjects (2004:53). A study by Gauchard *et al*, (1999) showed that practicing yoga and soft gymnastics improved their subjects' levels of proprioception. Interestingly, they tested a group to whom they assigned swimming, cycling and jogging as their training and this group did not enjoy the same improvements as the gymnastics/yoga group, underlining the importance of specific awareness of joint positioning and stressing the sensorimotor system during the training to enjoy the more significant improvements in proprioception. The major difference between activities like yoga, Tai Chi and gymnastics as opposed to swimming and cycling is the emphasis on awareness of precise joint position, limb placement and balance. As Xu *et al* note, 'The movements of Tai Chi are gracefully fluent and consummately precise because specificity of joint angles and body position is of critical importance in accurately and correctly performing each form' (Xu *et al*, 2004:53). It is the precision of movement and awareness of body positioning and limb placement and psychophysical fluency demanded by Tai Chi, yoga and gymnastics to a significantly greater extent than by swimming and running that make these types of activities particularly conducive to proprioceptive development. The study groups that took part in the Tai Chi, yoga and gymnastics groups all enjoyed a greater improvement in proprioception than the swimming and the running groups (Xu *et al*, 2004). The studies by Gauchard and by Xu *et al* demonstrate that psychophysical training through activities which emphasise sensorimotor function, balance, precision in joint angulation and limb placement and which therefore require greater levels of whole body awareness and co-ordination, can bring about increased proprioceptive acuity.

1.6 Application for artists.

The Venn diagram on the following page outlines how proprioception can lead to enhanced performance for artists:

Figure 2: A Venn diagram outlining links from improved proprioception to enhanced performance for performers:


Enhanced Performance
Quicker reactions, increase in coordination, enhanced bodily awareness.
Increased speed of reflex defence mechanisms, more appropriate muscular effort engaged, increased muscular and postural control.
IMPROVED PROPRIOCEPTION

As proprioception is the mechanism by which we can be aware of our moving bodies, it is an important sense for those participating in specialist skilled movement. More understanding about proprioception can support physical performers and actors in many ways. Earlier, we discovered that proprioception is more critical for performers and sportspeople who rely on specialist, skilled movement than those using their bodies solely to attend to daily living. And we have just seen research and evidence to demonstrate that proprioception can be enhanced and improved. Higher levels of proprioceptive acuity can support sensorimotor control and therefore functional joint stability. This enables more efficient and precise motor control, allowing them to achieve higher levels of physical performance. Higher levels of proprioceptive acuity will also decrease risk of injury through quicker reactions and reflex defence and can therefore also extend a performer's performing life. Enhanced proprioceptive acuity allows us to enjoy improved balance, and an increased speed of learning new motor skills (Waddington *et al*, 2000). All of these improvements relate directly to the work of the physical performer, and are summarised in table 3, below.

Table 3: How the benefits of improved proprioception are relevant to the work of the physical performer.

Benefit of Improved Proprioception	Relevance to the performer
Improved sensorimotor control	The increased ability to move comfortably and safely out of the centre of gravity and base of support. A decreased incidence of injury.
Improved joint stability	A decreased incidence of injury to the specific joints and corresponding muscle group. Improved stability in general in locomotion and in stillness. Improved postural control.
Precise motor control	Allows for precision when carrying out motor programmes (movement patterns). Allows for more precision when learning new choreography or form work. Allows for safer physical work when working alone or with

	a partner.
Increased accuracy and efficiency of movement	Allows for precision and mastery of new choreography, movement demands and form work. More efficiency means less fatigue and the resultant capacity to be able to work for longer periods of time. Enhanced physical performance.
Decreased incidence of injury	Fewer injuries can lead to a longer performing and working life for physical performers. It can mean they don't miss out on work and job opportunities due to injury.
Quicker Reflex Defence	Decreased incidence of injury. Quicker responses to destabilizing forces. Fewer falls. Joints are protected.
Improved Balance	Improved sensorimotor control. Decreased incidence of injury. Fewer falls. More capacity to work and move comfortably in positions that require more extreme balance. Enhanced physical performance.

The benefits listed in the table above all enhance the performance capabilities of the physical performer, as well as protect against injury and consequent potential deterioration of physical skills. In addition to these benefits, and as we have already noted, proprioception also makes possible the bodily awareness that is of such high value to theatre practitioners. Proprioception has been seen to be the key mechanism in providing the information for physical performers to extend their sensory awareness and develop greater degrees of psychophysical integration. The thesis will now explore how proprioception works on a physiological level and its relevance to body maps and body schema.

Chapter 2:

How proprioception works, body maps and body schema.

2:1 How proprioception works.

Everything we sense in the world outside our bodies and everything we sense inside our bodies comes into our brain via the sensory nerves (Hanna, 1988:6). Everything that we do in the world and every movement we make flows out from our brain and informs the body via the motor nerves. The sensory nerves control our perceptions of the world and of ourselves. Sensation at its simplest represents 'activation of sensory receptors' (Cameron, 2002:107) and perception is the experience resulting from this sensory activation. The motor nerves control our movements in space and inside ourselves by means of their attachment to the muscles of the skeleton. As Hanna explains; 'the sensory and motor functions are two sides of the same coin. In the spine we see the division of the two systems, but in the brain we see their integration' (Hanna, 1988:6). Hanna here is discussing the sensorimotor system, where the sensory and the motor come together.[11]

This interplay between sensory information and motor control and guidance is seamless and happens in our daily lives without our awareness. Sensory information is constantly being received and updated to allow response and control of our muscular movements. As Reimann and Lephart state, 'Critical to effective motor control is accurate sensory information concerning both the external and internal environmental conditions of the body' (2002:80). Reimann and Lephart are referring to the adjustments that must be made to adapt the motor programme for goal -directed behaviour. For example, when walking on uneven ground whilst picking up and carrying a heavy box, provisions must be made to adapt the motor programme, which is responsible for motor control, for walking when there are changes externally (uneven ground) and internally (centre of gravity shift due to heavy box). Reimann and Lephart describe the provisions made to adapt the motor programme: 'These provisions are stimulated by sensory triggers occurring in both

[11] This is very similar to Yuasa's 'external sensory motor circuit' described earlier on page 31.

feedback (mechanoreceptor detection of altered support surface) and feedforward (anticipating centre -of- mass change from previous experience) manners' (Reimann and Lephart, 2002:80). Feedforward mechanisms for motor control don't use sensory feedback, and require an 'internal model for accuracy' (Seidler *et al,* 2004:1776), such as anticipating changes from previous experience as described by Reimann and Lephart (2002). Feedback mechanisms for motor control, in contrast, involve the modification of on-going movement using information from sensory receptors (Seidler *et al,* 2004:1776), which include proprioception. The sensorimotor system therefore relies upon the feedback mechanisms of our sensory input as well as proprioception to provide it with the information it needs to allow us to make necessary adjustments and allow us to successfully and efficiently navigate our way through our daily lives.

Proprioception has an integral role in motor control (Reimann and Lephart, 2002) and enables us to adjust appropriately to our external environment. Developing the example given above, when carrying a heavy box on an uneven surface, proprioception gives the information which stimulates changes to the motor programmes to accommodate unexpected changes in external environment. Visual input plays an important part also, but it is not always available. If the person in question is more intent on concentrating on the box and its contents, they may not see and visually note the uneven ground. This is when proprioceptive input takes over and stimulates the motor programme modification required to safely navigate the external environment. The relationship between proprioception and visual sensory information often works in close harmony, but there are times when proprioception is the quickest and most accurate input information available (Reimann and Lephart, 2002) and this relationship will be discussed in further detail in section 5.4.

Proprioception also plays an important role in the planning and modification of motor programmes. A motor programme is a sequence of co-ordinated movements. Before undertaking any movement or motor command, the motor system must first consider the current and changing positions of all the limbs in carrying out the motor programme. And as Reimann and Lephart tell us, 'Proprioception best provides the needed segmental movement and position information to the motor control system'

(Reimann and Lephart, 2002:81). Proprioception has an integral role in motor control and therefore in the interplay within the sensorimotor system as a whole.

The sensory information provided by proprioception enters into the brain via sensory pathways. Many think falsely that there is a single brain site where all the sensory information goes to for processing. In fact, as Damasio points out, this does not exist:

> There is no single region in the human brain equipped to process, simultaneously, representations from all the sensory modalities active when we experience simultaneously, say, sound, movement, shape and colour in perfect temporal and spatial registration.
>
> Damasio, 2004:95

These sensory modalities, of course, include information from our multi-faceted proprioceptive sense. All this information enters the brain and is continually updated in a distributed system to provide us with an on-going representation of what is happening within our bodies and around us. As Damasio states, ‘That the body, in most of its aspects, is continuously represented in the brain is thus a well-proven fact’ (Damasio and Damasio, 2006:18). What Damasio and Damasio are talking about can be thought of as body maps: maps of the body in the brain.

2.2 Body maps.

Body maps were first posited by surgeon and brain researcher Wilder Penfield in the 1940s, as a way of talking about the way in which the body is mentally represented within the brain:

> Every point on your body, each internal organ and every point in space out to the end of your fingertips, is mapped inside your brain. Your ability to sense, move, and act in the physical world arises from a rich network of flexible body maps distributed throughout your brain – maps that grow, shrink and morph to suit your needs.
>
> Blakeslee and Blakeslee, 2007:5

Penfield became renowned for his work on discovering and exploring these 'maps' in great detail. In the 1930s he was a surgeon at the Montreal Neurological Institute and pioneered brain explorations via surgery to learn more about body maps and the human brain. Operating on brains with the patient under local anaesthetic only (this is possible because the brain has no pain receptors and is important as the patient can remain lucid throughout and offer feedback to the doctor), he found that he could stimulate different parts of the brain with electrodes. Each time he stimulated a different part of the brain, he asked the patient how it felt and where they could feel sensation. In this way he was able to build up a detailed picture of which parts of the brain correlated with which parts of the body. After extensive research, Penfield collated his data:

> Penfield catalogued a complete brain map of the body's surface. Penfield playfully nicknamed this map the "homunculus", an obsolete term from medieval philosophy that means "little man" in Latin. This was the first ever map of a human being's primary touch map, or somatosensory cortex' which lies along a narrow strip less than an inch wide that runs from ear to ear across the crown of the head.
>
> Blakeslee and Blakeslee, 2007:19

The somatosensory cortex is an area of the brain that processes the information derived from systems in the body that are sensitive to touch. Proprioceptive information plays a part here also, as it charts where our bodies are in space and where our limbs are in relation to one another – all information derived, in part, from touch. The somatosensory system is very refined and sensitive and allows us to experience a wide range of sensations. As the image below vividly illustrates, some parts of our body are more sensitive than others. This is because we have many more receptors for certain body parts than for others. Researchers have identified proportionally how much of the brain is dedicated to sensation from various areas of the body and that information is shown in figure 3:

Figure 3: The model representing the primary touch map – the somatosensory cortex. [12]

The lips and fingers have most receptors and are therefore much more sensitive than other body parts and this is represented in Penfield's 'touch' body map, and the resultant model representing this information shown in figure 3. As Neuroscientist Alain Berthoz describes, 'the distribution of these receptors on the skin is very uneven. They are concentrated on the parts of the body that are most involved in tactile perception' (Berthoz, 1997:30). This first map describes touch but Penfield

[12] This sculpture is a model on display at the Natural History Museum in London. (Copied from http://www.parismarashi.com/ppm/2007/10/20/our-bodies-the-skin/)

also discovered and explored the motor cortex (the region of the brain involved in planning and execution of voluntary movement) and outlined the maps responsible for human movement. Below is an image of a sculpture inspired from Penfield's findings.

Figure 4: A model representing the motor cortex – the map for human movement.[13]

Again, the motor homunculus is uneven in its distribution. Blakeslee and Blakeslee explain why this is:

[13] This sculpture is a model on display at the Natural History Museum in London. (copied from http://www.autismindex.com/Therapies/Therapy_Key_Word_Site_Map/sensory/motor_1.jpg)

> The muscle groups in your mouth and hands, which are used in fast – changing, highly co-ordinated way, receive far richer projections from your motor cortex than do less dexterous muscle groups like those in your back, knees and hips.
>
> Blakeslee and Blakeslee, 2007:22

The body parts that have greatest movement demands are represented as more detailed areas on the homunculus and these body parts therefore have more detailed maps. The hands, for example, are capable of intricate and dexterous movements and sensations, and therefore the brain devotes a larger area to sensing and controlling them.

Penfield continued his research to find lots of different body maps in the brain. There are body maps to map the space immediately surrounding our bodies – our peripersonal space (Rizzolatti *et al,* 1997:190). These maps within the brain of the space immediately around our bodies let us know when our bodies come into close proximity with other objects. These body maps can also extend to include objects we hold, and the clothes we wear. 'Every time you get in your car, the map includes the space around your body as it extends to the boundaries of your car. If you learned to operate a crane, your body map would extend out to the tip of the crane's shovel' (Farne in Frank, 2009:26). The same can be true when we wear clothes, hats and/or walk with a stick. Blakeslee and Blakeslee (2007) and Farne (in Frank, 2009) both argue that body maps can extend to encompass the clothes or object. When we learn to work with a weapon in martial arts, our body maps are updated and expanded to include the new object. These updates and expansions of body maps can include costumes and props for performers. Without any actual sensory feedback coming from the inanimate objects, the body maps' expansion must be built on prediction from experience and proprioceptive information acquired when using the prop or the object previously.

Our body maps are posited to be highly flexible and plastic. They can shrink, grow and merge. Blakeslee and Blakeslee tell us that; they are 'capable of significant reorganisation in response to damage, experience or practice' (Blakeslee and

Blakeslee, 2007:11). It is this point that is important to underline. Practice can cause these body maps to reorganise. They reorganize and expand when new motor skills are learnt, such as a new pose in martial arts or new choreography for dancers. If a physical performer needs to learn a new skill such as stage fighting or a choreographed movement sequence for a part, her body maps will reorganize to provide a blueprint for the newly learnt motor programme or skill. The body maps can grow bigger and more detailed when placed under demand. Pascual- Leone and Torres (1993), writing about the sensorimotor cortex, have demonstrated that a sample of Braille readers showed enlarged somatosensory representation of the right index finger compared to the left, which was not used to read. We can speculate that young people today will have more detailed body maps to represent the thumbs as so much time today is spent texting and sending emails on mobile smart phones. Body maps representing the fingers in a pianist will be enlarged in comparison to a non-pianist who does not require as much fine control over their finger movements. In fact, these maps are constantly updated to reflect demands being made on the body. As Feldenkrais practitioner Todd Hargrove states:

> You can sense changes in your maps instantly by doing a simple experiment. Try to imagine or sense the exact shape and position of your ears. Now rub just the left ear for a few seconds and then compare your ability to sense the left ear and the right. You will note that it is much easier to sense the left. The simple reason is that touching the ear activated its mechanoreceptors, which sent a signal to the brain, which activated the map for that area. Of course, the additional clarity is only temporary.
>
> Hargrove, 2008

To make permanent changes to our body maps, we need to make ongoing demands of our bodies and resultant demands on the corresponding body maps in the brain. As Hargrove explains further:

> When a certain body part or movement is used repeatedly in a coordinated and mindful fashion, there are actual physical and observable changes in the part of the brain that controls that body part or movement. This is part of the reason why you get better at what you practice.
>
> Hargrove, 2008

This process can also be reversed. When you stop an activity, the brain maps responsible for representing the body part and activity can shrink. An example to demonstrate this is when a finger is broken; often the treatment is to bind the broken finger to its two healthy neighbours. They will very quickly start moving as a whole block instead of three separate units (Hargrove, 2008). After a week, when the bind comes off, it is very hard to discriminate each finger and sensations can appear fuzzy at first. This suggests that the body map responsible for the fingers has ceased to maintain detailed information about them as separate digits. Hargrove, in the quote above, uses the term 'mindful' to describe a manner of attending to the movement with a quality of attention and awareness. Mindfulness is an awareness of the present moment that is cultivated by paying attention on purpose to the things that usually are not noticed (Kabat-Zinn, 2005). With regard to movement practices, mindful movement is when we pay attention to how our bodies feel whilst carrying out the movement, as opposed to moving on 'autopilot', where we are not aware of our bodies felt experience whilst moving. Mindful movement can enhance body awareness and it is mindful practice that causes the enlargement in certain areas of the body maps.

Neuroscientists Serino and Haggard use different terminology when talking about body maps. They clearly state, 'the brain contains several mental representations of the physical body. These include descriptions of the parts of the body, their arrangement into a structural whole, and the positions of these parts in space at any given moment' (2010:224). This is a more rigorous definition of what Penfield and Blakeslee and Blakeslee call 'body maps', although the term 'body maps' will be used throughout this thesis as it is more accessible terminology and used more widely when discussing the concept.

Blakeslee and Blakeslee expand on their work with body maps and define the links from body maps to a body mandala, which creates the subjective feeling of 'me-ness', feeling like oneself:

> The sum total of your numerous, flexible, morphable body maps gives rise to the solid – feeling subjective sense of 'me-ness' and to your ability to comprehend and navigate the world around. You can think of the maps as a mandela whose overall pattern creates your embodied, feeling self.
>
> Blakeslee and Blakeslee, 2007:12

Blakeslee and Blakeslee (2007) go on to explain that the body mandala is the 'physical network of body maps in your brain.' (Blakeslee and Blakeslee, 2007:32). These body maps contribute to your body's felt experience, which they term *body schema.* Body schema is the 'felt experience of your body constructed by these maps' (Blakeslee and Blakeslee, 2007:32).

2.3 Body schema and proprioception.

The term 'schema' was used as early as 1893 by Neuroscientist Bonnier to 'signify a spatial quality related to awareness of the body.' (Gallagher, 2005:19) Some time later, the idea of 'body schema' was first suggested by two neurologists, Head and Holmes, in 1911. They defined it as a 'postural representation of the body' (Gallagher, 2005:19). They also proposed that 'like touch information, signals from your body's musculoskeletal system are carried into your brain to determine your posture and the position of your limbs' (Blakeslee and Blakeslee, 2007:33). Body schema is a physiological construct created by the brain from proprioceptive (amongst other) information:

> Our brains are constantly updated with information about the position of our bodies. This information comes from an on-line, real time representation of the body position that has been termed 'body schema.
>
> Shenton *et al*, 2004:19

This on-line (instantly updated) map in our brains helps us to navigate our way through the environment and to react to whatever is going on around us. It is not a static construct, but changes plastically depending on one's experience as a response to what is happening around them. Proprioception is vital to the updating of our body schema; it is a 'major source of information for the maintenance and governance of movement – that is, for the normal functioning of body schema.' (Ziemke *et al*, 2007:279). The body schema is created by the brain using interaction between touch, vision and proprioception.

Proprioception updates body schema in the parietal lobe. Parietal neurons are not concerned with identifying things in terms of their names, identities or meanings. Rather, they are concerned with the composition of space and the body's relationship to its surroundings (Blakeslee and Blakeslee, 2007:38). The parietal lobe creates our understanding of where we are in the world and how we relate to it. This area's upper sector is called the posterior parietal lobe and is teeming with body maps:

> Highly processed information converges in the posterior parietal lobe from all your major senses – touch, proprioception, vision, hearing and balance – plus a constant stream of information about movements and action plans flowing in from your frontal motor maps. Probably more than any other region of the brain, this area constitutes the centre of your embodied self embedded in a wider world. Here is where your body schema, sense of balance, and feeling of physical wholeness "come together".
>
> Blakeslee and Blakeslee, 2007:38

The parietal lobe is where the feeling of our embodied selves is formed as it takes sensory information from proprioception and other sensory inputs to provide a sense of our bodies in space. It is the region where proprioceptive and visual information of one's own body is integrated (Shimada, 2005:1225).

There is much debate about the extent to which body schema can be conscious. Kolb defines body schema as a 'postural image', a 'perceptual image', or a 'basic model of the body as it functions outside of consciousness' (Kolb, 1959:89). Head also defines body schema as a postural model of the body (Head, 1920:606) but disagrees as to the extent to which body schema can be brought to consciousness, stating:

> Postural schemas actively organize and modify the impressions produced by incoming sensory impulses in such a way that the final sensation of position, or of locality, rises into consciousness charged with a relation to something that has happened before.
>
> Head, 1920:606

In 1926, Head explained in more detail that body schemas are 'outside central consciousness', but that they 'provide information about posture and movement that sometimes rises into consciousness' (Head in Gallagher, 2005:22). In Gallagher's exhaustive literature review about body schemas, he also stated that Schilder (1935) contends that body schema is 'a conscious representation' and that Merleau-Ponty associates body schema with 'global awareness' or 'marginal consciousness' of the body (1962).

The question and debate over whether or not body schema can be brought to consciousness is not as important as being aware that it can be trained to work even more effectively for us. It is working effectively when we attend to simple mundane tasks like climbing a staircase. It allows us to complete tasks without having to pay attention to them. When we train our proprioceptive acuity and therefore attend to our body schema, we can make this system work even more deftly and efficiently. In people who undertake highly skilled physical tasks, like dancers, sports people and physical performers, the body schemas are highly detailed and efficient. Blakeslee and Blakeslee illustrate the working of body schema in such a highly trained individual:

> Imagine soccer star Mia Hamm in the thick of a skirmish. She is hurtling towards the other team's goal just a few metres ahead. She is dribbling the ball between her feet. She is so well trained and talented, the ball is at one with her inside her peripersonal space, as integrated into her body mandela as her own feet. Her arms twist and arc to keep her balance. Her feet sense the texture of the grass beneath her. In a split second, she sees an opportunity. For another split second the motor intention forms in her parietal and motor body maps, and with a deft kick the ball rockets off towards its target.
>
> Blakeslee and Blakeslee, 2007:38

What Blakeslee and Blakeslee are describing is a physical performer (sportsperson) with highly developed proprioceptive acuity and this information efficiently informing the body schema to give Mia all the information she needs to be able and available to react quickly to the situation around her. Even a simple daily activity such as making a cup of tea requires an intricate system of body maps working together to create a unified body schema. How much more intricate then, must body schema be, to allow for the complex, skilled and rapid responses of the trained sportsperson or physical performer?

Chapter 3: Awareness.

Whilst ‘proprioception’ itself is not widely discussed in theatre training, a related interest in ‘awareness’ is strongly present in the field. It is within the context of ‘awareness’ that Zarrilli mentions proprioception, but his exploration of the term ends there. Many training modalities are designed to heighten or enhance the actor’s self awareness; to develop beyond habitual states in which we can lack physical awareness. As you are reading this paper now, are you acutely aware of yourself? Aware of how you are sitting and whether or not you are tapping your foot? It is probable that you were not. Drew Leder, M.D, PhD and Professor of Philosophy, discusses this in terms of what he calls the ‘absent body’:

> One’s own body is rarely the thematic object of experience. When reading a book or lost in thought, my own bodily state may be the farthest thing from my awareness.
>
> Leder, 1990:1

Whilst running and walking, or just undertaking daily activities and interactions in life, we are very often on ‘autopilot’, meaning that little attention is paid to the bodies’ felt experience.

The training and teaching methodology of many actor trainers and practitioners is firmly based in cultivating awareness in their performers. Actor trainer Jacques Lecoq says that an acquired physical awareness will form an indispensible basis for actor training (Lecoq, 2002:75). Grotowski’s[14] actor training methodology in the Laboratory Theatre involved heightening the individual’s awareness of themselves. He utilised an exercise called ‘body mapping’, where the aim is for participants to ‘get to know the body’ and to ‘awake an active attention’ (Cuesta and Slowiak, 2007:123). Getting to know the body and awakening active attention enables actors to develop their physical awareness and cultivate it to help them grow as expressive performers.

Lack of awareness is firmly acknowledged as a hindrance for performers and a problem seen in many drama schools and rehearsal rooms. Zarrilli, when exploring this common problem in his research with actors points out that Stanislavsky

[14] Context and further examples of Grotowski’s actor training methods are discussed in Chapter 5:3.

recognised this 'forgetfulness of the body' as a fundamental problem in both acting and everyday life (Zarrilli, 2009:51). Lorna Marshall, actor trainer, director and performance consultant concurs, stating, ‘Most of the time, we are totally unaware of what our body is doing’ (Marshall, 2001:11). Actors are often invited to address this lack of awareness of their own bodies in the training and rehearsal room:

> It makes sense to engage with your body, to ‘invite it to the party’ when you work. After all, it has lived, felt, experienced the world and responded through action and speech. It is you. Not separate and apart. To ignore it is to ignore the fullness of yourself. To refuse a major source of information and insight.
>
> Marshall, 2001:xiv

There are many training techniques and methodologies which work toward raising the performer’s awareness, aiming to teach the performer about their main tool of expression – the body. Specifically targeting proprioception is of high value to physical performers as it is the mechanism by which we can be aware of ourselves. It is logical, therefore, when discussing theatre methodologies concerned with body awareness, that the role and benefits of improved proprioception should be explored to better serve training and specific performance needs such as muscular and postural control, appropriate physical response to stimuli and accuracy of limb placement and positioning.

The link between proprioception and awareness can be seen clearly when looking at studies from Gauchard *et al* (1999) and Xu *et al* (2004), discussed earlier in the thesis, demonstrating improved proprioceptive acuity in practitioners of Tai Chi and yoga. A factor that both Tai Chi and yoga share is an increased awareness of movement. Acute awareness of body position and movement is demanded by the nature of the activity, and therefore these practices which pay specific attention to the body’s experience improve proprioception (Xu *et al*, 2004:53). The study groups who only participated in swimming and running, on the other hand, did not see the same improvements in proprioceptive acuity as the yoga/ Tai Chi group. This is because, although swimming and running provide good training for cardiopulmonary function and muscle strength, they do not have the same emphasis on mindful movement leading to awareness of joint position and limb placement.

3:1 Awareness of movement and proprioception.

In Zarrilli's 2004 paper, 'Toward a Phenomenological Model of the Actor's Embodied Modes of Experience', he introduces the term 'proprioception' as a mode of perception. He also links proprioception with Drew Leder's 'absent body', explaining,

> This commonplace disappearance of our surface body is made possible in part by the operations of a second mode of perception – proprioception - the 'sense of balance, position, and muscular tension, provided by receptors in muscles, joints, tendons and the inner ear'. Proprioception allows our surface body to adjust our limbs, muscles, etc. appropriately to any motor task; therefore, we do not usually have to think about how to walk up a set of steps.
>
> Zarrilli, 2004:658

In fact, the proprioceptive sense does not 'allow our surface body to adjust,' rather it provides the necessary information so that the sensorimotor systems can make the necessary adjustments. The fact that in daily life, very little attention is paid to the proprioceptive sense is an important factor to consider when talking about proprioception and our awareness of ourselves.

As Gallagher expands, 'In much of our everyday experience, and most of the time, our attention is directed away from the body, towards the environment, or toward some project we are undertaking' (2005:27). In normal conscious states, ones' awareness of the body's felt experience is limited. It is usually 'below consciousness'. Lorna Marshall expands on this point, outlining it as a problem for actors and explains: 'we have no sense of what is physically happening, moment by moment. The body simply follows the habitual programmes for walking, running, sitting, etc. that have been established over the years' (Marshall, 2001:11). These habitual programmes are powerful as they represent one's normal way of moving.

Zarrilli goes on to describe how this changes when learning a new skill. When learning a new pose in yoga or new choreography for the first time, one becomes more aware of the bodies felt experience:

> Skill acquisition is often at first characterised by a volitional shift of attention prompted either by a teacher's instruction to, for example, "check the alignment of the heels" or a self-conscious shift of one's attention to check one's own alignment.
>
> Zarrilli, 2004:659

Over time, as the new pose or skill becomes mastered, the individual no longer needs to pay the same attention to their movement or felt experience and can operate from a 'place of knowing how to move to and from the pose'. (Zarrilli, 2004:659) The individual has learnt a new motor programme. When these motor programmes are learnt, they can become recessive, meaning that the individual no longer has to pay as much attention to completing the programme, unless there is a reason for it to spring into consciousness again, for example, whilst losing balance:

> If for some reason the body-schematic performance fails, the body takes centre stage in the perceptual field. A loss of balance, disequilibrium between body and environment, may motivate a spontaneous appearance of the body in attentive consciousness.
>
> Gallagher, 2005:34

Gallagher underlines a reason why the motor programme may enter consciousness again – a loss of balance due to the adjustments that have to take place when the body is under stress or the centre of gravity is compromised.

For the proprioceptive system to remain below consciousness, with the ability to enter consciousness when needed or required, is a useful feature of the mechanism. In normal functioning of proprioception and body schema, the effectiveness of the systems at work allows the information to remain below consciousness, as Gallagher underlines: 'The successful maintenance of posture, an equilibrium attained between body and environment, allows us to be more attentive to the world and our surroundings than to our body' (Gallagher, 2005:34).

This can be well described in the act of driving, which is an extremely complex task when first learning, but soon becomes like second nature when drivers gain experience. When learning to drive, it is common to feel clumsy and awkward attending to new skills, like changing gear and applying the correct pressure to brake efficiently. These new skills are made more difficult to learn by being in control of a moving vehicle with a constantly changing environment at the same time. When proficient at driving, and navigating a common, well-known route, it is much easier. Often, it is described as being on ‘auto-pilot’, where the same attention isn’t needed in changing gear or ascertaining how the feet change between the clutch, brake and accelerator. These skills still require proprioception but the information coming in to help complete tasks can drop ‘below consciousness’ so we can concentrate on the changing events that are taking place immediately, like a pedestrian stepping out unexpectedly or the car in front suddenly braking. This can be advantageous as it allows other tasks to be attended to. As Marshall explains with an even simpler example, ‘In fact, we have worked hard to detach our awareness from our actions. I don’t want to think about how I use my body when I am washing the dishes. I want the dishes to wash themselves while I get on with planning what to do next’ (Marshall, 2001:11). The proprioceptive sensations can remain recessive or ‘below consciousness’ so that an individual’s attention can move to another concern. Thus, proprioception plays a part in both enabling us to move in habitual ways that are 'below consciousness' and also in enabling the development of the kinds of heightened awareness that are necessary for performance.

3.2 What happens when we place concentrated attention on how we move?

Placing concentrated attention on bodily experience and how we move changes how we experience ourselves. It allows learning on a deeper level. As explored previously, any physical activity utilises proprioception, but it is the raised awareness engaged in psychophysical training that can manipulate, and enhance the proprioceptive sense. Psychophysical practices are those in which attention is paid to the role of awareness when working physically. This is the important point to take into consideration when training to improve proprioception for physical performance. We have seen that all physical activity utilises proprioception but that psychophysical training can improve proprioception (Gauchard *et al* (1999) and Xu *et al* (2004)). The enhanced awareness (or 'mindfulness' to use Hargrove's (2008) term from earlier) that psychophysical training demands and placing attention to what is happening in our bodies allows the proprioceptive senses to sharpen.

Neurobiologist Bernard Baars uses the term 'spotlight of attention' to describe how stimuli competing for access to consciousness can be brought to attention and therefore consciousness. He uses a theatre metaphor in which our senses and ideas are 'players', competing for access to the 'main stage' of conscious experience. Unconscious processes, or processes below the level of consciousness are in the 'backstage' area (behind the scenes). We can bring different players to the conscious experience of the 'main stage', by 'shining our spotlight of attention' on them (Baars, 1997:42). It is a useful term for talking about bringing awareness and attention to parts of the body, the global bodily experience and to the senses bringing us that information, such as proprioception. For example, during a guided meditation, one may be asked to bring the spotlight of attention to the breath. Usually, very limited attention needs to be paid to the mechanism of breathing. It is a vital life process to keep us alive, yet we don't have to worry that we will stop in our sleep. Breathing is usually below consciousness, but can easily be brought to consciousness by 'shining the spotlight of attention' on it. By doing so, we can slow the breathing down, and control how deeply a breath can be taken.

By paying attention to awareness and attending to psychophysical training and exploration, performers are learning about the capabilities, the ranges of movement and motion, and habitual movement patterns of their main tool, the body. As the performer often ‘detaches’ from their body’s felt experience (as described by Leder earlier), they are often unaware of habitual movement patterns and excessive muscular contraction presenting as tension. The way they move has become the norm for them and, in some cases, the habitual muscular contractions can cause ‘stiffness, soreness and a restricted range of movement’ (Hanna, 1988:xiii). Enhanced sensory awareness provided by a psychophysical training environment (where the body is the main focus and attention is placed on sensory stimuli) acts as a powerful agent of change, a potent means of altering habits that may inhibit movement and thought (IADMS, 2009:2). This is an important concept for performers as habitual tendencies can provide blocks to the achieving of their potential. When a performer is unaware of her/his habitual tendencies, they are less likely to be able to change them. Physical and somatic training like this works on offering the possibility to alter the body schema. As body schema involves a system of motor capabilities, abilities, and habits that enable movement and the maintenance of posture, physical and somatic training allows unhelpful habits to be addressed.

When a concentrated effort and attention is placed on how we move, we are paying attention to our proprioceptive sense. It is a sense that is usually working ‘below consciousness’, but as Montero (2006), an academic writing about proprioception underlines, it can be brought to attention with awareness. Working on enhancing proprioceptive awareness and acuity, and therefore attending to our body schema, allows more positive modes of ‘cultivating the types of bodily awareness often required of the actor’ (Zarrilli,2009:55).

Although it has been shown that proprioception usually operates without our being consciously aware of it, some neuroscientists and physiotherapists argue that it can enter into consciousness. Stillman clearly states that proprioceptive information ‘*may* reach consciousness, although often does not’ (Stillman, 2002:676, italics my own). Montero furthers this point by agreeing that much of the proprioceptive information received about our moving bodies is below the level of conscious awareness, but by shifting awareness to the proprioceptive experience of our moving bodies, this can change (Montero, 2006:241). Montero is describing how a deliberate shift in awareness of how we move can bring proprioceptive information into consciousness.

Philosopher Sean Gallagher approaches the question of whether or not proprioception can be brought to consciousness, by splitting it into two parts – Proprioceptive information (PI) and proprioceptive awareness (PA) (Gallagher, 2005:46). 'Proprioceptive Information' (PI), is the 'result of physiological stimuli activating certain proprioceptors', but this isn't consciously experienced by the subject. (Gallagher, 2005:46). He explains that proprioceptive information, generated at 'peripheral proprioceptors and registered at strategic sites in the brain' is below the threshold of consciousness (Gallagher, 2005:46). This means that we are not directly aware of this incoming proprioceptive information. This is unlike 'proprioceptive awareness' (PA), which is a conscious awareness of one's own body (Gallagher, 2005). In Gallagher's book, O'Shaughnessy's (1995) definition of proprioception as 'a form of direct awareness that contributes to the knowledge, representation or image of our body' (O'Shaughnessy in Gallagher, 2005:46) would actually accord with Gallagher's PA. The idea of proprioceptive awareness allows the performer to tune in to their felt experience in a way that generic body awareness doesn't. 'Body awareness', a term often used in the rehearsal room is, a very general concept of being aware of the body as a whole. Proprioceptive awareness involves bringing an attention to the inner experience, and allows the differentiation between different body parts and how they are moving in relation to each other. It refers to the ability to locate body parts with eyes closed and to sense limb position:

> Without visual perception of one's body, for example, one can still sense limb position on the basis of proprioceptive awareness. One can still find one's knee with one's eyes closed. If I ask you to do so, I am asking you to use proprioceptive awareness in an explicitly reflective and what O'Shaughnessy calls 'involuted' way.
>
> Gallagher, 2005:46

So PI is a non –conscious process, according to Gallagher, and PA is a reflective awareness of movement, which can be brought to consciousness. (Gallagher, 2005:46). Following Gallagher's model, it is the PA – proprioceptive awareness – that performers need to develop, hone and improve. Doing so, allows them the opportunity to be more connected to their body's felt experience and may allow them to become aware of habits that may impede and restrict their movement. This can initiate an increase in their movement repertoire and allow them more choices when adopting a physicality for a role. Proprioceptive awareness allows a distinction to be made between differing limbs and joints, allowing how they move in relation to each other to be ascertained, enabling the judgement of muscular effort used and allowing individuals to sense fine discrimination of limb positioning. This specificity of movement and precision of limb placement is particularly useful when precise choreography or physical scores are required of the performer, and when the performer is working in physical contact with another, as it enables them to adopt appropriate force and effort. Any advancement in these skills may promote physical fluency in performance.

Most practitioners who work with movement will lead their performers through training that utilises their proprioception, whether they are aware of it or not. They may ask for their performers to pay attention to their inner experience, and ask them to differentiate between different body parts and be specific and precise with positioning in order to inhabit choreography or a certain pose from a psychophysical practice (such as yoga). This is asking for participants to pay attention to their proprioceptive awareness, although different terminology may be used, like the more general ‘body awareness’, described above. It has been previously ascertained that practitioners engaging in psychophysical training are concurrently training proprioception as well. With this enhanced understanding of the mechanisms at work in their training, practitioners may be able to expand and develop their work further.

From research into anatomy and physiology, dancers now have much longer careers on average than in the past. Research into sports science and dance medicine has shown that sportspeople, dancers and those who undertake specialist skilled movement require a higher level of proprioception (IADMS, 2009). This, and the performative benefits it brings with it, are available to performers through training focused specifically on those factors which test and extend proprioception. It therefore pays to know as much about our physical instruments as possible. Using the terms, ‘proprioceptive awareness’ and ‘body schema’, gives us a shared language and physiological paradigm in which to explore and discuss training methodologies and improvements in performance. Knowing that proprioception can be enhanced, and knowing the means by which to do so helps when designing targeted training from which performers may benefit. Knowing that improved proprioception helps individuals to be more reactive to their surroundings and physical impulses, to make more appropriate responses, and to stay injury free, can support practitioners to design training programmes incorporating safer, more efficient movement protocols.

Proprioception can be measured, evaluated and analysed, unlike other related concepts, such as ‘kinaesthetic awareness’, which means any improvements acquired through training can be measured, allowing training to be focussed and adaptable. Further, proprioception provides a useful point of reference for trainers and performers. Since proprioception manifests in observable movement features, it can be indirectly observed by external practitioners such as actor trainers, medical practitioners, and physiotherapists. The moving individual can also reflect from an experiential viewpoint, thus making proprioception a useful concept for corroborating experience from first and second person points of view.

The proprioceptive awareness (PA), described above, required to attend to activities of daily living is different from the PA required to carry out specialist skill demanding activity. There is a continuum from the level of PA needed for normal functioning and the enhanced level of PA required to develop and maintain accurate awareness of the fine detail required for assuming a choreographic pose or adopting a character physicality. The next chapter will look in detail at PA for performers and how accurate the information received from proprioception is.

Chapter 4:

Body schema and body image explored.

It is necessary to ascertain whether the information received from proprioception is always accurate. It is common, in the training studio, to observe performers not presenting with the physicality or posture that they think they are presenting with. For example, when working on a yoga pose or learning new choreography, and following the instructions by the teacher carefully, some people fail to inhabit the pose correctly, leaning too far forwards, perhaps, or presenting with a curved spine when the asana requires a straight one. What 'feels' straight, may not, in fact, be confirmed as straight by the observing yoga teacher or director.

Proprioception and body schema were previously discussed as mostly being 'below consciousness', with the possibility that they can be brought to consciousness when the spotlight of attention is shone on them. Sometimes, even when focussing on proprioceptive awareness and body schema, the information received appears not to be entirely accurate. One way of understanding how it is that proprioceptive information can come to awareness in ways that are not reliable lies in the relationship between body image and body schema.

According to Gallagher, 'Body image and body schema refer to two different but closely related systems' (2005:24). The distinction between body schema (introduced earlier) and body image is not easy to make as they are inter-related systems and many writers use the terms interchangeably. Gallagher explains,

> The terms "body image" and "body schema" have been used in a variety of disciplines, including psychology, neurology, medicine, psychopathology, psychoanalysis, and philosophy. In and across all of these literatures, however, one finds numerous conceptual confusions concerning distinctions that are either made or not made between these terms and other associated terms (such as "body concept" or "body-representation"). This confusion extends not only to definitions, but also to their clinical applications.
>
> Gallagher in De Preester, 2005:233

To address these confusions and issues, Gallagher undertook work to provide a clearer, more detailed definition of both body schema and body image. He explains the difference, stating that body image is ‘a system of perceptions, attitudes and beliefs pertaining to one’s own body’ (Gallagher, 2005:24). Doctor Jonathon Cole defines body image as

> a complex set of intentional states, perceptions, mental representations and beliefs in which the object is one’s own body and that this has a reflexive intentionality and includes a perceptual experience of one’s own body, a conceptual understanding of it and an emotional attitude towards it.
>
> Cole in De Preester, 2005:321

This detailed definition underlines the layered, multi- faceted and personal nature of body image, and makes a connection between perceptions of one's body and emotional attitudes. Body image is fed by body schema but is a larger concept, also embracing psychological factors such as beliefs and attitudes.

Body schema and body image are constantly evolving as we interact with the world around us and as we mature. Blakeslee and Blakeslee (2007) describe changes in body schema as we grow: ‘Arms get longer. Your reach is greater. Your legs lengthen. Your centre of gravity rises. Your stride increases. Your proportions fall into place. Hormones kick in. Girls grow breasts. Boys bulk up’ (Blakeslee and Blakeslee, 2007:42). These changes in body schema are universal in normal circumstances. Body image, however, relates much more to learned behaviour, past experiences, memories and learned attitudes about our bodies:

> Your body image is an amalgam of beliefs – attitudes, assumptions, expectations, with an occasional delusion thrown in - that are likewise embedded both in your body maps and in the parts of your cortex that store autobiographical memories and social attitudes.
>
> Blakeslee and Blakeslee, 2007:42

Body image and body schema are clearly two distinct, albeit closely related, concepts. Gallagher sums it up neatly when discussing the distinction between the two concepts by stating, ‘the difference between body image and body schema is like the difference between having a perception of (or belief about, or emotional attitude towards) one’s own body and having a capacity to move one’s own body’ (Gallagher in De Preester, 2005:244). Gallagher is explaining that body schema is necessary for movement and navigation around obstacles and surroundings in daily life, and body image is much more based in perception of self. It is important to make these distinctions clear in order to better understand how body schema and body image interact.

Body schema should update body image, but this doesn’t always work as it should. For example, if a person has recently lost a lot of weight, the body schema should reflect the loss of weight. The sensations from the clothes feeling different and the belt buckle being a notch tighter should result in an updated body schema and body image. However, this isn’t always the case. As Gallagher explains, ‘It is possible that as a set of beliefs or attitudes about the body, the body image can involve inconsistencies or contradictions (2005:30). In addition to these inconsistencies and/or contradictions, our beliefs systems can be very stubborn and can resist being updated. Deeply ingrained beliefs about body image can be highly resistant to change, resulting in the body schema (body proper) and the body image being ‘unsynchronised’. Blakeslee and Blakeslee describe the situation, which ensues when this is so:

> Your body schema has drifted remarkably out of touch with your body image, and you experience an internal psychic disconnect. Your body image is duelling with your body schema. Your beliefs about your body are out of sync with what your body maps or even your eyes are reporting to you.
>
> Blakeslee and Blakeslee, 2007:43

Blakeslee and Blakeslee are describing what happens when the body schema and the body image are incongruent. This happens when the body image and highly resistant belief networks prevent us from tuning in to proprioceptive awareness and body schemas. We place priority with the belief networks, which can lead to inaccuracies between what we believe is happening with our bodies and what is actually happening.

Participating in movement training allows us to attend to our body schema:

> When you work with instructors of dance, yoga, Tai-Chi, Pilates, Alexander Technique, Feldenkrais, or dozens of other kinds of movement training, you are basically working on body schema awareness. These methods teach you to purposefully attend to the many core elements of your schema as a means of self- exploration.
>
> Blakeslee and Blakeslee, 2007:37

Working on body schema awareness and the self - exploration described above can lead to distinct changes in body schema. Clients often report, after a manipulation or a suggested adjustment in the Alexander Technique, that they can't articulate what or how the adjustment feels different to how they presented. Physiotherapists often report similar experiences when working with patients on postural changes. Patients will often present to them with a verbal description of their posture that doesn't match their actual physical posture, objectively assessed by the physiotherapist. This mismatch leading to an inaccurate sense of where a body part is in relation to another can be due to injury, which causes proprioceptive acuity to be diminished. It can be due to lack of use, which can also cause decreased proprioceptive acuity. It can also come from our belief system being highly resistant to change. Our minds operate via prediction, constantly making predictions according to past experiences of, for example, movement sequences that have worked for us in achieving a certain goal. For example, after practising with a sword, martial artists can predict the exact distance they need to leave before making contact with their partner. When we see, hear or feel something, the informative input (including proprioceptive input) is balanced with prediction. For example, the brain is constantly comparing incoming information to what it already knows, expects, or believes - which, of course, may be incorrect!

> Your understanding of reality is constructed in large part according to your expectations and beliefs, which are based on your past experiences, which are held in the cortex as predictive memory. This is worth repeating: Many of your perceptions – what you see, hear, feel and think is real – are profoundly shaped and influenced by your beliefs and expectations. And this includes beliefs about your body.
>
> Blakeslee and Blakeslee, 2007:42

In other words, what we think of as reality can be a far cry from reality itself.

Having inaccurate beliefs about our bodies and how they move resonates with the work of FM Alexander and his concept of ‘faulty sensory appreciation':

> Almost all civilized human creatures have developed a condition in which the sensory appreciation (feeling) is more or less imperfect and deceptive, and it naturally follows that it cannot be relied upon in re-education, readjustment and co-ordination, or in our attempts to put right something we know to be wrong with our psycho-physical selves.
>
> Alexander, 1923:131

Alexander explained that faulty sensory appreciation can develop when we get into the habit of performing a certain act in a certain way (Alexander, 1923:131). Alexander observed that a majority of people stand, sit and move in a similarly habitual and defective way (Weed, 2007). Habit, by definition, is our usual way of doing something – it becomes our norm – and our mental and physical response to our preconceived idea of what is needed, therefore informing how we think and act (Kristl, 2001). Alexander’s work suggests ‘inhibiting’ or stopping the automatic habit and then consciously choosing how the action will be carried out (Kristl, 2001).

To clarify this point of ‘faulty sensory appreciation’ further, I look to Don Weed, a trainer of teachers and creator of the ITM (Interactive Teaching Method) Alexander Technique. Weed discusses the ‘feeling sense’ in his 2004 book, ‘*What you think is what you get’.* Weed explains that students often get the ‘impression that their teachers are saying that their feelings are unreliable’ (Weed, 2004:71). He goes on to explain that it is not the feelings that are unreliable:

> The information being brought to the brain from our input mechanism – the feeling sense- is always accurate and reliable. Our feeling sense is always reliable because this kind of ‘feeling’ is just the raw data going into the brain for processing. In the absence of disease or damage to the sensory mechanism, there can be no unreliability of the feeling sense.
>
> Weed, 2004:71

Weed’s term ‘feeling sense’ can be translated into the model being explored in this thesis, proprioception. According to Weed's analysis, 'in the absence of disease or damage,' the proprioceptive input and resultant body schema are accurate. It is how we translate the information that can make it appear unreliable.

In Weed’s lectures, he points out that a 'billion bits' of information come into the thalamus (one of the filters in the brain) in every second. From this massive amount of raw data, the thalamus filters less than a hundred of these bits per second for our recognition (Weed, 2004:71). Weed further explains:

> It is what we do with this accurate data that leads to unreliability of interpretation. It is the rules we use to assign meaning to the data and the rules we use to determine which hundred pieces of information we will pay attention to each second and which nine hundred ninety nine million, nine hundred ninety-nine thousand, nine hundred bits we will throw away that will determine much of what we experience.
>
> Weed, 2004:71

According to Weed, the incoming information is edited with regard to belief systems and habits, which are linked to body image (amongst other things), which can be unreliable as a guide.

Recall that the body schema is composed of dynamic sensory signals. If you are someone who has recently lost a lot of weight, you will be getting updated, new information as your skin rubs against your clothes in a different way. This new, updated information can let you update your body image alongside your updated body schema, if you let it. As Blakeslee and Blakeslee note:

> You have to work less hard to lug your body around your house, which also testifies to the changes you’ve achieved. But your belief-ridden body image has not changed. Beliefs can be enormously potent, potent enough to drown out your new-felt body sense.
>
> Blakeslee and Blakeslee, 2007:44

These examples of ‘faulty sensory appreciation’ (Alexander, 1923:131) and incorrect interpretations of sensory input represent the body schema being out of synchrony with the body image. How then might movement training address this disjuncture of body schema and body image, and bring the two together?

Blakeslee and Blakeslee (2007:45) describe the work of a personal trainer, Della Penna, based in the US. One of the aims of his work is to allow his primarily overweight clients to ‘get in touch with their body schema’. When body image is duelling with body schema, Blakeslee and Blakeslee explain: ‘you need to try something more direct, more dynamic, more tactile, more proprioceptive... More to do with body maps than strolls down memory lane’ (Blakeslee and Blakeslee, 2007:45). They describe Della Penna’s direct approach and suggest that it is more effective than so-called 'talking therapies' in addressing weight loss issues, because the root of the problem can be traced to duelling body maps. Della Penna’s direct approach is to use wobble boards. A wobble board (sometimes referred to as a balance board) is a wooden or plastic circular, flat platform mounted on a half sphere, which offers an unsteady surface designed to challenge balance and proprioception[15]. His intention in using wobble boards is that his clients will be able to begin to transform their relationship with their body image. By shining the spotlight of attention on their proprioceptive awareness through the wobble board work, and therefore on their body schema, they may experience the potential to change:

> Della Penna’s first task is to try and bring these clients’ bodies and minds back together – to fire up their body schemas. But he is more often than not astonished by the extent at which his clients are not in touch with their physical bodies.
>
> Blakeslee and Blakeslee, 2007:46

The wobble board work helps Della Penna to address the problems facing his clients. The wobble boards offer a way to get in touch with their body schema and allow this information to over-ride the stubbornly held beliefs of the body image, which may inhibit the acknowledgement of accurate felt sensations:

> In terms of body maps, the wobble board provides a powerful entry into body schema repair via stimulation of the vestibular cortex. By putting balance at the centre of attention, your body schema cannot be ignored.
>
> Blakeslee and Blakeslee, 2007:46

[15] Wobble boards can be seen in the DVD accompanying this thesis, ‘Proprioception in Action’. Clip Three offers a brief physiological introduction to what is happening in the body during the wobble board training, with examples of wobble board exercises.

The wobble board experience is one of stimulating the body in a way that it is not used to, by challenging balance, and by stimulation of the vestibular cortex, and, as such, offers a new experience in which the participant cannot do what they would normally do, since this would result in falling off the board. They must adapt, and it is the adaptation and the adjustments that they are forced to make that can allow the sensations coming from all over the body to be acknowledged, and not to remain ‘below consciousness’ as they normally would. Therefore attending to balance on the wobble board makes body schema impossible to ignore with the result that the disjuncture between body image and body schema may be lessened or corrected.

A desirable change for actors and physical performers is to have a more accurate understanding of their physical ‘habits’. If they can work towards cultivating a deeper understanding and body awareness, through use of proprioception and work to lessen the disjuncture between body schema and body image by using modalities such as the wobble board described above, they can work towards making their bodies more expressive, more open to react freely to stimuli around them and work to eliminate ‘blocks’ that may impede them and stop them from achieving their potential.

Chapter 5.

5.1 The functions of proprioceptive acuity for athletes, dancers and actors.

Physical performers have differing requirements placed upon their bodies depending on their vocation and training. To this point, I have been using the term 'physical performer' to describe those actors working physically in a theatre context. In the following section I am going to analyse some of the specific demands placed on three types of performer, with a view to identifying the specific functions that proprioception must perform for each. In order to distinguish between them, I will talk about the athlete, the dancer and the actor. The demands placed on an athlete's body vary depending on the sport they perform and the same is true for dancers, where demands vary according to the type of dance they practice. The situation is different for many actors working in a physical domain, as they require much more versatile bodies for their vocation, to address a wide range of performative needs. I recognise that the terms 'dancer' and 'actor' are increasingly fluid in contemporary contexts, particularly within dance theatre, but am making the following assumptions in order to draw broad distinctions between them. Dancers as described here are those working within particular codified dance forms, such as ballet. When describing the work of actors, I am describing the physical actor/performers who are required to undertake movement training in order to adopt a multitude of character physicalities throughout their career, or to perform with specific physical skills such as acrobatics, gymnastics and aerial ability.

An athlete's body needs to be trained with respect to the particular demands of their sport. For example, a footballer's movement patterns are quite specific to that sport. 'Soccer players' movements are characterized by a great amount of sprinting, side-to-side cutting, pivoting and sudden starts and stops. In addition, game play often involves physical contact with other players including intentional pushing, or kicking (foul play)'(Gerbino *et al*, 2007:501). Looking at common injuries sustained by football players can give us an insight into the physical demands placed upon these athletes as particular movement patterns and characteristics can lead to certain injuries being more prevalent in people who participate in certain sports. In the example of the footballer above, the most common injury sustained is a problem with the anterior cruciate ligament, the ACL, (Metzl *et al*, 1998:663) which supports the stability of the knee joint. The damage to the ACL is because of the side to side cutting movement patterns which involve sudden changes in direction and sudden stopping after fast sprint often performed by football players. The differing incidence of most common injuries is a good indicator of the differing, and often very specific demands placed on the body in different sports and physical activity.

Athletes often train to have very specific skills and strengths to be able to carry out their particular sport to a high level. Proprioception is acknowledged within the sports fields as being an important sense to train for the specific benefits enhanced proprioception brings to an athlete's performance, such as better balance, faster reflex defence mechanisms to prevent injury, enhanced muscular and postural control and more precision of limb placement, resulting in more accurate movement. It is common to find improved proprioception on the list of training outcomes due to the fact that it can be improved with specific training and because of these consequent well documented benefits to performance (Toledo *et al*, 2004, Waddington, 2000, Burton 1986, Gauchard *et al*, 1999, Miuaidi *et al*, 2009).

Proprioception is also on the agenda of dance training, thanks to a growing interest in the benefits shown by organisations like IAMDS (International Association of Medicine and Dance Science). There have been studies and research conducted to show its value to dancers (Batson, 2008, Walker 2009). Dancers working within codified dance forms such as ballet, also require training targeted to achieve the particular demands of the dance form. Ballet dancers require extreme flexibility in their bodies, particularly at the ankle joint, with the level of plantarflexion required for the dancer to work 'en pointe'. Working 'en pointe' is when ballet dancers dance on the tips of their toes. Ballet students can only start 'pointe' work when they have a suitable level of plantarflexion at the ankle joint, do not suffer from hypermobility and have the core strength required to safely hold their body upright whilst working en pointe. They must also be able to perform a sufficient 'turn out'. Turn out is a fundamental physical attribute for ballet and describes when each leg is rotated in the opposite direction from the other and facing away from the midline of the body. '"Ideal" turnout traditionally has been identified as 180 degrees of outward rotation (also called external rotation and lateral rotation) of both legs combined (Wilmerding and Krasnow, 2011:1).

Working within this codified dance form requires, as with the example of soccer players above, focussed training. Despite dancers having a different set of concerns and priorities to athletes, many of their concerns overlap with those of athletes: discipline, precision and accuracy of movement, good balance and developed muscular and postural control are all shared desirable qualities. In looking at the pattern of common injury in dancers, it is possible to highlight some of the differing demands placed on their bodies from athletes. In a study looking at differences between soccer players and dancers (where the dancers had classical ballet training), researchers Gerbino *et al*, (2007) found that: ‘Dancers’ injuries are most commonly a result of over–use and are generally not traumatic in nature’ (Gerbino *et al*, 2007:502). Over-use injuries are generally more insidious and worsen over time as opposed to being a result of a traumatic incident. This could be because dancers working to specific choreographic demands know what is coming and train to achieve it, and have more specific body types (as evidenced by the physical attributes such as being able to have a good ‘turn out’ and work ‘en pointe’ as described above). This is unlike the highly unknown, improvised element of a footballer’s performance. Unless the dancer is taking part in an improvised performance, they are following set choreography which requires that they familiarise themselves with the motor programmes needed to execute the movement patterns the choreography demands. Even when working within more flexible dance contexts, such as contemporary dance, the dancers often use set movement patterns and choreographic segments from their movement repertoire, so it stands to reason that the most common injuries will be over-use, which is not restricted to a specific body part. Dancers train to be able to have flexible and strong bodies that allow them to learn the motor patterns needed to be able to carry out the choreography required of them. There is often certain technique required of the dancer, and a pressure on them to conform to how a certain movement should look:

> Modern and classical ballet dancers... have denied their ‘naturalness’ and have adapted another means of scenic behaviour. They have undergone a process of ‘acculturation’ imposed from the outside, with ways of standing, walking, stopping, looking and sitting which are different from the daily.

Barba and Savarese, 2005:190

Barba and Savarese are discussing how the dancer's body is trained to look and move like other dancers' bodies within a particular style; this is a process of ‘acculturation’. ‘Acculturation’ occurs when dancers take on the cultural, behavioural and in this case motor patterns of a particular culture, for example, of the particular dance form they are training for. Acculturation implies a new way of organising the body. Another example of acculturation is the training of kathakali performers in India, where trainees undertake many years of intensive, rigorous training in order to learn the highly specific positioning required of the artform (Watson in Hodge, 2010:243). Proprioception assists these dancers in being able to learn the new way of moving as it is responsible for the ability to learn, plan and modify new movements and motor programmes. Proprioception does this by giving the motor system information about the current and changing positions of all limbs involved in carrying out the motor programme, allowing the body schema to be constantly updated with how the body is moving in space. It provides the trainee with the required segmental movement and position information necessary to execute the motor programme, or to embody a position required of them for their dance form (such as working ‘en pointe’). Enhanced proprioception will support the trainee even further with their learning and performance by providing them with increased accuracy of limb placement, postural control and balance, enabling them to better cope with the rigorous demands of training.

So what kind of bodies do actors need to have in order to excel at their work? I have already underlined that when talking about actors, I am discussing those who primarily have a physical approach to their work, and those who participate in movement training in order to achieve the demands of their work. These actors, when working physically to undertake a particularly physical role, or working to achieve a physical score for a certain performance certainly have demands placed upon them which resemble those placed on an athlete or a dancer. The need to be able to learn new motor programmes quickly and efficiently, to have precision and control when moving, to have good balance and neuromuscular control are all qualities that actors working within these physical contexts and athletes and dancers have in common.

For the actor, there may not be a propensity towards a certain body shape or type, but as for athletes and dancers, there is a need for the actors' body to have certain qualities, which can include discipline, responsiveness, flexibility, coordination and motor control. Director and teacher Brigid Panet describes confidence, poise and balance as being important qualities for an actor to be able to draw from (Panet, 2009:86). Stephen Wangh when describing Grotowski's work, outlines the need for actors to activate all the parts of their bodies, to be able to move fully and freely and with precision in movement (Wangh, 2000:xli). Meyerhold trained his company of actors in a variety of physical skills to provide a solid awareness of balance, control and expressiveness in their bodies (Potter, 2002:4). These qualities, described by a range of practitioners working in different contexts, are all qualities that would benefit a dancer, and some would benefit an athlete as well.

Some demands placed on actors (even working in very physical domains) are different though. The majority of actors and physical performers working within a theatre context do not work in codified forms and therefore the range of demands on their bodies are not limited to specific trainings and skill sets. The primary demand is for flexibility, and the ability to adapt to a number of different performative needs. One main difference between the actor's body and the body of a dancer or an athlete is that the actor's body must be versatile enough to play a wide range of characters and to engage in a wide range of performative styles, physical scores and actions. Director and choreographer Annie Loui asks 'what do we look for in a good actor?' She formulates her answer by describing how an 'alert, well-articulated and flexible body is capable of a range of 'being', and inhabiting a range of characters' (Loui, 2009:1). It is this range of characters that places additional demands on the body of an actor; the need to be able to change and adopt a different physicality for each character they play, and acknowledge how that physicality is different to their own so that they can develop the character in more depth. Proprioception is the mechanism by which actors can be aware of their habitual posture and way of moving, and how they can move from their own physicality to adopt a very different way of moving in order satisfy the role of a character. Engaging in practice such as somatic training mentioned by Batson (2008) above, and movement training that allows us to attend to our body schema (explored in detail in chapter 4:1), can support the actor with these demands. Thus in addition to the benefits of improved proprioception listed above for the athlete and dancer (including improved motor control, precision of movement and improved balance), proprioceptive acuity in the physical performer also functions to provide enhanced awareness to be able to manipulate physicality, posture and gestural characteristics to suit a number of very different characters and performance styles.

Proprioception may have another important function to offer performers. Athletes and dancers usually retire from professional performance between the ages of 30 and 40. Actors, on the other hand, perform well into old age and need a trained, healthy body that supports them to achieve this. Proprioception has been shown, in the absence of training, to diminish with age (Ahmed, 2011), leading to increased risk of falls, injury and physical degeneration. Studies have been undertaken with participants in old age, showing that with appropriate proprioceptive training, levels of proprioception can be maintained or improved in older people, leading them to acquire many of the benefits listed earlier, such as improved balance. The study by Ahmed showed a significant positive correlation between balance, proprioception and functional activity level after proprioceptive exercise in an elderly patient cohort (Ahmed, 2011:310). Older actors would therefore benefit from maintaining their proprioceptive acuity through proprioceptive training as they continue their performing lives into older age, keeping their bodies as healthy, flexible, responsive, and injury-free as possible.

We have seen that proprioception has been well documented and researched in a number of studies looking at sport (Toledo *et al,* 2004, Waddington, 2000, Burton 1986, Gauchard *et al,* 1999, Muiadi *et al,* 2009) and, as a result, has impacted on the training of athletes. It is starting to make an impact on dance training and performance as well, manifesting in information sheets for dancers and dance teachers such as Batson's article on proprioception for IADMS (2008). Batson lists activities such as wobble board exercises, Pilates reformer exercises, and the practice of somatic education methods (such as Feldenkrais Awareness through movement) as modalities that can train for improved proprioception (Batson, 2008). For physical performers and actors working within a theatre context, however, it is rare to hear proprioception mentioned in the training room, or included in training methodology and rationale. At the time of writing, I am unaware of any studies that research the effects of training proprioception in actors apart from the two conducted as part of this thesis. Due to proprioceptive training and awareness being embraced by the sports world and the dance world, it would make sense that it may be of interest and use to those working to train actors to achieve physical fluency and expressiveness. Before we move on to the studies that will look in detail at how we can improve proprioception in physical performers working within theatre, we shall look in detail at the qualities that practitioners are seeking to develop in their trainee physical performers working within theatre, and explain how an improvement in proprioception will address these developments, and better serve performance.

5:2 How proprioception fits into a theatre training methodology.

Rebecca Loukes, a theatre practitioner who trained with Zarrilli, discusses the importance of performers being ready to react and respond appropriately to stimuli:

> Contemporary performer training has been concerned with strategies or methodologies to help the performer firstly be 'ready' to act, react, and respond to others, and then be able to carry out specific actions, reactions, and responses within a given performance structure or dramaturgy.
>
> Loukes, 2006:395

Proprioception allows us to react appropriately to physical stimuli around us as performers, and allows us to formulate an appropriate response with appropriate muscular force. This can be seen when watching skilled contact improvisers as their bodies respond rapidly and sensitively to physical cues and 'offers' from other performers.

Such readiness and capacity to react appropriately could be described as 'responsiveness', underlined as a starting point for Peter Brook's actor training (Marshall and Williams in Hodge, 2000:179). Brook is a British theatre director whose international work led to the founding of the International Centre for Theatre Research in Paris in 1970. According to Marshall and Williams, Brook's goal, to amplify the actors' capacities as instruments responsive to all the sources of the creative process, has been pursued and refined by him to the present day (Marshall and Williams in Hodge, 2000:176). For Brook, such 'responsiveness' and 'respons-ability' is 'developed physically through the body' and describes:

> The ability to sense and play with, and off, material in a simple, direct way. This 'material' can be impulses arising within the actor or suggested externally, in the relationship with another performer or performers.
>
> Marshall and Williams in Hodge, 2000:179

Proprioception directly relates to responsiveness, as it is the mechanism that allows us to be able to physically respond and react to stimuli from others and from within our own bodies. Training and enhancing proprioception allows instantaneous, safe and relevant physical response. These responses can be used to explore physical relationships between performers, and can be used to build a shared understanding of how each other moves and reacts physically to stimuli around them.

Professor and actor trainer David Zinder[16] lists responsiveness and 'openness and availability' as a principle needed for successful improvisation (Zinder, 2002:13). It is clear to see this when watching performers participate in contact improvisation. Contact improvisation is 'pure abstract improvisation based on a continuous, totally contentless sharing and exchange of body weight and tension' (Zinder, 2002:95). Zinder underlines the practice as highly useful for actors interested in a 'physical approach to theatre' (Zinder, 2002:95). Confident contact improvisers who have high levels of proprioceptive acuity can respond instantaneously with touch, weight transfer and even move and improvise into complex lifts working with momentum.

Being responsive, ready to react and respond appropriately to stimuli was a concern for Grotowski also, throughout the various phases of his career. The following sentence sums up the actor's task for Grotowski, as summarised by Slowiak and Cuesta:

> Stimulation - Impulse - Action – Contact.
>
> Slowiak and Cuesta, 2007:121

Impulse, as defined by Grotowski, refers to a 'seed of a living action born inside the actor's body which extends itself outward to the periphery, making itself visible as physical action' (Wolford in Hodge, 2000:199). 'Before a small physical action, there is an impulse' (Grotowski in Richards, 1995:94). Grotowski says that 'without impulse an action tends to stay on the level of gesture. The impulse is born inside the body, precedes the action, and pushes from the inside toward the periphery of the body, to become visible in the action' (Slowiak and Cuesta, 2007:65). In order to be open to stimulation and impulse and to allow the resulting action and contact, it is desirable for the performer's body to be responsive and to react appropriately.

[16] Zinder is an actor trainer who also teaches the Michael Chekhov technique. More about his work can be found in Zinder (2002).

Although a desirable principle of actor and physical performer training, there are many blocks to achieving receptivity and responsiveness:

> The problem, however, is that actor's bodies seldom are receptive to stimulations; or if they happen to receive the stimulus, something blocks the flow of impulses; and if the impulses do occur, often the actor does not know how to channel these impulse into precise actions or forms in order to make contact with a partner.
>
> Slowiak and Cuesta, 2007:122

The 'something' that blocks the flow of impulses can include unnecessary and excessive tension in the body and habitual physical tendencies which can block the flow of movement. Other blocks to achieving responsiveness and the flow of impulses include fear, embarrassment, pain, and even restrictive, unsuitable clothing. This list is by no means exhaustive; in fact it is just the beginning. The blocks can include anything that restricts us from being open, hinders our availability to receive impulses or that inhibits our capacity to move freely and expressively as performers.

Tension is a common block to allowing the flow of impulse and response. It is also a cause of habitual physical tendencies. The term is used often throughout this thesis and in the resulting research studies, and it is important to be clear about what is meant when this term is used. Don Weed's explanation of tension serves to provide a definition for my use of the term in this thesis. He describes how motion is caused by the contraction of muscles, and when the force of muscular contraction acting on a particular bone in one direction is greater than the force of muscular contraction acting on the same bone in the opposite direction, the result is movement (Weed, 2004:55). When two opposing muscle groups are both contracting at the same force, they cancel each other out:

> But, there would be ‘movement’. In fact, there would be two ‘movements’: one pulling in one direction and one pulling in the opposite direction. This kind of kinetic stalemate is what we mean when we say someone is ‘holding a position’. It is not that these people are being ‘still’ so much as they are involved in a kind of balancing tug of war in which they are trying to move in at least two opposing directions at once. The resulting muscular overaction serves no useful purpose but rather layers on successive amounts of purposeless force. This purposeless force is what we mean by tension.
>
> Weed, 2004:55

A distinction should be noted between the tension Weed is describing, and more useful, controlled tension, when one deliberately holds a pose or moves with excessive tension, for example, when directed to 'work with more tension'. The muscular behaviour in each case is the same, but in one instance it is deliberately deployed and in the other it is an unintended habitual behaviour, which can be very limiting. As Weed goes on to clarify:

> There is no such thing as tension! 'Tension' is nothing more nor less than a persistent and unnecessary combination of 'movements' of constant and purposeless muscular contraction that people habitually carry out to their detriment, often as part of a more complex pattern of habitual movements.
>
> Weed, 2004:56

Weed is describing an excess of unnecessary muscular work that can result in pain and ineffective movement. The opposite of this unintended muscular conflict we call tension is balanced and coordinated use of the relevant muscles. He goes on to explain:

> When our muscles are working in a balanced way that satisfies the motion needs equation for a given movement, this use of our muscles provides harmony and an increased quality of performance. When the use of our muscles is out of balance and in violation of the motion needs equation, the muscles produce distortions and a decrease in quality of performance.
>
> Weed, 2004:56

Weed's useful explanation of this phenomenon that is being described as 'tension' in this thesis and in the research studies clarifies what is actually going on in the body. However, the term 'tension' shall still be used in this thesis and within the training as it is a common one in people's vocabulary and it is how the majority of people describe the excess muscular contraction they are using. With Weed's explanation though, comes a very useful way of thinking of this excess, superfluous muscular contraction. It can be 'let go', or 'released'. Any physical blocks and habitual physical tendencies can also be released, which is of huge interest to the physical performer. As we have seen, the ability to accurately ascertain muscular behaviour and the degree of force required by them is a product of enhanced proprioceptive awareness.

Often, physical performers are unaware of their physical blocks and unaware of the habitual tendencies that are preventing them from being receptive and responsive. The blocks or the excessive tension they employ appears to them to be normal. This takes us back to our discussion about lack of awareness, fixed and often incorrect conceptions of our bodies, and duelling body maps. As Slowiak and Cuesta explain, Grotowski understood that 'very often the imagination we have of our bodies has little to do with the reality of our anatomy' (Slowiak and Cuesta, 2007:123). In Slowiak and Cuesta's book, Grotowski acknowledged that our experience of ourselves can be very different from what others see clearly. These misconceptions can prevent performers from being able to acknowledge their 'blocks' without help and guidance, education and training. Slowiak and Cuesta go on to state that:

> Grotowski understood that actors have many blocks, not only physical blocks, but also in terms of their attitudes towards their own bodies. Being ashamed or your body or narcissistic towards it both indicate a lack of acceptance of your body.
>
> Slowiak and Cuesta, 2007:124

We can understand some of the actor's blocks in terms of the paradigm of duelling body schemas and body images. When the actor trainer understands this paradigm and can assist the performer to understand its implications, both can move forward with the knowledge to be able to challenge these duelling maps and commit to training that can assist them to eliminate physical blocks that are impeding their progress as performers. According to Blakeslee and Blakeslee, on the basis of the evidence represented by Della Penna's work, it is possible to address these blockages, not directly and psychologically, but through targeted physical training. That training would consist of challenges to balance, be focused on proprioception, and bring about a confrontation with body schema such that a more accurate body image would have to be admitted.

Training proprioception assists this process in the following ways: it helps the physical performer to become more aware of their body and its movement, which enables them to have a more accurate representation of their body as this information feeds the body schema. Knowing that body image can distort our view of our bodies arms us with the knowledge to be open to and make use of others' feedback. Training proprioception then assists the physical performer in a number of practical ways. Improved proprioception manifests in quicker physical response and reaction time, quicker reflex responses, and a resultant decrease in injury incidence when in the training room. The physical responses are also more sensitive to appropriate force and can improve the performer's responsiveness and receptivity in physical tasks and exercises such as contact improvisation. Improved proprioception also benefits those learning new choreography and motor programmes which can include new skills like yoga, Tai Chi and other forms of training reliant on correct placement, postural alignment and form as it enables more accurate awareness and limb placement. Improved balance is another benefit of improved proprioception, and is discussed in Chapter 5:4. We shall now look at proprioception within the context of two different case studies detailing examples of theatre methodologies.

5:3 Proprioception examined within specific theatre examples.

Example One: Grotowski.

This first case study details some specific examples of proprioception in action within the work of Jerzy Grotowski. During the 'Laboratory Theatre' phase of his work, founded in 1959 (Wolford in Hodge, 2000:196), Grotowski advocated the need for the actor to commit to daily training and on-going professional education in addition to his/her work on performances (Kumiega, 1985:110). Training serves to strengthen the actor's physical and receptive capabilities (Wolford in Hodge, 2010:206). Despite many drawing on Grotowski's work to inform their own practice and training methodologies, Grotowksi was loth to be prescriptive when describing the exercises he used. As Grotowski states,

> in the final analysis there are no prescriptions. For every individual one must discover the cause which impedes him, hampers him and then create the situation in which this cause can be eliminated and the process liberated.
>
> (Grotowski in Kumiega, 1985:111)

Despite his resistance in defining his work and exercises he used, there are a few categories of work that developed within Grotowski's Laboratory Theatre, that are outlined in detail in his book, 'Towards a Poor Theatre' (1975). They are as follows:

- Exercises *plastiques*
- Exercises *corporels*
- Vocal and respiratory work

These categories of work used by Grotowski all served to improve physical capacities such as strength, stamina, flexibility, agility and gestural articulation (Wolford in Hodge, 2010:207). More fundamentally, they also served to take away from the trainee all that impeded them, all that prevented them from achieving their potential. Grotowski described this methodology as a 'via negativa'. The object of Grotowski's methodology was to take away from the actor all that obstructed him or her in regard to movement, breathing and, most importantly, human contact (Grotowski, 1975: 177).

We shall now look at the exercises *Plastiques* in more detail in order to identify what is happening proprioceptively.

Exercises *plastiques:*

The *plastiques* are exercises that focus on ‘precise detail and on the articulation of movements emanating from the spine and tracing their way outward toward the periphery of the body’ (Wolford in Hodge, 2010:210). Their fundamental principle is the ‘study of opposite vectors’ and the ‘study of opposite movements’ (Grotowski, 1968:107). This is when one body part is moving in one direction, and the adjacent body part is moving in the opposite direction. Grotowski gives the example of a hand making circular movements in one direction and the elbow making circular movements in the opposite direction (Grotowksi, 1968:107). The object of each exercise is to research the body’s range of motion, one’s own means of expression and to highlight areas of resistance (Grotowski, 1968:108). These areas of resistance could be areas of excess muscular tension, where the muscles are working harder than they need to in order to perform the desired movement, the result of which is movement which is impeded, limited and not as efficient as it could be.

When watching one of Grotowski’s long term actors Ryszard Cieslak teach the p*lastiques* to two Danish students in a film (available online at http://www.youtube.com/watch?v=1VCyGPm1VJM), we see Cieslak demonstrating extreme precision in limb placement from fine, detailed motor movement to gross motor movement. The *Plastiques* ‘worked on the actor’s ability to create forms, with precision outlined as a key principle’ (Slowiak and Cuesta, 2007:138). In one movement sequence, he begins with such precise hand and finger placement in a pose, that he pushes each joint to its maximum range of motion, and allows the muscles to move sequentially from the fingertip across the arm, and across the whole body. He begins with articulating the distal interphalangeal joint and the proximal interphalangeal joint of his finger, and moves each adjacent joint in turn from distally to proximally (from the extremities towards the midline of the body).

In order to be this precise with his movement and limb placement, Cieslak is relying on his proprioceptive information giving his various joints and body parts information about where they are in space in relation to each other. This allows him to be very precise in his joint positioning (demonstrated when he repeats the starting hand position very exactly to show the two Danish students). As he moves around the space, he is able to let the movements 'flow' through his body, often starting from the spine and emanating outwards to the body's extremities. The physical nature of the exercises is complex, with many different muscle groups working at the same time. Throughout the exercise, Cieslak displays a high level of proprioceptive acuity, demonstrated by his highly effective motor control. This motor control is evidenced by his ability to isolate joints and corresponding muscle groups at fine motor level and by the lack of unintentional postural sway and ease of movement at a more general, gross motor level. The result is Cieslak moving confidently and fluidly, without any areas of noticeable excess muscular tension. His joints are being used to their full range of motion, giving him a wide and varied movement repertoire.

As the proprioceptive system is part of the nervous system which provides for sense of the spatial and mechanical status of the musculoskeletal framework, the information transmitted by the proprioceptive system allows us to know where our bodies are in space, and where our limbs are in relation to each other. In the example explored above, the exercises Cieslak is performing demand focussed attention to be paid to movement at each joint and very detailed awareness of how the muscles are interacting to produce movement. The proprioceptive information tells Cieslak exactly where his joints and limbs are in space in relation to each other, which allows his body to make adjustments at a very detailed level. This level of proprioceptive acuity will also give Cieslak the information he needs to be able to use appropriate force and effort to carry out the movements efficiently and be in total control of his movement.

Example Two: Kalarippayattu.

Kalarippayattu is a compound term referring to the 'traditional martial art and physical therapy healing techniques unique to the southwestern coastal region of Kerala, India (Zarrilli, 2011:246). 'Kalari' means the place of training (an earthen pit), whereas 'Payattu' means to 'be trained, accustomed, practice', and refers to the martial exercises practised in the rehearsal space (Zarrilli, 2011:246).

Kalarippayattu demands a lot of the trainee, including body mind awareness, control of the internal energy/breath (prana-vayu), strength of mental power manifesting in one–point focus and meditation (Zarrilli, 1994:14). The repetition of poses is only a part of the Kalarippayattu training, but it is here that we will focus our enquiry into the role of proprioception in the training process.

According to Zarrilli, Kathakali originated from kalarippayattu (Zarrilli, 2011:247). Kathakali, meaning literally 'story play', is 'a genre of dance – drama dating from the late sixteenth century enacting stories from the two great Indian epics, the Mahabharata and Ramayana, as well as stories about the Krishna' (Zarrilli, 2011:247). Practitioners of kalarippayattu and kathakali seek knowledge of the body in order to master the two arts. As Zarrilli underlines:

> A Muslim master of kalarippayattu explained how any student who wants to become a master must possess complete knowledge of the body. Therefore training begins with *meyyarappatavu*, or 'body – control' exercises. The first step in preparing, perfecting, or gaining complete knowledge of the body is by repetition of the basic exercises and forms that constitute a specific mode of embodied practice.
>
> Zarrilli, 2011:249

The mastery of the poses is hard work and demands extreme precision of limb placement. Balance is challenged and students are encouraged to work out of their base of support. As the students become more experienced, they begin to show not only transformation of the body, but also a transformation of their relationship to doing the exercises (Zarrilli, 2011:249). Zarrilli explains that:

> The relationship between the doer and what he does has been qualitatively transformed from an external process that only engages the gross physical body to a psychophysical one in which the practitioner's inner experience, awareness, attentiveness, and perception are ideally engaged and altered.
>
> (Zarrilli, 2011:250)

The 'transformation' that Zarrilli talks about here happens with the daily commitment to practising the exercises and poses. The muscles adapt and the exercises that were very difficult for the student in beginning, become like 'second nature' over time. When the student begins the training, the poses and exercises are very unfamiliar to them and they need to pay close attention to their proprioceptive awareness in order to master them.

Proprioception plays an important role in the planning and modification of motor programmes. We have seen already in Chapter 2 that a motor programme is a sequence of co-ordinated movements, such as the exercises of kalarippayattu. To adopt a pose and to move from one pose to another, the motor system must first register the current position and changing positions of all limbs required to carry out the motor programme. Proprioception provides this segmental movement and position information to the motor control system and allows students to move from one kalarippayattu pose to another, learning each pose as it becomes a motor programme. 'The poses (vadivu), usually numbered eight, are named after animals. They are not static forms, but configurations of movements which embody both the external and internal essence of the animal after which they are named' (Zarrilli, 1994:26).

When learning a new pose in kalarippayattu, such as the elephant pose, the student becomes more aware of the body's felt experience as the body is moving into positions that may be totally new to the student, and involve the moving of joints further than is habitual. The elephant pose, which represents the stability and dynamism of the elephant, is a low pose and requires very deep flexion at the hip joint. The teacher can encourage the student to check their positioning and alignment, which can bring about a shift of attention. As the student improves, the student no longer needs to pay the same attention to their movement, limb positioning or felt experience and can move smoothly from one pose to the next. This is because the individual has learnt a new motor programme. As outlined earlier in Chapter 3:1, when motor programmes are learnt, they can become recessive. The individual therefore doesn't need to pay as much attention to completing the pose unless there is a reason for it to spring into consciousness again, for example, when losing balance or when reacting to another person in the space.

We have already seen that this ability for the proprioceptive system to remain below consciousness, with the ability to enter consciousness when needed, is a useful feature of the system. It allows us the advantage of being able to attend to other tasks if necessary, such as placing the attention on the breath or when working with another student in the space. As the student becomes more fluent when working with the poses, s/he can place his or her attention elsewhere, such as on the inner experience.

This feature of proprioception can also hinder trainees, as the ability to master a motor programme allows the trainee to be able to detach from the body's felt experience as Zarrilli describes here:

> Training through repetition of forms can too easily become empty and habitual - like the mind-less way in which some people work out in a sports centre through repetition of exercises while watching television or listening to the radio. The mind can be elsewhere while the body is being exercised and toned.
>
> Zarrilli, 2009:30

Therefore, students must be encouraged to keep their attention on their body and its felt experience whilst in the exercise, so the trainee can 'engage fully one's awareness in what one is doing as it is done' (Zarrilli, 2009:31). Paying attention to our proprioceptive awareness and shining what Baars (1997) calls our 'spotlight of attention' on what we are doing allows us to cultivate this enhanced state of awareness desired by practitioners and trainees of kalarippayattu.

In this example of kalarippayattu as a form of training, proprioception is seen to be important at every level of training. From the mastery of poses and exercises, proprioception is used to assist the trainee to master the motor programme and allow the body to make adjustments to fine body positioning using proprioceptive information, telling us exactly where our limbs are in space. This accuracy of information improves with training, allowing for more precision, speed and quicker mastery of poses, especially when working out of the trainee's base of support and when challenging their balance. Proprioception also allows us the enhanced awareness that is demanded by this psychophysical training modality. Being familiar with the features of proprioception allows us to acknowledge that when motor programmes are learnt, they can become recessive (and drop 'below consciousness'), so the trainee has the potential to allow the mind to wander. Whilst this feature is useful when attending to daily activities, it is not useful in the training room. Instead, being aware of this risk can support teachers to advise their students against it, and to encourage them to pay attention to their body in action. They can do this by choosing to place their attention on their felt experience, and therefore cultivating the proprioceptive awareness further, and not allowing the detachment that happens when the trainee's mind wanders. This offers the trainee the opportunity to enter into more and more subtle levels of psychophysical awareness.

5.4 Balance and proprioception.

Proprioception plays a vital role in providing information for our balance. Improved proprioception leads to improved balance. Balance is a function ‘requiring the adjustment of muscle activity and joint position to preserve the centre of gravity of the body according to its base of support in static or dynamic conditions’ (Sevgi *et al*, 2008:186). The study by Sevgi *et al* (2008) outlines other studies underlining the importance of proprioception for balance and postural control. Lee *et al* (2009) state in their study that any type of dysfunction in proprioception, or any deficits in proprioception (caused by injury, illness, lack of use, and neurological problems) lead to a resultant impaired balance and postural control (2009:387). The reverse is also applicable; an increase in proprioception can lead to better balance and postural control. The maintenance of balance depends on proprioceptive stimuli, as well as visual and vestibular stimuli. The vestibular system is in the inner ear and is very helpful in balance as any changes in fluid in the inner ear tell us that we are off-balance. However, as noted by Walker, ‘the brain is relatively slow at processing information from the vestibular system. The fastest system is the proprioceptive one’ (2009:53).

Balance is important for everyday movements and navigation, and even more so for those participating in specialist skilled movement. When balance is impaired, incidence of injury is more common, particularly in activities such as sport where the body’s balance system is put under more stress than is found in everyday situations (Sevgi *et al*, 2008:186). Physical performers need good balance in order not to limit their movement repertoire. The better the balance, the more movement options we have as performers.

When we have developed a strong core balance, we can give attention to qualities in performance that Theatre Anthropologist Eugenio Barba talks about when he discusses ‘precarious balance’, and ‘luxury balance’. Whilst Sally Goddard Blythe, Director of the Institute for Neuro-Physiological Psychology, defines balance as the ‘art of not moving’ (Goddard-Blythe, 2005:10), Barba is talking about something very different when he discusses precarious and luxury balance. He is talking about pushing and challenging our balance to create 'balance in action' and a 'dynamic balance', which comes from an 'alteration of balance and unstable balance' (Barba and Savarese, 2005:32). Barba discusses dynamic balance and 'balance in action' as desirable states for performers to explore. Although he doesn't specifically use the term, Barba is actually talking about challenging proprioception, and as a result balance.

This challenge to our balance and proprioceptive system allows the performer to abandon everyday balance in favour of a precarious balance, where the proprioceptive system is put under more stress than in daily activity:

> The characteristic most common to actors and dancers from different cultures and times is the abandonment of daily balance in favour of a 'precarious' or extra-daily balance.
>
> Barba and Savarese, 2005:32

Balance is a core skill required of everyone, and by stressing their central nervous systems and proprioception, performers can strive towards working in an extra-daily way, a technique often required of the performer:

> In discovering what the principles governing a performer's scenic bios, or life, might be, lies in understanding that the body's daily techniques can be replaced by extra-daily techniques, that is techniques that do not respect the habitual conditionings of the body. Performers use these extra-daily techniques.
>
> Barba and Savarese, 2005:7

An extra-daily technique is one that is designed for the stage and has a performative quality. It is not the 'everyday' energy, but a use of the body that heightens energy. Having followed the trail of the performer's energy, Barba perceives the nucleus to be 'in the amplification and activation of the forces that are at work in balance.' (Barba and Savarese, 2005:18) This helps the performer with presence, energy, and to seem 'alive', as he explains:

> Extra-daily balance demands a greater physical effort – it is this extra effort that dilates the body's tensions in such a way that the performer seems to be alive even before he begins to express.
>
> Barba and Savarese, 2005:32

The reflex defence ‘saving’ mechanisms and the proprioceptive mechanisms at work in a falling body or a precariously placed body provide internal momentum and energy for performers. Precarious balance can also be used as a means of expression in performance and is used in forms of performance such as contemporary dance, ballet, mime, and as Barba notes, commedia dell’arte (Barba and Savarese, 2005:32). It is used in many forms of highly physical performative work, and training to improve proprioception and therefore balance will allow the performer to approach working and moving into positions of precarious balance with more confidence, less incidence of injury and a greater ability to push further out of their centre of gravity.

5.5 Vision and proprioception

Underlining the links between vision and proprioception can also help with designing a theatre training methodology and explain why certain training approaches are adopted. Vision and proprioception are closely related. For our bodies to know where they are in space and to gain information about movement and position sense, the proprioceptive mechanisms work in collaboration with the visual senses.

> The brain normally receives input from at least two senses: vision, seeing the hand in a given position; and proprioception, the information coming from muscle and joint receptors.
>
> Snijders *et al*, 2007:496

The manner in which this sensory information is integrated remains unclear (Shenton *et al*, 2004:19). We do know, however, that we combine the information we receive from sight with proprioception to gauge where to place our arm, and what force to use if we want to pat someone on the back, or reach for another's hand. We also use experience of the world to assist us. If we reach out to catch someone when they fall, we use visual input, proprioception and our memory of having felt the weight of a human being before. This all happens simultaneously to help us navigate our way around our environment.

However, the senses operate from different modalities as Snidjers *et al* explain:

> The information available from these two sensory modalities may differ substantially. Vision initially operates in an eye-centred reference frame, and therefore may have different directional-sensitivity compared to proprioception, which initially operates in body-centred coordinates (e.g., centred on the arm and shoulder joints).
>
> Snidjers *et al*, 2007:496

The information coming from visual sources doesn't always synchronise with information coming from proprioception. Many studies show that humans often rely more on vision than proprioception, and that visually based location information, when it is available, may override proprioception (Van Beers *et al*, 2002, Snidjers *et al*, 2007, Ghez *et al*, 1995 amongst many others). The picture that emerges from such studies is that (when all visual cues are available) the estimate of limb positions relies more on vision than on proprioception, sometimes expressed as “vision dominates proprioception”(Van Beers, 2002:834).

Studies by Ramachandran (1995) and Holmes *et al* (2004), amongst others, have shed more light on the complex relationship between vision and proprioception using ‘mirror illusion’ tests. In the mirror illusion tests, a mirror is used to present visual information regarding a participant's “virtual hand” that substitutes for their real but unseen hand which is placed behind the mirror. The mirror offers visual information about the apparent position of the hand that may conflict with proprioceptive information concerning the actual position of the participant’s hand.

> This conflict can influence subsequent reaching movements made with the unseen hand, in that participants make greater terminal reaching errors in the direction predicted by the systematic integration of visual and proprioceptive information concerning hand position.
>
> Snidjers *et al*, 2007:496

When the mirror is taken away, or no hand is seen in the mirror, the studies showed a much smaller error. This is using proprioceptive sense alone, thereby indicating dominance by visual information over proprioceptive information. ‘Some form of “visual bias” therefore appears to influence reaching movements when we receive visual information concerning our body via mirror reflection’ (Snidjers *et al*, 2007:496).

This phenomenon explains why the Royal Ballet have now covered up the mirrors that used to dominate their rehearsal rooms. Ballet, along with many other forms of dance, was traditionally practiced with mirrors lining the walls, to allow the performers constantly to check their technique, alignment and positioning. Now the preference for some is to work without mirrors (Bull, 2003). In my own practice as a dancer, I often found it a disconcerting experience to work in front of a mirror and intuitively felt that it didn’t help my learning and body integration. I can now understand why that was the case, and when leading movement or dance workshops, I cover the mirrors up. This allows the further training of the proprioceptive feedback and allows the performers further to 'tune in' to their bodies.

In the absence of mirrors, we still receive visual information about the body's position and movement. However, it becomes more of a negotiation between the two. If visual information is not available (on a stage in blackout or when the performer's eyes are closed), 'proprioception may provide the primary source of information about body part location' (Shenton *et al*, 2004:19). Because of this, I often lead exploratory movement workshops with a part of the session 'blind', as it allows the performer to hone their proprioceptive awareness.

Obviously, we can't conduct all our training, and certainly performance, with our eyes shut (unless necessary for the role we are playing), but it is a useful training exercise as it helps strengthen the accuracy of proprioceptive inputs and shifts sensorimotor dominance from vision to proprioception. It also helps support the performer in training and in performance, as often our eyes are used not only to give us visual information, but also to communicate with our fellow performers and the audience:

> Vision and proprioception may both be critical to the planning of action with their respective roles weighted according to the specifics of the planned action and the environment in which it is to be executed.
>
> Van Beers *et al*, 2002:834

Performers often manipulate their eyes and vision for artistic and communicative purposes rather than to assess how and where they are moving. This is where enhanced proprioceptive sense can help them as it allows them to be able to do this more without using their vision to take landmarks:

> The expressivity of the gaze is important as its direction and all body movements express a feeling. Indeed, the head and eyes are oriented for artistic expression rather than for motor strategy.
>
> Golomer *et al*, 1999:189

As performers normally rehearse and train before taking to the stage in front of an audience, appropriate training as discussed in this thesis will support them to train their proprioceptive senses so they are not so dependent on visual stimuli, freeing their eyes for use in more artistic, communicative ways. Golomer *et al* (1999) conducted a study testing the proprioceptive capacities of trained dancers, hypothesising that the dancers should enjoy more developed proprioception and therefore less reliance on visual information than untrained individuals. They found in tests that the dancers did indeed have better proprioception and suggest that 'professional physical training may shift the sensorimotor dominance from vision to proprioception' (Golomer *et al*, 1999:192).

5.6 Wobble boards and physical perfomer training.

Wobble boards have been clinically proven to improve levels of proprioception. A study by Waddington *et al* (2000) showed that training with wobble boards improved proprioception (and therefore balance). The same study also showed that improved proprioception led to better position sense and movement discrimination. This study was undertaken with football players and found that individuals with better movement discrimination 'perform better' due to more accurate limb placement in co-ordinated movements (2000). All these results are desirable for those training physical performers within theatre contexts.

In addition, Personal Trainer, Della Penna, whose work involves attempting to bring duelling body maps of body schema and body image together also works with wobble boards to help him achieve his aims. As we have seen, he claims that when working with wobble boards and putting balance at the centre of attention, the body schema cannot be ignored (Blakeslee and Blakeslee, 2007:46). By paying more attention to our proprioceptive awareness and therefore body schema, Della Penna hopes that this information will override the often unhelpful body image which can distort people's experience of their bodies. This experience works by changing the participant's centre of gravity. As their balance and centre of gravity is compromised, the habitual tendencies that exist on 'dry land' may change when on a wobble board. It forces the participant to hold their body in a different way to their everyday habitual tendencies and can help them become more aware of what their particular habitual tendencies are.

In my practice as a physiotherapist, I used exercises on wobble boards for years to improve proprioception in my patients, and also used it as a test to measure any improvements the exercises were making. Simply standing on the wobble board and timing how long the participant can stop the sides of the board from touching the floor is a measurable indicator if proprioceptive acuity is improving or not. The wobble board is therefore both a modality to train proprioception and a modality to measure if proprioception is improving.

It was for all these reasons that I chose the wobble board as a training modality to train proprioception, proprioceptive awareness and body schema. It is also a cheap, easy, lightweight way to train physical performers and is easy to work with and transport around and therefore the wobble board became the starting point for the design of the performer training undertaken and became the centre of the study design.

Chapter 6.

6:1Evaluating efficacy of practice.

Another aim of this thesis is to explore a practice led model for research into physical performer training, and to consider how efficacy of practice can be monitored and evaluated. As mentioned earlier, Mark Evans has pointed out that the training of actors represents a field of practice which has been subject to very little in terms of either quantitative or qualitative research (Evans, 2009:2). How do practitioners know if their training methods are working to achieve their objectives? How can practitioners be supported to find ways to provide data for reflection upon their practice in order to make adjustments and adaptations to better serve themselves and their trainees? This thesis attempts to combine quantitative and qualitative research methods in order to allow reflection, and inform the practice.

Reflective practice is discussed within the context of practice led research and Boyce-Tillman *et al*, use the term 'reflective practitioner' (Boyce-Tillman *et al*, 2012:17). In my practice as a physiotherapist, I was encouraged to participate in Reflective Practice, through engaging in activities that contribute towards 'continuing professional development' (CPD). The Chartered Society of Physiotherapy defines 'Reflective Practice' as: 'a process by which you stop and think about your practice, consciously analyse your decision making and draw on theory and relate it to what you do in practice.' It also adds that it, 'refocuses your thinking on your existing knowledge and helps generate new knowledge and ideas. As a result, you may modify your actions, behaviour, treatments and learning needs' (CSP website, www.csp.org.uk). Reflective practice helps to underline strengths and weaknesses of professional practice and therefore point to areas where improvements can be made.

Despite many practitioners in the theatre world reflecting on their practice, there is little evidence of an objective measuring of efficacy of practice. Physiotherapists are encouraged to look for ways to quantitatively measure whether their practice is effective, as well as respecting the power of qualitative results. In physiotherapy, these two methods allow the practitioner to measure the exercises and/or treatments they are using and establish whether they are actually bringing about improvements in desired outcomes for their patients. In this thesis, the quantitative results are designed to be used in the same way, to ascertain if the training is actually bringing about the desired outcome.

This thesis uses both quantitative and qualitative methods through which to explore the area under examination. The first study will seek to demonstrate that wobble board training can improve proprioception in physical performers, and has been designed to address the following hypothesis:

Hypothesis Study One: The level of proprioceptive skill in physical performers can be improved by proprioceptive training procedures involving the use of wobble boards.

The quantitative results from study one can offer a measureable outcome for charting improvements in propriception, for both the researcher and for the participants, and can provide the data to show the training is providing the intended outcome of improving proprioception. The practice will then use the empirical data collected from study one to provide a rationale for embarking on a second, more comprehensive practice led research study to offer an insight into proprioception for the physical performer, which will include both quantitative data and qualitative methods that will seek to pursue the 'insights of relational understandings produced through experience' (Nelson, 2006:19). This study design will address the following hypothesis:

Hypothesis Study Two: Proprioception in physical performers can be improved with specialised and focussed proprioceptive training.

In Study Two, the training methodology will be designed after reflecting on the results of Study One, and include more comprehensive proprioceptive training exercises that are more firmly based in theatre contexts (including performative exercises such as contact improvisation).

The following studies have been designed as purposefully low-fi, technology- light and are not reliant on expensive equipment. A simple but effective test which can easily be reproduced has been chosen with which to measure proprioception in physical performers. This allows a model of research to be shared that allows other practitioners to assess if their training methodologies can improve proprioception in their performers. The following studies have been written in order to be able to stand alone as research studies that can be taken out of the thesis and retain their coherency.

Chapter 6:2.

Research Study One.

The effects of a four week proprioception training programme on trainee physical performers using wobble boards.

Abstract

Objectives: To investigate the effects of a four week proprioception training programme on trainee physical performers using wobble boards.
Hypothesis: The level of proprioceptive skill in physical performers can be improved by proprioceptive training procedures involving the use of wobble boards.
Participants: The trainee physical performers were ten students from Edge Hill University who were all studying modules in physical theatre and performance. All participants were injury free at the time of the study.
Method: The group took part in proprioception training using wobble boards for three days a week for four weeks.
Results: Proprioceptive training involving the use of wobble boards improved the performance outcomes for every participant in the study group.
Conclusion: The results from this study indicate that levels of proprioception can be improved in trainee physical performers using wobble boards.

Study Dates: The following study was undertaken in February 2010 at Edge Hill University in Ormskirk, England.

Introduction

The limbs of physical performers, like dancers, are subjected to extraordinary physical demands (Rein at el, 2011:1602). Physical performers who engage in specialist, skilled movement require greater range of movement, greater muscular control, and high levels of coordination, balance, postural control and flexibility to achieve an optimum level of skilled performance (Miuaidi *et al*, 2009:103). They also require accurate limb placement and the ability to react quickly and appropriately to changes in environmental circumstances. The ability to make fine discriminations in limb placement is a desirable skill for physical performers as it assists them with more precise mastery of specific choreography or poses required in some physical training such as yoga and Tai Chi and supports freedom of movement in improvisation. These attributes also reduce the risk of physical injury occurring, as precise limb placement should reduce the likelihood of moving into ranges of movement, which may cause injury. Injury can delay training and reduce the performing lifespan of the performer by causing limbs to become functionally unstable.

Practicing and refining the proprioceptive sense means greater speed, accuracy, and quality of movement as well as expressiveness (Batson, 2008), which demonstrates its importance for physical performers. To be more precise, proprioception greatly contributes to postural control and functional stability at limb extremities including the foot and the ankle (Zwipp in Rein *et al*, 2011:1602), which manifests as the ability to demonstrate more discrimination in accuracy of limb placement (Waddington *et al*, 2000). Coordinated movement is a result of the normal functioning of the proprioceptive system and high levels of proprioceptive acuity are more critical for skilled tasks that require accurate limb placement than for activities of daily living (Barrack *et al*., 1983;Barrack *et al*., 1984, b; Lephart *et al*., 1996).

A wobble board (sometimes referred to as a balance board) is a wooden or plastic circular, flat platform mounted on a half sphere, which offers an unsteady surface designed to challenge balance and proprioception. Wobble boards have been shown to improve levels of proprioception and coordination in subjects, notably in relation to rehabilitation following injuries of the ankle and knee joints (Clark and Burden, 2005 and Waddington *et al*, 2000). Wobble board training has also been clinically proven to improve the markers of proprioception in healthy subjects with no ankle instability (Chong *et al*, 2001, Hoffman and Payne, 1995, and Waddington *et al*, 2000). Wobble boards are easy to use and easily transportable, making them a good choice for designing a training programme that can be easily replicated. The majority of studies in this area use participants who are active sportspeople and/or those with reported injuries or a history of injuries in the lower extremities. There do not seem to be any other research studies investigating the levels of proprioception in performing arts students at the present time, indicating a lack of research in this area.

In order for a wobble board to be effective in making demands on the proprioceptors, and therefore coordination, the angle of tilt needs to be sufficient to destabilise the body and stress balance but not enough to injure the ankles or lower limbs (Burton, 1986). Most wobble boards found in UK physiotherapy departments are 85mm high and 400-500mm circumference, although different sizes of wobble boards can be used at different levels of proprioceptive rehabilitation as the subject adapts to the level of destabilisation. Although wobble boards have been proven to be effective in improving levels of proprioception and coordination, no studies have been found investigating the optimal dimensions for a wobble board to provide maximum efficacy (Burton 1986). The present study will include the use of three different wobble boards to allow for compensation as participants adapt to the level of destabilisation that each wobble board provides in order to investigate the following hypothesis:

HYPOTHESIS: The level of proprioceptive skill in physical performers can be improved by proprioceptive training procedures involving the use of wobble boards.

Methods

Equipment:

Three wobble boards of differing dimensions were used in the study. There were ten pink plastic wobble boards (diameter: 40.5cm, height: 5cm) and ten black plastic wobble boards (diameter: 40cm, height: 8cm), used to take baseline measurements pre and post study. Ten wooden wobble boards were also used (diameter: 40cm, height: 6.5cm) for training exercises only.

Participants:

The ten participants were all between the ages of 19 – 21. Table 1 displays the mean age for the group.

Table 1: Mean age for study group.

Group	Age
Exercise	20.7

The participants were all trainee physical performers, who were all studying modules in physical theatre and performance at Edge Hill University. None of the participants had an injury at the time of the study, and all agreed not to participate in any other sporting activities or physical training throughout the duration of the study.

Ethical Considerations:

Participants directly participated within this study after a clear and full written and verbal explanation about the nature of the research and their specific contribution. They all volunteered and applied to be part of the study group. The rights, safety and well-being of the participants were of paramount importance throughout the research study. The researcher who carried out the physical training holds a BSc (Hons) in Physiotherapy, and therefore holds the appropriate training and qualifications to undertake this training study. All exercises were designed with the participants' safety and well being in mind. No injuries were sustained throughout this research study.

All participants were over 18 at the time of the studies. The participants all provided informed consent, by way of signing a consent form for their images (both static and moving image) to be used as part of the writing up of the research. They also provided informed consent for their statistics and measurements of proprioception to be used, discussed and reported as part of the thesis. No participants requested that their data was kept confidential or that their identity was made confidential. Each consent form gave information about the study, what would be expected of the participants during the study and how the data and images would be used.

Procedure:

Baseline proprioceptive measurements were taken prior to starting the training, and at the end of the training. Each participant performed ten proprioceptive/balance tasks and recorded their results in seconds. These baseline tests are standard tests currently conducted by physiotherapists to measure proprioception in patients and they are simple to carry out and repeat. The tests are commonly used as both baseline measurements for proprioception and to monitor participants' progression and improvement (Ross, 2006). The tests are described in table 2 below and were carried out by the researcher who is a qualified physiotherapist.

Measurements were taken and recorded in seconds. As tests 5 – 6 involved for many the first time on a wobble board, three measurements were taken so as to get a fair result. Three measurements were also taken for tests 5 – 6 at the end of the training programmes for parity. When measuring duration on a wobble board, time is taken until a side of the wobble board makes contact with the floor. Timing was capped at 120 seconds to prevent those who were comfortable maintaining position being there for long periods of time.

Table 2: Baseline Tests used to measure levels of proprioception pre and post study.

Test	Description
1	Standing 1 foot in front of the other, eyes open
2	Standing 1 foot in front of the other, eyes closed
3	A 1 leg balance, eyes open
4	A 1 leg balance, eyes closed
5	Wobble Board Pink eyes open (3 measurements taken)
6	Wobble board black eyes open (3 measurements taken)

The proprioceptive training programme:

The exercise programme was designed and delivered by the researcher (a qualified physiotherapist). Over a period of 4 weeks, the participants undertook proprioceptive training on 3 days of each week. The training lasted an hour each day.

Some of the exercises were taken from a study by Clark and Burden (2005), designed to improve proprioception using wobble boards and are detailed in table 3 below. The rest have been designed by the qualified physiotherapist/researcher. The exercises outlined in table 3 are the initial exercises used at the start of each training session. The pink and the black plastic wobble boards were used as they are known as 'beginner' boards, and were more appropriate for this study group who hadn't used wobble boards previously. The black plastic wobble board was acknowledged as being slightly easier to use than the pink board due to its slightly wider base, and the wooden wobble boards were more advanced boards. The exercises were carried out on the easier black wobble board on week one of the training study and on both the pink and black wobble boards from week two. The more difficult wooden wobble board was also used for training from the end of week two, although measurements were not taken from this board for the baseline measurements as it is much harder to use without the sides touching the floor. It was therefore used for training only.

Table 3: Initial wobble board exercises (1-4 are adapted from Clark and Burden (2005)).

Exercises	Description
1	Stand with feet parallel on board, rock forwards and back
2	Stand with feet parallel on board, rock board from side to side
3	Stand with feet parallel, rock board in a circular motion
4	Repeat 1 – 3, with knees slightly flexed
5	Stand with feet parallel on board, arms straight up in air
6	Stand with feet parallel on board, arms abducted to 90^0
7	Stand with feet parallel, eyes closed for 5 seconds, then open for 5 seconds
8	Stand on board with 1 leg, repeat with other leg
9	With feet in parallel, bend to touch toes and stand up straight again
10	With feet in parallel, side flex torso to right, then left
11	Feet close together, rock forwards and backwards
12	Feet close together, rock board side to side
13	Feet close together, rock board in circular motion
14	Perform 5 squats whilst balancing on board, feet parallel

Other training exercises involved practising standing with one foot in front of the other, with eyes open and eyes closed, and the single leg balance with eyes open and eyes closed.

Collecting post study data to test hypothesis:

On the last day of the study, the baseline measurements outlined in table 2 were repeated, measured in seconds and recorded.

All results were tested to see if any differences pre to post study had statistical significance. To test statistical significance, a null hypothesis should be stated. A null hypothesis is usually paired with the alternative hypothesis, which is the hypothesis stated at the beginning of this research study, which aims to assert a link between two variables, in this case, the link between the training and the results. The statistics tests then go on to ascertain if the null hypothesis can be disproved instead of attempting to prove the alternative hypothesis. The null hypothesis in this case was: The exercise programme will have no effect on the proprioceptive scores of participants.

To compare the exercise group pre and post study and to test the null hypothesis, a t-test was used. The t-test was used as it is one of the most common means in which to test statistical significance and to test a hypothesis and is a relatively simple test to carry out. It is the most common test used within psychology, medicine and education research (Bridge and Sawilowsky, 1999:229). The t-test works to determine a p-value that indicates how likely it is to have gained these results by chance. By convention, if there is less than 5% chance of getting the observed differences by chance, the null hypothesis can be rejected and a statistically significant difference between the two sets (pre and post study) of results can be recorded. 'If the data provides evidence to reject the null hypothesis, then one can infer that the intervention in question has had a real effect on the outcome' (Daya, 2003:105). The statistical testing was done post study and is analysed below.

Results:

Table 4: Pre study baseline proprioceptive test results for study group. Timings in seconds. Averages to be found at bottom of each column.

Test	1 foot in front of other Eyes Open	1 foot in front of other Eyes Closed	Single leg Stance Eyes Open	Single leg Stance Eyes closed
Participant A	50	6	34	8
Participant B	120	120	120	42
Participant C	74	42	52	12
Participant D	120	120	120	88
Participant E	120	16	89	7
Participant F	120	67	120	12
Participant G	97	13	78	24
Participant H	88	34	70	11
Participant I	120	120	70	23
Participant J	120	102	120	72
AVERAGE	90.9	64	87.3	29.9

Table 5: Post Study baseline proprioceptive test results for study group. Timings in seconds. Averages to be found at bottom of each column.

Test	1 foot in front of other Eyes Open	1 foot in front of other Eyes Closed	Single leg Stance Eyes Open	Single leg Stance Eyes closed
Participant A	120	110	89	45
Participant B	120	120	120	108
Participant C	120	120	120	120
Participant D	120	120	120	120
Participant E	120	79	120	55
Participant F	120	120	120	103
Participant G	120	95	120	120
Participant H	120	78	120	58
Participant I	120	120	120	98
Participant J	120	120	120	120
AVERAGE	120	108.2	116.9	94.7

Table 6: Pre study wobble board results with eyes open for study group.
Times in seconds.
Each participant had 3 attempts on each board. The averages are at the bottom of each column.

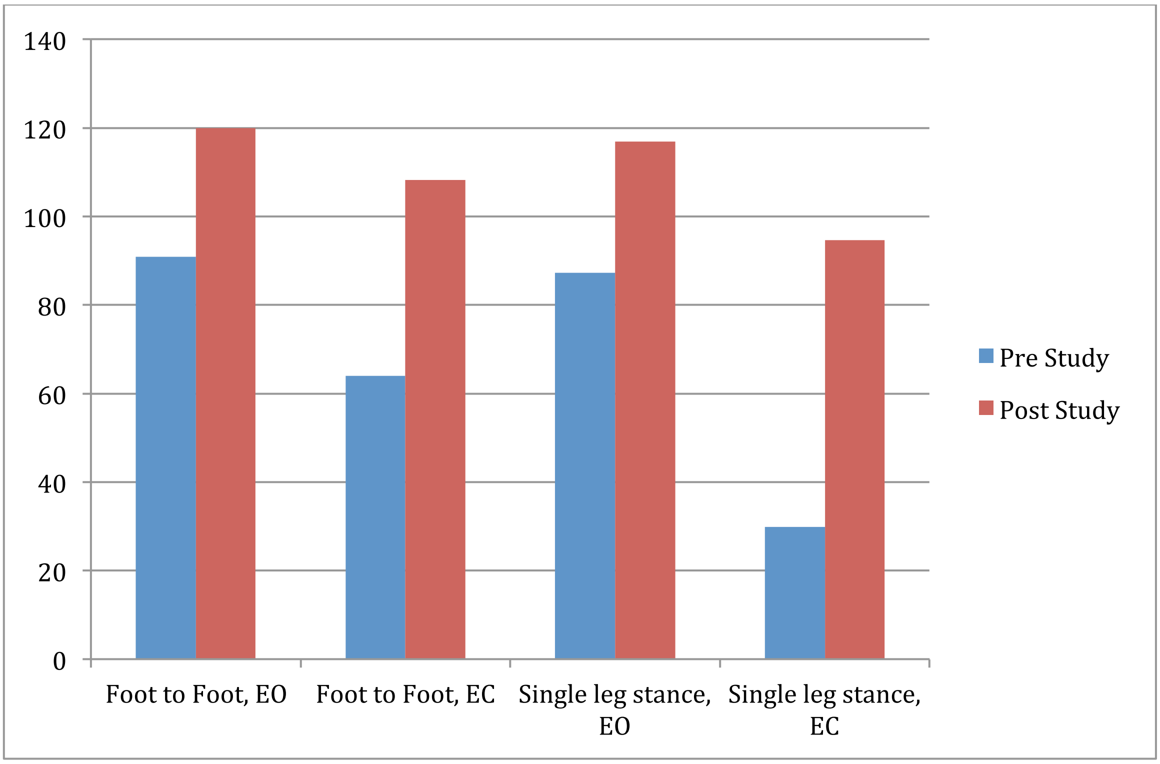
Test	Pink WB EO1	Pink WB EO2	Pink WB EO3	Black WB EO1	Black WB EO2	Black WB EO3
Participant A	15	46	58	24	42	65
Participant B	47	45	88	90	120	120
Participant C	6	5	12	56	47	36
Participant D	4	6	5	72	32	43
Participant E	120	120	120	120	120	120
Participant F	70	37	97	120	120	120
Participant G	120	120	120	120	120	120
Participant H	50	35	65	120	109	98
Participant I	43	61	98	120	120	120
Participant J	12	6	42	120	98	112
Average	48.7	48.1	70.5	108.2	92.8	83.4

Table 7: Post Study wobble board results for study group with eyes open.
Times in seconds.
Each participant had 3 attempts on each board. The averages are at the bottom of each column.

Test	Pink WB EO1	Pink WB EO2	Pink WB EO3	Black WB EO1	Black WB EO2	Black WB EO3
Participant A	98	110	120	120	120	120
Participant B	120	120	120	120	120	120
Participant C	89	57	93	111	117	120
Participant D	73	80	106	120	113	94
Participant E	120	120	120	120	120	120
Participant F	120	120	120	120	120	120
Participant G	120	120	120	120	120	120
Participant H	120	120	120	120	120	120
Participant I	120	120	120	120	120	120
Participant J	42	78	94	120	82	120
Average	102.2	104.5	113.3	119.2	115.2	117.4

Analysis of Results:

Chart 1: Comparison of baseline proprioceptive tests for group pre study and post study. Timings on left axis are in seconds.
EO = eyes open EC = eyes closed.



The first test was the foot to foot stand with eyes open. 60% of the participants managed to stand for the full 120 seconds pre and post study so there was no improvement in this measure pre and post study in these participants as measuring was capped at 120 seconds. The remaining 40% of participants who didn't manage to keep position for the 120 seconds pre study all improved their scores, with 100% of participants managing to keep the position for the full 120 seconds measured post study. The improvement from the average timing pre to post study was **statistically significant.**

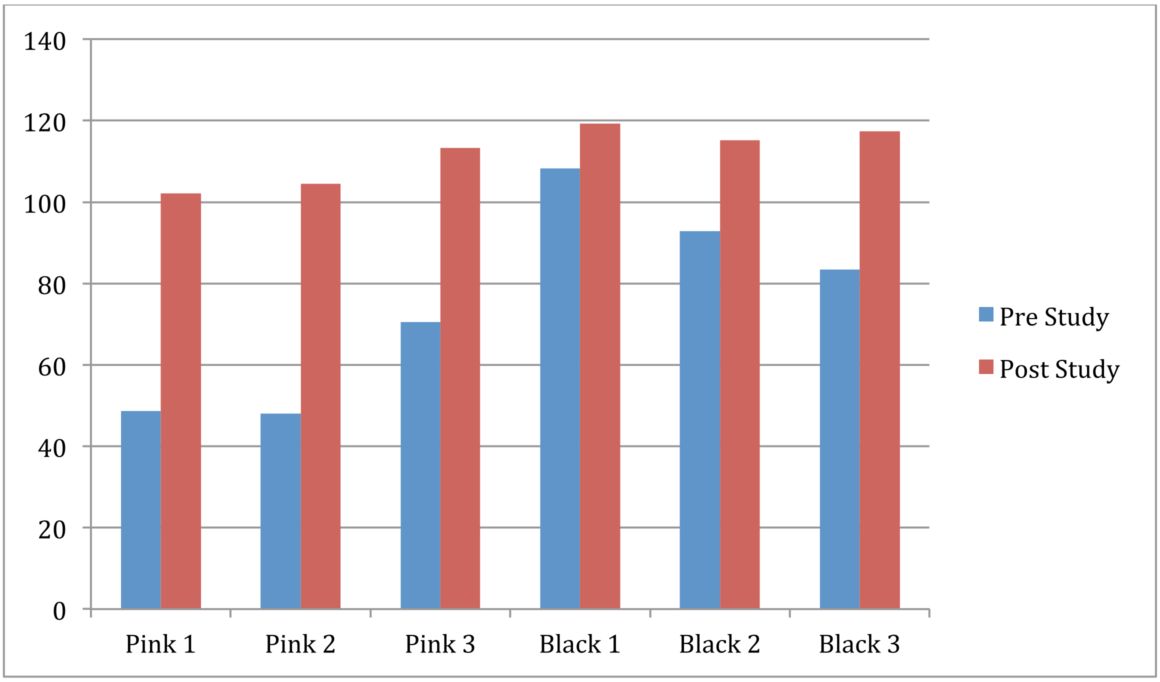
The foot to foot stand with eyes closed test also yielded **statistically significant** improvements in measurements pre to post study. The average measurements taken for this test improved from 64 seconds to 108.2 seconds from pre to post study, which demonstrates an improvement of 69% across the cohort.

The single leg stance with eyes open test showed an improvement from an average of 87.3 seconds pre study, improving to 116.9 seconds posts study. This result demonstrates an improvement across the cohort of 33%. The improvement recorded for this test was shown to be **statistically significant.** The single leg stance with eyes closed test also shown better scores recorded throughout the cohort from pre to post study. The average measurements improved in this test from 29.9 seconds to 94.7 seconds, where participants more than trebled their pre study results. This improvement was found to be **statistically significant.**

Wobble Board Results Analysis:

Chart 2: Bar chart comparing average duration of time achieved on each wobble board on each attempt pre and post study.

Timings on left axis are in seconds.



Wobble Board Results:

The pink wobble board results with eyes open all improved pre to post study. The results also showed an improvement between the first and second attempt and the third attempt, which may indicate a fast learnt reaction helping participants to increase their scores with each attempt on the board. To combat the effects of this potential learned reaction, the average results of the three attempts were also tested to see if they were statistically significant pre to post study. Each participant improved their results regardless of attempt, and each improvement for each attempt was **statistically significant** from pre to post study. Attempt 3 on the pink wobble board eyes open did score higher pre study than attempts 1 and 2, but the same was true for attempt 3 post study, and the improvement recorded had statistical significance. The averages of all 3 attempts also improved with statistical significant results. Taking an average of the 3 attempts on this test, the results increased from 55.7 seconds to 106.6 seconds, which is an improvement of 91%.

The black wobble board with eyes open results did not show the same improvements from attempt 1 to attempt 3 pre or post study. The results showed clear improvements from pre to post study, but didn't find the same pattern as the pink wobble board where participants scored higher times with each attempt on the board. This could be because although many people find the black wobble board easier than the pink (which is reflected in higher scores on the black wobble board), as it has a wider base of support, the base of support is slightly higher, so when a wobble sets in, the participant finds it harder to re-establish equilibrium before the sides have touched the floor than with the pink board, which is closer to the floor. It is beyond the scope of this study to test this in more detail. Taking an average of all 3 attempts with this board, eyes open, showed the results increasing from 94.8 seconds to 117.2 seconds, demonstrating an improvement of 23%, which was found to be **statistically significant**. Improvements for each attempt pre to post study were all found to be statistically significant also.

Results Summary:

The most significant outcome from the study is that proprioceptive training involving the use of wobble boards improved the performance outcomes for every participant in the exercise group as measured by the foot to foot stand, the single leg stance and the wobble board timings on each board.

Discussion:

Other studies (Chong *et al*, 2001, Hoffman and Payne, 1995, and Waddington *et al*, 1999) have shown that proprioception can be improved in healthy subjects who take part in sports with a proprioceptive training programme. This study has demonstrated that the same is true for trainee physical performers who are studying in a performing arts department.

Proprioception is relevant to physical performers due to its role in giving us information about movement and limb position, accuracy of limb position, balance, reflex protection of joints and consequent protection of the body against falls, body awareness, motor control and neuromuscular control.

More research needs to be done to investigate the benefits of improved proprioception in physical performers, and the information needs to be disseminated to the performing arts field.

Limitations:

The participants measured each other in pairs. This will have affected the accuracy of the measurements. The results would have been more accurate if taken by the same person to ensure parity. Absence was occasionally a problem for some participants, with all missing a session at least once. 100% attendance would have made for more reliable results.

Chapter 6:3: From Study One to Study Two.

Study One is a primarily quantitative study which simply shows that proprioception can be improved in physical performers with wobble board training. These results provide a rationale for Study Two, a more comprehensive practice led research study.

In addition to the two research studies carried out for this thesis, the author also undertook a research week in the Motion Capture Laboratory at Sheffield Hallam University (SHU). The research week was part of a wider project analysing and celebrating human movement as part of Yorkshire's Cultural Response to the Olympic Games.

The author was a lead artist on the project, working alongside disabled and non-disabled dancers and physical performers, and the team of scientists from SHU. The technology in the Laboratory enabled movement to be examined in detail with the help of high speed cameras (which capture many more frames of footage per second than the human eye is capable of recognising). The research week at SHU enabled the author to work alongside performers with extremely high levels of proprioceptive acuity, and to ascertain how these levels of proprioception manifest. The author also documented the process by filming the work, to provide clips of the performers in action, in order to help present how improvements in proprioception can lead to enhanced performance and psychophysical fluency.

Study One demonstrates that proprioception can be improved in trainee physical performers, and shows that the training methodology works to achieve its aims. The week in SHU, demonstrated why the trainees in Study One would benefit from improved proprioception as it allowed footage of proprioception in action to be filmed in high level physical performers. The video clips in the DVD present this evidence of why high levels of proprioception are desirable for physical performers.

Examples of why high levels of proprioceptive acuity are desirable for physical performers can be seen in the DVD.

DVD: Clip One: Proprioception in Action: How high levels of proprioceptive acuity manifest.

Description: Documentation showing how high levels of proprioceptive acuity manifest in highly trained performers. See examples of how improved balance and postural controls benefits performers and examples of reflex defence mechanisms at work.

The next DVD clip shows the difference between a highly trained performer and a performer early on in the training process.

DVD: Clip Two:

Proprioception in Action: High levels of proprioception versus improving levels of proprioception.

Description: Documentation which compares and contrasts a performer with very high levels of proprioceptive acuity with a performer who is new to the training. The film analyses how differences in their proprioceptive ability affects their performance.

Study Two now moves to combine the quantitative approach from study one with qualitative research methods, including records of the personal experience of trainees and external observers who watched and commented on any improvements they witnessed. These experiential subjective accounts taken alongside the objective measurable results allow the study not only to measure whether the training is working to improve proprioception, but also look at how these improvements in proprioception manifest in the trainees.

The study design builds from Study One and uses both wobble boards and other forms of proprioceptive training. Examples of the wobble board training can be seen on Clip Three of the accompanying DVD.

Examples of the wobble board training can be seen on the DVD.

DVD: Clip Three:

Proprioception in Action: Looking physiologically at the wobble board training.

Description: A brief physiological introduction to what is happening in the body during the wobble board training, with examples of wobble board exercises.

Chapter 7: Research Study Two.

The effects of a one week proprioception training programme on trainee physical performers using wobble boards and other forms of proprioceptive movement training.

Abstract

Objectives: To investigate the effects on trainee physical performers of a one- week proprioception training programme using wobble boards of differing dimensions, alongside other proprioceptive training including movement training and ball work.
Hypothesis: Proprioception in physical performers can be improved with specialised and focussed proprioceptive training.
Participants: The trainee physical performers were ten students from Edge Hill University who were all studying modules in physical theatre and performance. All participants were injury free at the time of the study.
Method: The group took part in proprioception training using wobble boards and other forms of specially designed proprioceptive movement training for 5 hours a day for 5 days.
Results: Proprioceptive training involving the use of wobble boards, ball work and movement training significantly improved the quantitative and qualitative performance outcomes for every one participant in the study group.
Conclusion: The results from this study indicate that levels of proprioception can be improved in trainee physical performers using wobble boards and other proprioceptive movement training.

Study Dates: The following study was undertaken in August 2010 at Edge Hill University in Ormskirk, England.

Introduction

This study was designed as a follow on from an original study undertaken by Haughey (2010) called 'The effects of a four week proprioception training programme on trainee physical performers using wobble boards'. The original study demonstrated that proprioception in trainee physical performers could be improved after a training programme using wobble boards. The benefits of improved proprioception include greater speed, accuracy, and quality of movement (Batson, 2008) as well as increased discrimination of limb placement which leads to better postural and motor control (Waddington, 2000). The training and resultant improvement in levels of proprioception can also lead to increased efficacy of movement and enhanced neuromuscular control (Toledo *et al,* 2004:75).

The original study solely utilised wobble boards as a proprioceptive training modality, and recorded baseline pre-study and post-study measurements of proprioception in the participants using simple tests used in clinical settings by physiotherapists. The original study results only demonstrated improved proprioception at the ankle joint, as all baseline tests were undertaken using a wobble board, and no other form of measuring was utilised. The present study retains the same baseline tests for ease, simplicity and budgetary reasons, meaning that accurate results for the ankle only will be collected. The rest of the body is not being measured, although other studies have shown that benefits to proprioception for the whole body can be inferred by wobble board work. Most clinical studies demonstrate the improvement of proprioception in the ankle or knee joints but wobble boards have been shown to have an effect on the whole body (Burton, 1986). Balancing on a wobble board will involve use of muscles acting over the ankle, knee, hip, lower trunk and back muscles such as erector spinae, which is engaged alongside the lower limb muscles to bring the centre of gravity back over the board (Burton, 1986). Upper back muscles and upper limbs are also engaged when on the wobble board, particularly in reflex defence mechanisms to assist in staying upright.

The original study by Haughey (2010), hereby known as Study One, proved the hypothesis that proprioception can be improved in physical performers by participating in wobble board training. The present study moves from solely proving the hypothesis to a deeper exploration around proprioception and its benefits for physical performers. Wobble boards are used in the present study to train proprioception and also to take pre-study and post-study measurements for a quantitative analysis as to whether the participants' levels of proprioception improve during this study. The present study then includes qualitative research such as participant experience, more descriptive analysis of how the improvements in proprioception manifest in performing arts students and includes commentary by qualified external observers. Other forms of proprioceptive training will be engaged that more closely resemble forms of training physical performers are used to participating in.

The proprioceptive sense can be sharpened through a number of disciplines. Activities requiring balance, co-ordination, agility, power and movements that challenge the body's normal range of motion are good ways to cross-train for proprioceptive adaptation. Any skill or practice that stresses our balance and ensures sensorimotor control will help improve proprioception. A study by Xu *at el* (2004) demonstrated improvements in proprioception of participants after practising Tai Chi and a study by Gauchard *et al* (1999) showed that practicing yoga and soft gymnastics improved their subjects' levels of proprioception. These practices demand sensorimotor control, co-ordination, balance, challenges to the body's normal ranges of motion and emphasis on the precision of joint and limb placement. The proprioceptive training programme design employed in this present study ensures that all these qualities are included in activities of training.

Methods

Equipment:

10 pink plastic wobble boards (diameter: 40.5cm, height: 5cm), 10 black wobble boards (diameter: 40cm, height: 8cm) and 10 wooden wobble boards (diameter 40cm, height: 6.5cm) were used in this study. Juggling balls were also used as a training modality. Photographic evidence and moving image was captured with a video camera and stills camera. Participants were asked to wear loose fitting clothes and work in bare feet.

Participants:

Ten students who were all studying modules in physical theatre and performance at Edge Hill University volunteered for the research study. The participants received proprioceptive training involving wobble boards and other psychophysical training techniques.

Table 1: Mean age for study group.

Group	Mean Age
Exercise	22.9

The students were all in their second or third year of their degrees and had all worked together prior to the study. None of the participants had an injury at the time of the study, and all agreed not to participate in any other sporting activities throughout the duration of the study.

Ethical Considerations:

Participants directly participated within this study after a clear and full written and verbal explanation about the nature of the research and their specific contribution. They all volunteered and applied to be part of each study group. The rights, safety and well-being of the participants were of paramount importance throughout the research study. The researcher who carried out the physical training holds a BSc (Hons) in Physiotherapy, and therefore holds the appropriate training and qualifications to undertake this training study. All exercises were designed with the participants' safety and well being in mind. No injuries were sustained throughout this research study.

All participants were over 18 at the time of the studies. The participants all provided informed consent, by way of signing a consent form for their images (both static and moving image) to be used as part of the writing up of the research. They also provided informed consent for their statistics and measurements of proprioception to be used, discussed and reported as part of the thesis. No participants requested that their data was kept confidential or that their identity was made confidential. Each consent form gave information about the study, what would be expected of the participants during the study and how the data and images would be used.

Procedure:

Baseline proprioceptive measurements were taken prior to starting the training, and at the end of the training. Each participant performed 10 proprioceptive/balance tasks and recorded their results in seconds. These baseline tests were chosen as they are tests conducted by physiotherapists in order to measure proprioception in patients and they are simple to carry out and repeat. The tests are commonly used as both baseline measurements for proprioception and to monitor participants' progression and improvement (Ross, 2006). It is important to note that the baseline proprioceptive tests employed in this study only really address the balance facet of proprioception, as to test other facets of proprioception would require more expensive equipment, or clinical skill is required and the study would lose one of its most desirable features; its ability to be replicated easily and without requiring budget, experience or expensive equipment. However, as Stillman underlines, the single leg stance tests and foot to foot stance (both with eyes open and eyes closed) also all test the 'total body motor control functions of the proprioceptive system' (Stillman, 2002:674). The wobble boards provide the next level in testing this facet of proprioception, by causing increased instability. The increased instability causes 'greater foot and ankle joint motion, and therefore greater proprioceptive feedback from the foot and ankle proprioceptors' (Stillman, 2002:674). The tests were therefore deemed highly appropriate for this study and act as good general indicators of proprioception.

The tests are described in table 2 below and were carried out by the researcher (a qualified physiotherapist). Measurements were taken and recorded in seconds. As tests 5 – 10 involved for many the first experience of a wobble board, three measurements were taken so as to get a fair result. Three measurements were also taken for tests 5 – 10 at the end of the training programmes for parity. When measuring duration on a wobble board, time is taken until a side of the wobble board makes contact with the floor.

Table 2: Baseline Tests used to measure levels of proprioception pre and post study.

Test	Description
1	Standing 1 foot in front of the other, eyes open
2	Standing 1 foot in front of the other, eyes closed
3	A 1 leg balance, eyes open
4	A 1 leg balance, eyes closed
5	Wobble Board Pink eyes open (3 measurements taken)
6	Wobble board pink eyes closed (3 measurements taken)
7	Wobble board black eyes open (3 measurements taken)
8	Wobble board black eyes closed (3 measurements taken)
9	Wooden wobble board eyes open (3 measurements taken)
10	Wooden wobble board eyes closed (3 measurements taken)

Collecting post study quantitative data to test hypothesis:

On the last day of the study, the baseline measurements outlined in table 2 were repeated, measured in seconds and recorded. All results were tested to see if any differences pre to post study had statistical significance. To test statistical significance, a null hypothesis should be stated. A null hypothesis is usually paired with the alternative hypothesis, which is the hypothesis stated at the beginning of this research study, which aims to assert a link between two variables, in this case, the link between the training and the results. The null hypothesis in this case was: The exercise programme will have no effect on the proprioceptive measurements of participants, or on their experience qualitatively post study.

To compare the pre and post study results from the group, to test the null hypothesis, and to demonstrate if the results had statistical significance, the commonly used t-test was used. More information about the t-test can be found in Study One, and has been used for the same reasons as outlined there (Haughey, 2010). The results of the statistical testing, carried out post study, are displayed in the appendix and the results are analysed below.

Collecting post study qualitative data:

Alongside the measuring of changes in proprioception pre and post study using the proprioceptive tests outlines in table 2, other forms of result taking were employed in this present study. Photographs were taken of each participant pre and post study, forward facing and side profile shot. Interviews were also recorded with the participants throughout the week about their experiences. Each participant was also encouraged to keep a working journal of his or her experiences to provide alternative material after reflection in writing and to provide an account of the work in the absence of questioning, which can be leading.

Results and observations were also recorded by external observers, Kate Engineer and Bill Hopkinson. Kate is a Laban trained dancer, an anatomically trained massage therapist and lecturer in dance. Bill is a senior lecturer at Edge Hill University whose research interests lie in neuroscience and acting. Both external observers have extensive backgrounds in working with performers in training, and both had worked previously with all the participants. The observers were asked to record any noticeable changes in posture, the differences in the participants' movement vocabularies, how the training affected their movement expressivity, and any other changes they observed.

Bill attended training every day for at least two hours. Kate came on day one and then again on the final day to note any differences she observed between the two days. Both external observers recorded their observations in written form, as well as taking part in verbal feedback after the sessions they attended.

The proprioceptive training programme:

The exercise programme was designed and delivered by a qualified physiotherapist. Over a period of one week, the participants undertook proprioceptive training each day from 10am until 4pm. A one hour break was taken for lunch at around 12.30pm. An afternoon break was also taken to allow for rest.

The initial wobble board proprioceptive training exercises were taken from either Study One (Haughey, 2010) or from a study by Clark and Burden (2005). All exercises were designed to improve proprioception using wobble boards and are detailed in table 3 below. The exercises outlined in table 3 are the initial exercises used at the start of each training day. The exercises were carried out on the black wobble board on day one, the pink wobble board on day two and the wooden wobble boards on day three onwards. This reflects the order of difficulty in each wobble board. The black and pink wobble board were classified as 'beginner boards', with the pink being slightly more difficult to use as the black wobble board has a wider base of support. The wooden wobble board was classified as an 'advanced wobble board'.

Table 3: Initial wobble board exercises (1-4 are adapted from Clark and Burden (2005), 5 – 14 are taken from study one (Haughey, 2010)).

Exercises	Description
1	Stand with feet parallel on board, rock forwards and back
2	Stand with feet parallel on board, rock board from side to side
3	Stand with feet parallel, rock board in a circular motion
4	Repeat 1 – 3, with knees slightly flexed
5	Stand with feet parallel on board, arms straight up in air
6	Stand with feet parallel on board, arms abducted to 90^0
7	Stand with feet parallel, eyes closed for 5 seconds, then open for 5 seconds
8	Stand on board with 1 leg, repeat with other leg
9	With feet in parallel, bend to touch toes and stand up straight again
10	With feet in parallel, side flex torso to right, then left
11	Feet close together, rock forwards and backwards
12	Feet close together, rock board side to side
13	Feet close together, rock board in circular motion
14	Perform 5 squats whilst balancing on board, feet parallel

Other training exercises involved practising the exercises used as baseline markers of proprioception: one foot in front of the other, with eyes open and eyes closed, and the single leg balance with eyes open and eyes closed. These exercises were repeated daily.

The training also included forms of proprioceptive exercises that more closely resemble forms of training that physical performers are used to participating in. This part of the training was designed by the researcher, a qualified physiotherapist who also has over ten years experience working within the physical performing arts domain. The proprioceptive training included exercises that aimed to challenge the sensorimotor system and stress balance as activities that do so have been shown to improve levels of proprioception (Ahmed, 2011, Xu *et al,* 2004). Exercises that encouraged attention to be paid to proprioceptive awareness via touch (and therefore body schema awareness) were also included. This is because of the other studies demonstrating that activities such as Tai Chi (where participants place concentrated attention on body position) have been shown to improve levels of proprioception (Xu *et al,* 2004 and Gauchard *et al,* 1999). Below is a table detailing all exercises with the aims of each exercise clearly stated.

Table 4 below outlines the exercises employed.

Table 4: Proprioceptive training exercises, descriptions and aims of each exercise.

Exercise	Description	Aims
Playing with precarious balance off boards	In a circle, the group starts with feet on floor in parallel position, hip width apart. They then start by massaging feet with the floor. The whole body is used, starting from the feet's interaction with the floor.	To increase connection with the floor.
	The participants are then encouraged to explore their balance through single leg stands, squats and exploring ranges of flexion and extension at the hip, knee and ankle joints.	To increase beyond 'normal' range of movement.
	They are encouraged to find out where their centre of gravity is and where their base of support is. From this, the participants are asked to explore and stress their own balance by pushing their body out of their normal base of support. The whole body is included.	To stress the balance and sensorimotor system.
Touch Awareness	In partners, one stands with eyes closed with feet in parallel. The seeing partner touches various parts of their partner's body. The seeing partner can experiment with touch of differing force, duration and	To stimulate proprioceptive awareness and body schema awareness.

	intensity. The seeing partner must be wary of leaving time in between touches so they don't overlap and overload their partner's system. They must also be wary of falling into any patterns so their partner doesn't anticipate where they will be touched next. The 'blind' partner uses the exercise to bring their awareness and attention to the body part touched by the seeing partner.	
Impulse work off the board.	In partners, one stands with eyes closed and feet in parallel. The seeing partner offers the blind partner 'stimuli': touches of differing force, feel and duration. The 'blind' partner can respond to the stimuli provided in any way they want, allowing the body to react and move in response. The seeing partner should be in charge of the exercise and the 'blind' partner should allow the body's response to happen without forcing it.	To stimulate proprioceptive awareness and body schema awareness.
Wobble Board Flow	In this exercise, the participant is told not to 'try to balance', but to allow the wobble board to 'be in charge'. The participant is free to take impulses from the board and allow them to flow through the whole body, even if it means momentarily losing balance and having to step off the board. The movement quality is soft and about 'letting go'. Participants can adopt different positions as they become more relaxed within the exercise, and try flexing and extending at the ankle, knee and hip joints. The whole body is engaged in this exercise and this should be encouraged with verbal cues.	To train proprioception. To stress the balance. To allow movement to flow through the body without blocking it. To become aware of any tension existing in the body that is preventing flow of movement.
Impulse work on the Wobble board	This is the same exercise as the impulse work described above, but this time one partner is on a wobble board, and one is on firm ground. The partner on firm ground is providing the impulses to the partner on the wobble board, who should let the impulses travel through the body without blocking them. The stimuli can be given to any part of the body, and time must be given for the partner on the board to regain control and balance in between each stimuli and resultant impulse.	To train proprioception. To stress balance. To allow movement to flow through the body without blocking it.

		To become aware of any tension in the body that is blocking flow of movement.
The ball game off the boards[17]	The participants stand in a circle, throwing a ball around the group in a random order. The game develops until as many balls as the group can cope with are flowing round the circle. Participants are given verbal cues to bring their attention to the game taking place and be present for the game, not thinking about other things. Participants are encouraged to become aware of habits such as preferring to throw and/or catch with a dominant hand, and throwing harder from one side of the body than the other.	To increase attention on the task in hand. To train coordination. To be 'in the moment'. To train proprioception. To become aware of any habits that get in the way of playing the games successfully – ie throwing and catching with a dominant hand.
The ball game on the wobble boards	As the ball game above, but this time the participants are standing on wobble boards in a circle. They are told not to worry about trying to keep good balance on the wobble board, and just to play the ball game. One participant at a time takes turn to run around and pick up dropped balls and keep throwing them back in.	To train proprioception. To train coordination. To stress balance and the whole sensorimotor system. To be 'in the moment'.
Duet ball game off boards[18]	Two participants have two balls between them. The left hand of one participant throws to the right hand of their partner and the right hand throws to the	To train proprioception.

[17] This exercise was inspired by the work of John Britton, actor trainer and practitioner, who specialises in training actors psychophysically. More about John's work can be at www.**ensemble**physicaltheatre.com
[18] Another exercise inspired from John Britton's work.

	partner's left. The balls must not cross diagonally from left to right. With practice, the partners must attempt to make the game harder by avoiding falling into a rhythm (which is simpler as participants can predict the timings of the throws) and use throws of differing power, length and width. Ie the participants should stress their partners by throwing outside of their reach so they have to move out of their base of support.	To train coordination. To push each other out of the base of support and therefore stress balance, whilst attending to an external task (of catching ball).
Duet ball game on wobble boards	Same game as duet game described above but this time both participants are on a wobble board and 1 extra participant is free to pick up dropped balls and assist the pair working.	To train proprioception. To train coordination. To stress balance and sensorimotor system.
Physiotherapist Facilitation off boards	Each participant takes turns at working one on one with the physiotherapist, with the rest of the group observing. The participant stands with feet parallel, hip width apart. The physiotherapist assesses how each participant presented at the beginning of the training, and noted any areas of unnecessary tension, movement habits and postural habits. With this information in mind, the physiotherapist offers small facilitations to combat this tension or habits. The facilitations can be a touch, a passive movement to move the participant, or an inhibition of a muscle or muscle group.	To offer different suggestions of how to move. To make the participant more aware of habitual physical tendencies and areas of unnecessary tension.
Partner Facilitation off the wobble boards	From the demonstration with the physiotherapist, the participants find a partner and explore this work further. The facilitating partner doesn't need to have the anatomical or therapeutic musculoskeletal training as they are not mobilizing or engaging in manipulation, but gently offering differing suggestions of where to move from and how to move using light touch to provide stimulation to various limbs. This is similar to the impulse work, but much more focused on habitual tendencies.	To offer different suggestions of how to move. To offer different postural changes. To bring the participants awareness to

		different body parts and how they move habitually.
Partner Facilitation on the wobble boards	Same exercise as above, but this time one partner is on the wobble board whilst the facilitating partner is on firm ground. More time is left in between facilitations to allow for the participant to recover and regain balance.	To offer different suggestions of how to move and postural changes. To train proprioception. To stress balance and sensorimotor system. To bring participants in touch with their body schema.
Solo ball overload on the wobble boards	Each participant takes a turn on a wobble board facing the rest of the group. The rest of the group throw balls at the balancing participant, taking care to make sure the throws are at an appropriate height, but that are pushing the end limits of what is in reach so the balancing participant really has to work hard to catch the balls. More than one ball can be thrown at once – so the balancing participant is deliberately overloaded.	To train proprioception. To stress balance and sensorimotor system. To bring participants in touch with their body schema.

Towards Performative Structures:

The training exercises outlined above were completed each day, with developments to make the exercises more difficult where needed. This was in order for the group to keep making improvements, if possible, in their levels of proprioception, which was measured post study quantitatively. Other more qualitative outcomes of the work are noted in the results section, and explored in the discussion section. After the exercises outlined in table 4 were completed, the group were guided towards more performative structures, including contact improvisation training exercises which are outlined below in table 5.

Contact Improvisation:

Contact improvisation is a form of movement training that involves working with 1 partner or more in the space, and working through making physical suggestions to each other that materialise as continuous movement improvisations. The point of contact between the performers provides the starting point for the movement exploration. Contact improvisation is about sharing and exchange of weight and accepting and rejecting stimuli and impulses from partners. It requires good energy and body awareness, and an openness to receive and accept impulses from partners. It also requires precision of limb placement and appropriate force and sensitivity of muscular action to be used. In short, high levels of proprioception facilitate ease of movement and high levels of performance in contact improvisation. The very qualities that we are looking to improve through proprioceptive training can be seen in action during contact improvisation and other forms of movement improvisation by skilled performers. Actor trainer David Zinder amongst others recommends contact improvisation as a good training tool for actors as it employs many qualities that are desirable to the work of the actor (Zinder, 2002). These desirable qualities include being receptive and responsive (being open and available to receive impulses and physical suggestions from other performers), being sensitive and using appropriate force through movement when working with others, being creative and able to improvise, accurate limb placement and therefore accuracy of movement, having quick, appropriate (and therefore safe) reactions to impulse and external stimuli, and having good balance, coordination and neuromuscular control.

Contact Improvisation Exercises explored:

As well as free flow partner contact improvisation work, other movement tasks inspired around contact were explored with the group. These exercises are described in table 5.

Table 5: descriptions of the contact improvisation exercises used throughout the proprioception training.

Exercise	Description
Contact Improvisation In pairs	In pairs, freestyle dance and movement improvisation, based around touch and contact between the 2 partners. Lifts and other forms of weight transfer and exchange can be explored. Partners should try to be open to receive physical suggestions from partner so momentum can support the exploration of movement.
Contact Group lift Exercise	In this exercise, the group has the task of travelling from corner to corner of the room. At each corner, a new member of the group must be lifted off the floor and a way of carrying them must be improvised in the moment, with decisions made as a group.
Contact Group Travel with lifts	The group begins close together, with all in physical contact to at least one other person. The group travels as a unit, improvising how they move, from one area in the room to another clearly defined area. Throughout the improvisation, lifts and rolls over each other may be incorporated.

Results:

All results are tabulated in this section. All quantitative pre and post study results have been tested to see if they have statistical significance. The statistical tables can be found in the appendix.

Quantitative Results:

Table 6:Pre Study Baseline Results for proprioceptive exercises.
Times in seconds.
The averages are at the bottom of each column.

Test	1 foot in front of other Eyes Open	1 foot in front of other Eyes Closed	Single leg Stance Eyes Open	Single leg Stance Eyes closed
Participant A	120	120	57	43
Participant B	120	120	120	52
Participant C	120	120	120	20
Participant D	120	120	120	96
Participant E	120	17.7	109	8.92
Participant F	120	120	120	17
Participant G	120	13	120	33
Participant H	120	120	120	29
Participant I	120	120	70	23
Participant J	120	102	120	100
AVERAGE	120	97.27	107.6	42.16

Table 7: Post Study baseline results for proprioceptive exercises.
Times are in seconds. Averages are at the bottom of each column.

Test	1 foot in front of other Eyes Open	1 foot in front of other Eyes Closed	Single leg Stance Eyes Open	Single leg Stance Eyes closed
Participant A	120	120	120	73
Participant B	120	120	120	86
Participant C	120	120	120	45
Participant D	120	120	120	120
Participant E	120	120	120	65
Participant F	120	120	120	120
Participant G	120	120	120	120
Participant H	120	120	120	120
Participant I	120	120	120	44
Participant J	120	120	120	120
AVERAGE	120	120	120	91.3

Table 8: Pre study wobble board results with eyes open.
Times in seconds.
Each participant had 3 attempts on each board. The averages are at the bottom of each column.

Test	Pink WB EO1	Pink WB EO2	Pink WB EO3	Black WB EO1	Black WB EO2	Black WB EO3	Wooden WB EO1	Wooden WB EO2	Wooden WB EO3
Participant A	7	35	120	120	120	120	0.9	2	2.3
Participant B	31	32	108	90	120	120	2.4	3.1	3.2
Participant C	6	82	120	120	120	120	0.7	1	2
Participant D	120	120	120	120	120	120	0.8	1.4	2.1
Participant E	2	2.5	3	18	48	53	0.5	0.5	0.5
Participant F	11	31	106	120	120	120	0.6	0.8	1
Participant G	120	120	120	120	120	120	1	1	1
Participant H	50	35	120	120	120	120	1	1	1
Participant I	61	101	103	120	120	120	0.5	1	0.5
Participant J	5	11	10	120	120	120	1.4	1.5	1
Average	41.3	56.9	93	105.8	112.8	113.3	0.98	1.33	1.47

Table 9: Post study wobble board results with eyes open.

Timings in seconds. Averages to be found at the bottom of each column.

Test	Pink WB EO1	Pink WB EO2	Pink WB EO3	Black WB EO1	Black WB EO2	Black WB EO3	Wooden WB EO1	Wooden WB EO2	Wooden WB EO3
Participant A	5	120	120	120	120	120	1.5	2	2.4
Participant B	120	120	120	120	120	120	3.2	3.1	3.2
Participant C	120	120	120	120	120	120	1.5	2	2.5
Participant D	120	120	120	120	120	120	1.5	2	1.5
Participant E	120	120	120	120	120	120	1.5	2	1.3
Participant F	120	120	120	120	120	120	1.1	1.7	12
Participant G	120	120	120	120	120	120	1.8	1.6	3
Participant H	120	120	120	120	120	120	2	1.5	3
Participant I	120	120	120	120	120	120	1.4	2.3	6
Participant J	5	11	10	120	120	120	1.8	2.5	2.5
Average	108.5	120	120	120	120	120	1.68	2.03	3.74

Table 10: Pre study wobble board results with eyes closed.

Times in seconds. Average results are at the bottom of each column.

Test	Pink EC1	Pink EC2	Pink EC3	Black EC1	Black EC2	Black EC3	Wooden EC1	Wooden EC2	Wooden EC3
Participant A	2.2	3.8	5	6	6.6	13	0.9	1.9	2
Participant B	3.3	4.2	4.8	3.2	10.4	12	1.5	1.7	1.5
Participant C	3	3	5	4	4	5	0.9	1.9	2.4
Participant D	4.2	4.5	15.8	24	28	36	0.5	1	1.8
Participant E	1.5	1.5	2	2	3	4	0.2	0.2	0.2
Participant F	1.8	1.9	2	3	4	11	0.9	1	1.6
Participant G	2.8	4.5	5	5	18	32	0.8	0.5	0.5
Participant H	5	5	10	6	6	12	0.5	1	1.5
Participant I	2.5	3	7	3	3.5	15	1.5	1	1.5
Participant J	2.3	3.2	2.2	3.2	3.2	4.9	0.5	0.5	1
Average	2.86	3.46	5.88	5.94	8.67	14.49	0.82	1.07	1.4

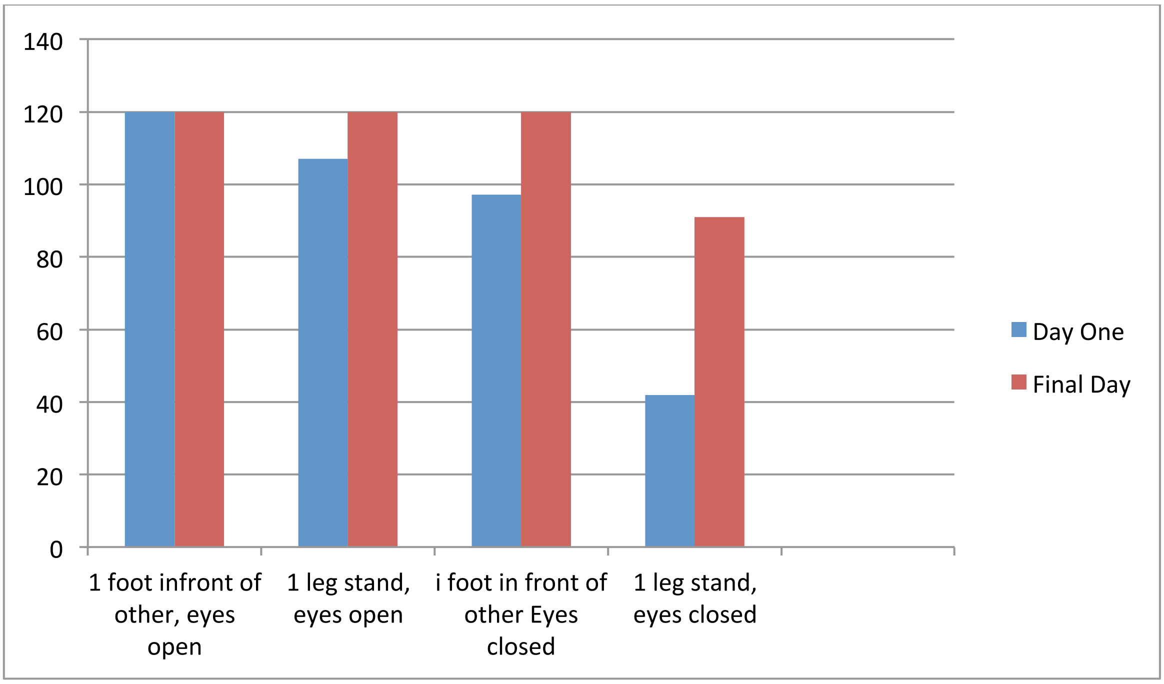
Table 11:Post study wobble board results with eyes closed.

Timings in seconds. Averages are at the bottom of each column.

Test	Pink EC1	Pink EC2	Pink EC3	Black EC1	Black EC2	Black EC3	Wooden EC1	Wooden EC2	Wooden EC3
Participant A	2.5	7.4	9	60	50	59	1.7	1.6	2.3
Participant B	3.8	4.5	6	10	30	14	1.5	2	1.5
Participant C	8	7	9	102	100	90	2.5	2	2.5
Participant D	11.5	9	18	120	120	120	1	1.5	2
Participant E	3.2	5	6	15	20	22	1	1	1.1
Participant F	3	6	8	8	9	10.5	1.3	1	1.6
Participant G	6.2	4.6	10.9	10.9	22	24	2.7	1.5	2
Participant H	4	7	17	12	15	22	1.5	2	2.7
Participant I	3	3.5	8	46	34	35	1.5	1	2.5
Participant J	5	6.5	4.8	71	78	54	1	0.5	1.2
Average	5.02	6.05	9.67	45.49	47.8	45.05	1.57	1.41	1.94

Analysis of results:

Chart 1: Comparison of baseline proprioceptive tests (without wobble boards) pre study and post study. Timings on left axis are in seconds.



The first test was the foot to foot stand with eyes open. All participants managed to stand for the full 120 seconds pre and post study so there was no improvement in this measure pre and post study. This test would have flagged up if there were any major proprioceptive problems and therefore balance problems in the group with short timings in this test, of which there were no participants in this cohort.

There was no statistically significant improvement in the foot to foot stand with eyes closed from pre to post study. Only 3 participants didn't manage the 120 seconds pre study and had to take a step out of position to stabilise themselves. From the 3 participants who didn't manage the 120 seconds pre study all improved significantly post study and managed to maintain position for the full 120 seconds.

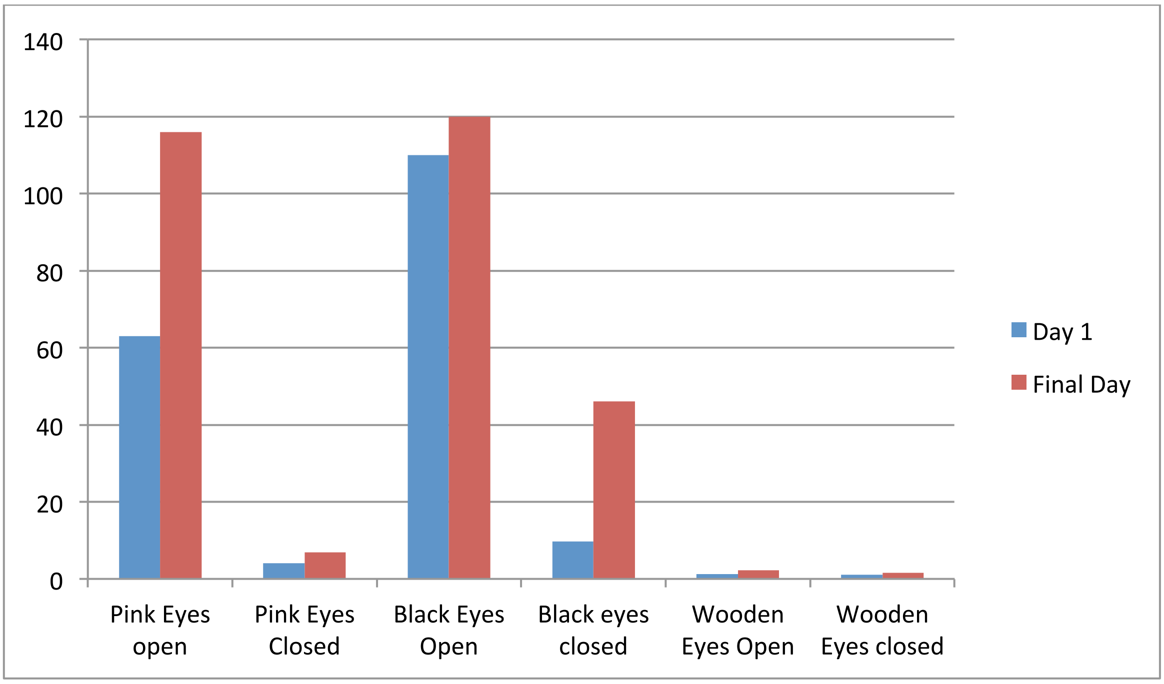
The results of the single leg stance test (eyes open) did not show statistically significant improvements from pre to post study. This was because there were only 3 participants who did not manage to hold position for 120 seconds, so although those 3 participants all improved to be able to maintain position for 120 seconds post study, there was not enough of them for the improvement to be statistically significant. The improvements in these first three tests, although not statistically significant, still clearly show an improvement in results pre to post study.

The results for the single leg stance with eyes closed yielded a **statistically significant** improvement in the cohort from pre to post study. In this test, not one participant was able to maintain position for 120 seconds pre study, whereas 50% of the cohort managed 120 seconds in position with eyes closed post study. The 50% that didn't manage the full 120 seconds all improved their results from pre to post study, with many doubling their times in position. The most significant improvement was seen in participant F, who improved from 17 seconds to 120 seconds, where timing stopped.

Wobble Board Results:

Chart 2: Bar chart comparing average duration of time achieved on each wobble board with eyes open and eyes closed pre and post study.

Timings on left axis are in seconds.



In the pink wobble board with eyes open results pre study, the results yielded **statistically significant** results in the first and second attempts on the board from pre to post study. 100% of participants improved their results in the first and second attempt of the board. The results for the third attempt on the pink board with eyes open was not statistically significant. This was because pre study, 50% of the cohort managed 120 seconds on the board without the sides touching, so the improvement, although clear, wasn't as significant across the group. Despite not being statistically significant, the 50% who managed times of 120 seconds improved to 90% of the cohort managing 120 seconds post study. 100% of participants improved or maintained their results. When all the pink wobble board (eyes open) test results were combined, and an average of the three attempts taken, the improvement pre to post study was statistically significant.

In the black wobble board (eyes open) results, none of the three attempts yielded results of statistical significance pre to post study. This is because so many participants managed to maintain balance on the board for 120 seconds pre study, so the improvements in timings are diluted within the group. Despite not being statistically significant, every participant maintained or improved their results from pre to post study.

The wooden wobble board test with eyes open yielded results that were **statistically significant** in each of the three attempts, with the participants improving the timings on the board without the sides touching from pre to post study. Taking an average of the average of each of the three attempts, the cohort improved from 1.26 seconds to 2.48 seconds, showing an increase of 96%.

The results on the pink wobble board with eyes closed were **statistically significant** in each of the three attempts, with the results improving from pre to post study across the cohort. Taking an average of the average of each attempt, the cohort improved from 4.06 seconds to 6.91 seconds, showing an increase of 70.19%.

Unlike the black wobble board results for eyes open, in which there was an improvement but it wasn't statistically significant, the improvement in black wobble board results with eyes closed were **statistically significant,** in each of the three attempts undertaken by participants. Taking an average of the average of the three attempts, the improvement found was still statistically significant. Participant C had the largest improvement, going from 4, 4 and 5 seconds in each of the pre study attempts to post study timings of 102, 100 and 90 seconds in each of the respective three attempts. The post study result is 20 times better than the pre study result, when averages are taken.

The wooden wobble board results with eyes closed also showed a **statistically significant** improvement in timings pre to post study. Each participant improved their timings and taking averages of each attempt, the cohort demonstrated an improvement of just over 50%.

Quantitative Result Summary:

The most significant outcome from the study is that proprioceptive training involving the use of wobble boards, balls and movement training improved the performance outcomes for every participant in the exercise group as measured by the foot to foot stand, the single leg stance and the wobble board timings on each board.

The tests that saw a statistically significant improvement were: single leg stance (eyes closed), the average of the pink wobble board results with eyes open, wooden wobble board with eyes open, and on each of the wobble boards with eyes shut. The results that were not statistically significant all improved pre to post study, but the difference in results were not enough to demonstrate statistical significance as the results were capped at 120 seconds.

Qualitative Results:

Qualitative results were recorded by interviewing the participants and the external observers on a daily basis throughout the study period, at the end of the training each day. All participants were asked to keep a log about their experiences throughout the study, and the external observers were asked to keep a log to record their observations and thoughts about the training and any changes they saw in the participants from day to day or during/after a certain exercise. Photographs were also taken to document presenting posture of each participant pre and post study for comparison.

Below is table 12, which outlines each exercise and any observations or experiences noted by the participants, the external observers or the researcher. These observations or experiences are the main findings for each exercise and were taken from written logs and/or from authors' notes taken from interviews. More detailed quotes will be used to help explore these findings in more detail in the discussion later.

Table 12: Table of observations/experiences noted by the participants, external observers and the researcher in response to each exercise. Observations are numbered to provide easy reference in the discussion.

Exercise	Observations (written from logs or transcribed from interviews)	Participant/ Observer/ Researcher
Precarious Balance off Boards	1.Emotional Release (usually laughter).	Both
	2. Fear to go out of base of support initially.	External Observer (Bill)
	3. Increased connection with the floor post exercise exploration, seen when feet are back in parallel, hip width.	External Observer (Bill)
	4.Reflex defence mechanisms observed in whole body, not just lower extremities.	Researcher
Touch awareness	5.Increased awareness of body parts in relation to each other.	Participant
	6. It felt easier with eyes closed to bring attention to different body parts.	Participant
	7.Increased sensitivity to touch (whole body).	Participant

Impulse work off boards	8.Increased awareness of body parts in relation to each other.	Participant
	9.Increased awareness of how the body parts move in relation to each other.	Participant
	10.It was clear to see where physical blocks existed in the body – areas where the flow of the movement was stopped.	External Observer (Kate)
	11.In the majority of participants there were accelerated response times, closing the gap between stimulus and response.	External Observer (Bill)
Wobble board flow	12.Emotional Release (usually laughter).	Participant & External Observer
	13.Fear to go out of base of support initially.	External Observer (Bill)
	14.There seemed to be less resistance and physical blocks to movements flowing through the body than in the 'Impulse off the board' exercise.	External Observer (Kate)
	15.Where physical blocks did exist, it was clear to see them. They manifested as areas where the flow of movement was stopped.	External Observer (Bill)
	16.Increased responsiveness in all participants.	Researcher & External Observers.
Impulse work on the wobble board	17.This time it was much easier to respond to the facilitating partner without thinking about the movement. It just happened.	Participant
	18.The responses to suggestions of impulses from facilitating partner seemed much more authentic.	External observer (Bill)
	19.The reflex defence mechanisms were clear to see in the whole body.	Researcher
	20.The participants seemed more comfortable with being 'off balance' during this exercise.	External Observer (Bill)
	21.The movements seen in the participants during this exercise were very responsive, reactive and instant.	External Observer (Bill)
	22.There were fewer blockages and resistances to movement seen in this exercise than observed in the 'impulse off the wobble board' exercise.	Researcher & External Observer (Kate)

	23.Increased responsiveness in all participants. An increased openness and receptivity to external stimuli and each other.	Researcher & External Observers
The ball game off the boards	24.The ball game demands that you are 'in the moment' and your thoughts don't stray much.	Participant
	25.As the group improved, more surprise catches were made successfully (catches you don't expect to make, or find in your hand without the pre planning to catch).	Participant
	26.Participants became aware of habitual tendencies such as throwing and catching from a dominant hand, throwing longer with dominant hand and short with non-dominant hand and not using both sides of the body equally.	Participant & External Observer
	27.Focus and concentration were high throughout this exercise & improved with more practice.	Participant & External Observer (Kate)
	28.A clear improvement from day one to day five noted for this exercise, including more catches of balls (with consequent fewer ball drops).	Researcher and External Observer (Bill)
	29.An improvement noted from day one to day five in precision of closing fist around ball to make a secure catch.	Researcher
	30.Reaction time was quicker from day one to day five, manifesting in more balls being caught, even when multiple catches landed with a participant at the same time.	Researcher & External Observers
	31.An improvement noted in number of balls the group can successfully cope with in this exercise.	Participants, External Observers
	32.Unexpected catches and catches out of the comfort zone of the kinesphere were more frequent.	External Observer (Bill)
The ball game on the wobble boards	AS ABOVE with added observations: 33.The game was made harder and therefore became even easier to concentrate.	Participant
	34.The task of staying upright on the wobble board became easier as our attention shifted to catching balls.	Participant

	35.This exercise generated a very high amount of energy for all participants involved.	Participant
	36.Progression to greater ease and flow with less tendency towards fatigue.	External Observer (Bill)
Duet ball game off the boards	37.Increased use of non-dominant hand and awareness of that side of the body as a result.	Participant
	38.Increased awareness of physical habits such as throwing short from non dominant hand	Participant & External Observer (Kate)
	39.An improvement in number of catches successfully made was observed from day one to day five. The participants were also able to challenge their partners more by throwing balls wider, higher, and pushing each other out of their base of support.	External Observer (Bill) Researcher
	40.An increase in precision of catches and the mechanics of actually closing the fist around the ball was observed from day one to day five, resulting in more successful catches, despite the difficulty of the exercise being increased each day.	Researcher
Duet ball game on wobble boards	41.Balancing became easier as attention was on catching balls.	Participants
	42.The exercise generated a very high amount of energy for all participants involved.	Participants
	43.Increased coordination demonstrated by ability to multitask effectively and catch more balls from day one to five.	Participants & External Observers.
	44.An improvement in number of catches successfully made was observed from day one to five.	Participants & External Observers.
Physiotherapist facilitation off boards	45.A change in posture was experienced. The facilitations and resultant new positions felt strange.	Participants
	46.Some of the facilitations caused changes physically that felt different to how the group reported they looked visually.	Participants
	47.Certain body parts were more resistant to movement than others.	Researcher & participants
	48.Changes in posture were observed. Some were maintained,	Researcher &

	some were let go.	External Observer (Bill)
	49.Increased body awareness, and how body parts move in relation to each other.	Participants
Partner Facilitation off the wobble boards	50.Through different suggestions from the facilitating partner, there was an increase in body awareness and awareness of areas of tension and blocks.	Participants
	51.Increased awareness in how body parts move in relation to each other, particularly at spinal level.	Participants
	52.Postural changes were experienced.	Participants
	53.Postural changes were observed.	Participants, External Observers & Researcher
	54. A release of habitual tensions was observable in the majority of participants generally in the shoulders and upper back. In some participants adjustments in the pelvis were notable: either anterior/posterior or lateral.	External Observers
Partner Facilitation on the wobble boards.	55.More obvious postural changes were experienced.	Participants
	56.More obvious postural changes were observed.	External Observers
	57.Increased awareness in how movement flows through different body parts, in relation to each other.	Participants
	58.Less resistance to facilitations experienced.	Participants.
	59.Less resistance to facilitations observed.	External Observers & Researcher.
	60.Similar adjustments (postural changes) to those noted above but with more emphasis on engagement with the pelvis. These seemed to be retained throughout session.	External Observer (Bill)

Solo ball Overload on The wobble board	61.Massive energy generated for the participant.	Participants & External Observers
	62.More catches were made from day one to day five, even though as the exercise developed, the throws were made harder and out of reach.	Participants & External Observers
	63.Despite the chaos, there was less stress noted in the bodies and more fluidity of movement.	External Observer (Bill)

The observations/experiences described above by the participants, external observers and the researcher will be explored in detail in the discussion section of this study report.

Observations from the Contact Improvisation Exercises:

Table 13 below, will outline the specific observations noted or experienced by the participants, the external observers or the researcher. The observations relate specifically to improvements noted from day one to day five of working within this performative structure.

Table 13: Results from observing developments in the contact improvisation exercises from day one to day five.

Person making observation	Observation
External Observers	64.Improvement in physical responsiveness.
External Observers	65.Improvement in accuracy of limb placement and therefore accuracy of movement demonstrated in more successful complex lifts and weight transfer between participants.
External Observers	66.Better neuromuscular control demonstrated by more coordinated movement patterns being used (including complex improvised lifts and weight exchanges between partners).
Participants, External Observers	67.A perceived improvement in balance demonstrated by more lifts, more precarious balance positions being adopted by participants, and more incidences moving out of the base of support whilst improvising.
Participants, External Observers	68.An increased awareness of movement potential was observed, demonstrated by a wider range of movement being explored, and a willingness to take more risks physically and explore wider ranges of movement at each joint.
Participants	69.Faster reaction times as demonstrated in the speed of the work and the speed of reactions to each other.

Photographic Results and Evidence:

Photographic evidence was also documented with photos of each participant being taken pre and post study, with a straight to camera shot and a side profile being captured. The purpose of the photos was to compare and contrast any postural changes noted in any of the participants as a result of the proprioceptive training. Note that these photos below are indicative examples, and not the only postural changes to have occurred.

Participant A:

Fig 3: Participant A before the training:

Fig 4: Participant A after the training:

Participant A : discussion of Fig 3 and Fig 4:

Participant A presented in resting standing position with her feet inverted and weight to one side, making it look like she had uneven leg length. On palpation of the iliac crest (the top of the hip bone) this was shown not to be the case. It was just the way A held herself, and was her ‘normal’ presenting posture. The external observers noted that at the beginning of the workshop, from entering the room to participating the early work, she had a tendency to walk with her feet inverted, which affected her movement considerably. It also limited her movement particularly at the lumbar spine, which tended to move as a block instead of articulating at each spinous process as it was capable of doing. Through engagement with the training, she felt her connection with the floor improve and was moving equally from both sides. By the end photo, her pelvis looks nearly horizontal, with what looks like equal weight distribution on each foot. This changed her movement potential significantly, and she discovered a new range of movement at lumbar spine level as well, which helped her widen her movement repertoire.

Participant B:

Fig 5: Participant B before the training:

Fig 6: Participant B after the training:

Participant B: Discussion of fig 5 and fig 6.

Participant B presented with increased tension in her upper trapezius muscle (upper back), and tension across her back, causing her pain and limitations in her movement across her back and moving into the shoulders. She found the training helped her to ‘let go’ some of this tension and the post study photo shows less muscular contraction in upper trapezius, causing the shoulders to drop, and for more space to exist between the shoulders and the ear. She reported a decrease in pain after the workshop despite it being very physical and strenuous. Participant B has not experienced resurgence in pain in her upper back and shoulders. Her shoulders have stayed in a lower position.

Participant C:

Fig 7: Participant C before the training.

Fig 8: Participant C after the
training.

Participant C: Discussion of fig 7 and 8:

Participant C presented with tension across the upper trapezius muscle and her upper back and shoulders area. She complained of pain across this area at the beginning of the workshop. The difference in the shoulders and across the upper back is clearly visible from these 2 photos. The shoulders have clearly dropped down and there is more space between her ears and shoulders. She appears much more ‘grounded’ in the final photo as a result. Her feet have a much better connection with the floor and this was also apparent in her movement possibilities towards the end of the training workshop. C reported a decrease in pain at the end of the workshop and a visible difference in the way her shoulders moved was identified by C herself and the external observers.

Participant E:

Fig 9: Participant E pre study (front facing):

It is difficult to see in this photo due to her shirt obscuring the view, but participant E presented pre study with more weight going through her left side, which gave the impression that she had unequal leg length. On palpation of the relevant bony landmarks to ascertain if this was the case, E was found to have no discrepancy between leg length on left and right side. She just habitually preferred to stand on this side. Her quadriceps (thigh) muscles exhibited excess tonicity (they were working harder than they needed to). Her upper trapezius muscles were working harder than needed with the result that E’s shoulders are held higher than they need to be, with an unnecessary amount of tension.

Fig 10: Participant E pre study (side profile):

In the pre study side profile photo, more detail can be seen, particularly when looking at E's back and neck. It is clear to see a rounded cervical spine, with E's chin protruding forwards. The area to pay close attention to is round the shoulder blades (scapulae), as E presented complaining of pain in this area and this pain resulted in a hesitancy to move the neck and upper back freely. E also presented with an increased lumbar and thoracic curvature, with the freedom of movement in the back affected by postural presentation.

Participant E post study:

Fig 11: Participant E post study (forward facing):

The weight going through E's feet was much more evenly distributed, and iliac crests were level on palpation. There was less muscle tonicity in the quadriceps muscles than on palpation pre study. Post study, E had stopped relying on putting her weight through her left side more and moved equally from both sides. Post study, E held her shoulders slightly lower, with less recruitment of the upper trapezius muscles used when compared to how she presented pre study in this area.

Fig 12: Participant E post study (side profile):

This photo clearly shows changes to E's back and neck region post study from how she presented pre study. The increased lumber and lower thoracic curvature noticed on the pre study photo is much flatter in this post study photo. Palpation backed up this, and had the result that E was moving each individual spinous process during certain movements (for example, when touching her toes), instead of parts of her back moving as a block, which was how she presented pre study.

There are changes to be noted at E's neck as well. She is holding her chin further back towards her cervical spine than noticed in the side profile pre study photo. In the profile shot, E's back as a whole has a much flatter appearance, with more natural curves, instead of the very pronounced curvatures noted in the pre study photos.

E's movement demonstrated how these postural changes affected her. When standing in neutral with feet hip width apart, and asked to touch her toes, she was moving from each distinct spinous process. She was also happier to work through rotation of the spine when asked to twist and flex, and again was making use of more ranges of movement at each joint in her spine. The external observers and E herself noticed a freedom in movement post study, which changed the way she moved. The photographic evidence points to many useful postural changes experienced and observed by the participants, the external observers and the researcher. How these changes may have come about are discussed in the discussion section of this study report.

Summary of qualitative and quantitative results:

Table 14, summarises all the quantitative results and the qualitative results from the study.

Table 14: A summary of all quantitative and qualitative results from the proprioceptive training employed in this study.

Qualitative and quantitative results of the proprioception training exercises

Improved proprioception
Improved reaction time
Increased accuracy of movement and limb positioning
Improved muscular control
Improved balance
Increased confidence when moving out of base of support
Increased coordination
Participant has improved proprioception and is therefore brought into touch with their body schema
Increased understanding by participants of the aims of the work and the underlying science behind the aims
Changes in posture and physicality
Increased movement potential
Increased body awareness
More ability to describe postural changes in themselves without others having to explain
Increased physical responsiveness
Being ‘present’ and ‘in the moment’
Improved connection with the floor

Discussion:

Each result from table 14 above will be discussed in detail in this section, along with other results and observations (from table 12 and table 13), additional quotes from the external observers and participants (where they have been used to highlight certain points in more detail) and photographic evidence from the training study.

Wobble Board Work:

When participants first stepped onto the wobble board, there was often an emotional release associated with the experience, usually laughter and fear (observation 12 from table 12). Many participants reported feeling 'out of their comfort zone' and ‘fear to go out of their base of support’ (observation 13 from table 12) when on the board, and many claimed a lack of confidence when working with balance. This soon changed during the study. Confidence grew as levels of proprioception and balance improved. External Observer Bill Hopkinson noted this manifested in enhanced times on the board but also in a general sense of enjoyment of the work, a lessening of fear and a fluidity of physical response to being off-balance (Hopkinson, 2010). The first time most people step onto a wobble board, there is a period of ‘trying to balance’, in which tension in the body can increase as the person attempts to keep or regain balance. After a few sessions on the board, and with verbal cues if necessary, participants usually let go of this newly acquired, additional tension and relax into the experience. This initial stage (where additional tension may be recorded in participants’ bodies) does need to be acknowledged as it is the following stage, when participants ‘let go’ of the newly acquired tension that useful discoveries can be made in the training. These discoveries can include new ways of moving, different postures and new physical experiences.

Improved proprioception:

In this study, each participant quantitatively and significantly improved their level of proprioception as measured by the baseline tests after participating in the proprioceptive training for five days.

Visual examples of baseline proprioceptive tests with eyes open and eyes closed can be seen by watching the DVD:

Proprioception in Action: Clip Four: Balance and Proprioception.

DVD Description: In this clip we see examples of proprioception and balance, and the differences when working with eyes open and eyes shut.

Improved proprioception manifested in many ways:

Quicker reaction times:

Quicker reaction times were observed, experienced and noted during many exercises throughout this training. One example was the daily improvement of participants when playing the ball game, off and on wobble boards. More catches were made and more balls could be introduced to the game as the training progressed, which indicated that participants could cope with more balls and stimuli being thrown at them, and were still able to make multiple catches (observation 25 from table 12) Many described the improvement, during interview afterwards, as presenting in them being able to make more catches as their level of proprioception improved, as well as making more of the catches that they perceived as difficult (i.e. those that challenged their base of support and seemed to be ‘out of reach’):

> My arms and hands just seemed to be in the right place at the right time to make catches I didn’t think I could make, meaning I consistently surprised myself with the catches I was making. My hand placement got more and more accurate as the training went on and better catches resulted.
>
> Study participant B, 2010.

Participant B's experience was seconded by many others during the study. This improvement was also observed and recorded by the external observers (observations 28 – 32 from table 12).

Improved reaction time was also both observed and experienced away from the ball game and manifesting in other exercises and areas of performance improvisation, such as contact improvisation. Faster reaction times mean partners can respond more spontaneously to each other when improvising, with fewer hesitations to interrupt the natural flow and momentum of the movement between the performers (observation 69 from table 12). 'We (the external observers) noted the quicker reaction time as manifesting in fewer hesitations, fewer physical rejections of impulses (when a performer 'blocks' a physical suggestion by another), more efficient partnership working and, more subjectively, more exciting improvised performance' (Hopkinson, 2010).

Visual examples of how improved reactions manifested in the participants can be seen by watching the DVD:

Proprioception in Action: Clip Five: Improved proprioception leads to quicker reactions.

DVD Description: In this clip we see how improved proprioception leads to increased reaction times and how this manifests in performance through the ball game and partner

More accurate limb placement and accuracy of movement:

Limb placement is more accurate with increased proprioceptive acuity (Toledo *et al*, 2004:75). More accurate limb placement and resultant accuracy of movement was demonstrated in the ball game, with more accurate catches being made and hands closing to secure the ball precisely (observation 25, 28, 29, 30 and 31 in table 12). Despite, at times, many balls flying towards a participant, the accuracy of limb placement ensured that even balls that a participant had to reach for were more successfully caught towards the end of the training period, highlighting an improvement. More accurate limb placement and accuracy of movement was also demonstrated in action during the contact improvisation exercises (observation 65 in table 13). Participants appeared more sure-footed and confident in their foot placement and placement of other limbs when working. More accurate limb placement also means they can be safer and more efficient when working, as participants are less likely to fall or lose balance. It can support participants when working with lifts and weight transfer, as it allows them to create a strong base from which to move and improvise. This was maintained into contact improvisation in almost all participants; in some cases to a very marked degree (Hopkinson, 2010).

Increased muscular control:

Increased muscular control is another advantage of increased proprioception. It includes accurate limb placement as well as how limbs move in relation to each other to create patterns of movement. Along with assisting us to have more muscular control and accuracy in our movement, proprioception also plays an important role in letting us know how much effort and energy we need to be able to carry out a particular movement. It is the sense that indicates to us whether the ‘body is moving with required effort, as well as where the various parts of the body are located in relation to each other’ (Surhone *et al*, 2010:1). Muscular control, which involves using appropriate force and effort to limbs moving efficiently in relation to each other all rely upon the general underlying capacity of proprioception. Increased muscular control was demonstrated in the ball game, in the number and accuracy of catches made (observation 40 from table 12), and in the contact improvisation work, where complex lifts and sharing and exchanges in weight were observed as participants worked (observation 66 in table 13). As one of the external observers noted, ‘contact improvisations were more controlled as well as more precise in connection and reaction (Hopkinson, 2010).

Improved balance:

Proprioception is directly related to balance. Balance requires the continuous adjustment of muscle activity and joint position to retain the body's centre of gravity over the base of support (Lee, 2009: 387). Balance is important for everyday movement tasks and even more critical for those engaging in specialist skilled movement such as physical performers. Better balance leads to a decrease in risk of falling (and therefore injury), and an increased ability to participate in complex movement patterns that require more than everyday balance, as found in dance and physical performance.

Improved balance was demonstrated in the present study by participants achieving increased times on the wobble board without the sides touching the floor, improved times on the foot to foot stance (eyes open and eyes closed) and in the single leg stance (eyes open and eyes closed):

> Balance times on the boards improved markedly between days one and five when I was observing.
>
> Engineer, 2010

Improved balance was also observed during all the wobble board exercises as the training progressed, and was seen to manifest in action during the contact improvisation exercises. Here, improved balance was demonstrated by more participants being willing and comfortable to move beyond their base of support and when working in positions of precarious balance, where balance is actively stressed in extreme positions out of the base of support (observation 62 in table 13). Participants were also able to lean further without losing stability and had better directional control (when quickly moving from one direction to another). They demonstrated a better ability to jump off the floor and work from a one limb base of support. This confidence alongside the improved balance improved the movement potential of the participants when working alone and with partners.

Increased coordination:

Coordinated movement is the interplay between lots of different muscle groups and neural information and is closely linked to accuracy of limb placement and muscular and motor control. Recent research on motor control, especially movement sequences, has shifted its attention from the role of central control to the importance of sensory input in coordinating motor behaviour (Shields *et al*, 2005). In particular Sanes *et al* (1985) showed that proprioceptive afferent inputs are important for accurate limb placement, postural control and for the fine control of movement. Coordinated movement is dependent on proprioception. Sainsburg *et al* (1993) demonstrate that loss of proprioception or decreases in proprioception due to injury, underuse or illness disrupts interjoint coordination. Improved proprioception, however, leads to improvements in coordinated movement (Muiadi *et al*, 2009). This improvement in coordination manifests in smoother and more efficient execution of motor programmes and movement sequences and affects the speed in which they can be carried out.

Increased coordination, shown to be a result of the training in this study, was demonstrated in the ball game, on and off the board (observation 29 and 40 in table 12), and in the contact improvisation exercises (observation 66 in table 13). More balls were caught as the coordination of the participants improved. The participants also demonstrated increases in coordination when improvising physically around obstacles and each other in the space. The external observers noted increased coordination as one of the benefits to have come from the training, as compared to the participants on day one of the study:

> Coordination improved in the ball games, but the increase in precision on Contact Improvisation could also be interpreted as displayed elements of improved precision of movement: there were less stumbles and missed opportunities to connect by day five.
>
> Hopkinson, 2010

Additional benefits of improved proprioception:

Another significant benefit of improved proprioception is a reduced chance of injury (Bartlett and Warren, 2002:132). Due to improved proprioception leading to faster reaction time, increased neuromuscular control, more accurate limb placement and accuracy of movement, and a better ability to judge appropriate force and effort when moving, it is logical that there will be a lower chance of injury. Improved balance has also been found to lead to less falling and less fear of falling (Field, 2011). This isn't something measurable within this study period, although it can be confirmed that no injuries occurred, despite the participants working very physically throughout and several participants complaining of pain at the beginning of each study.

Body Schema:

Qualitative results include the following which are closely linked, so will be discussed together:

The participant has improved proprioception and is therefore brought into touch with their body schema.

Increased understanding by participants of the aims of the work and the underlying science behind the aims.

Proprioception is closely related to body schema. Indeed, proprioception is a major source of information for the normal functioning of body schema (Ziemke *et al*, 2007:279). Body schema, like proprioception can be trained to work more effectively. The wobble board provides an opportunity to tune into to the body schema 'via stimulation of the vestibular cortex. The vestibular system deals with balance and co-ordinates information about movement and spatial awareness. By putting balance at the centre of attention, your body schema cannot be ignored' (Blakeslee and Blakeslee, 2007:46). By shining the 'spotlight of attention' (Baars, 1997) on body schema and proprioceptive awareness, participants can work towards becoming more aware of their physical habits and tendencies, which gives them more opportunity to undertake improvements which will allow them more efficient movement.

Increased awareness was noted by the participants and the external observers throughout the study (observations 49, 50, 51and 57 from table 12). Informing the participants of the relationship between proprioception and body schema gave them a background in the science underpinning the research being explored within the study:

> Learning about proprioception and body schema gave us a common language to discuss our experiences.
>
> Study participant G, 2010.

This shared language allowed easier dissemination of information and experiences in the group discussions and interviews with the participants after the training each day and post study. It helped the researcher to provide a framework for the aims of the training undertaken and with some of the participants, the scientific knowledge imparted changed the way they experienced the training exercises:

> After learning about proprioception and body schema, the exercises felt different, in particular the assisted facilitation on the wobble board. I was receiving impulses from other participants to different parts of my body whilst on the board and they felt very different to when the same exercise was explored without the wobble board. I felt like I was blocking without the wobble board and reacting how I thought I *should* react. On the wobble board, the sensations actually felt different, like I was feeling certain body parts for the first time. It knocked me totally off balance at first!
>
> Study participant J, 2010.

Participant J’s experience could be due to the inability to ignore your body schema whilst on a wobble board (Blakeslee and Blakeslee, 2007:46). The participants’ responses in this study, including J’s response above, supported Blakeslee and Blakeslee’s ideas, particularly in the assisted facilitation phase of the wobble board work. Being on the wobble board means it is harder to maintain habitual physical behaviours, as the centre of gravity is displaced, meaning the body must adapt to its new experience on the wobble board. When the facilitations are offered, the body must find new solutions or ways to move in response to the facilitations as old patterns may not work when the balance is disrupted.

Changes in posture and physicality:

There were many postural changes, observed by the researcher, the participants, and the external observers (Observations 45, 46, 48, 52, 53, 55 and 56 from table 12). According to the participants, in transcriptions of the interviews, the changes experienced by some of the participants in their posture and physicality were the most important benefits to come out of the training studies:

> My shoulders and upper back felt totally different at the end of the training study. My level of pain had decreased and I felt like I had more movement at the shoulder joint. I felt different.
>
> Study participant B, 2010.

Participant B, also photographed above, is describing one of these postural changes to have resulted from the training study (see fig 5 and 6 above). The majority of participants who felt their posture had changed in some way all presented pre study with some form of unnecessary, excess tension.

Many of the participants when describing their experiences and physical changes in themselves and those observed in others used these terms: ‘letting go’ and ‘released’:

> Being on the wobble board and getting facilitations to my body caused the tension in my shoulder and neck to be released and let go. It felt freer and I had more range of movement.
>
> Study participant E, 2010.

Participant E was not the only one to use these terms when describing the reduced muscular contraction she was engaging. Often, the tension that people describe is habitual over-contraction of certain muscle groups, often in opposition over certain joints. It is so habitual for them that it seems normal to them. Putting a person on a wobble board, adjusts their centre of gravity and base of support, and thereby allows them an opportunity to move differently.

When first starting the wobble board training and stepping onto the board for the first time, even more ‘tension’ or increased muscular contraction is observed as the participant ‘tries to balance’ by contracting muscles all over the body in an attempt to maintain their balance. When verbally prompted to 'let go', after a period of time familiarising themselves with the experience of being on the board, the most useful postural changes are observed and experienced. Participants are encouraged 'not to try and balance but to let the board be in charge' and just to react to how it is moving. The journey on a wobble board is a dynamic one, where it isn't as easy to hold the body in fixity as it is in daily life. Therefore the habits that work (or impede us) day to day are challenged as the environment we are in is different and there is a whole new centre of gravity (which is constantly moving). As Buchanan states: 'As old habitual patterns begin to dissolve, new options become possible' (Buchanan, 2001:316). Wobble board work can disrupt and displace physical habits, and in cases where people are using an excess of muscular contraction, this can be 'let go', presenting as a 'release', which is often accompanied by a change in pain level and a change in range of movement. Wobble board work helps to disturb habitual movement patterns buried in the body schema.

With this release and 'letting go' comes a chance to do things differently, to move differently, which is a desirable outcome for a physical performer. External Observer, Kate Engineer, identified over 50% of the participants experienced a 'releasing in the back', by which she described a decrease in tension throughout the back muscles in a number of participants (Engineer, 2010). She is describing a decrease in unnecessary muscular contraction here. She noted, as did many of the participants when describing what they saw in others, an increased freedom of movement as a result of the 'letting go', which was seen by the participants as one of the major benefits of the training study (observations 48, 54 and 60 from tables 12 and 13). Participant B, who is photographed above, reported less pain post study in her upper back and across the shoulders. She has been able to identify and turn off the excess muscular tension she was employing in that area, and now uses a more appropriate muscular force. She first experienced the 'letting go' of her shoulders whilst experiencing assisted facilitation on a wobble board. As noted by an external observer, 'release was found in both the manipulations and the wobble board work but was more marked and in more of the students with the wobble board work.' (Hopkinson, 2010).

In relation to the 'letting go' of 'tension' or unnecessary muscular contraction, the external observers and the participants also noticed increased vocal freedom and release (Engineer and Hopkinson, 2010). When participants were on the wobble boards, there was less vocal constriction and more open larynxes. Often, the wobble board work was accompanied by giggling and laughter fits and, occasionally, the work caused an outbreak of tears and emotion. As the participants made new discoveries and let go of physical habits that had been impeding their movement, there was often a resultant release in emotion (observation 12 from table 12).

An increase in movement potential:

As described above, the 'letting go' of unnecessary excess tension can lead to greater physical freedom, and an increased range of movement experienced at various joints. The other results noted in this training study also led to an increase in movement potential, such as improved balance leading to more confidence when working out of the base of support, and increased accuracy of limb placement leading to an increased confidence when moving.

Increased body awareness:

More ability to describe postural changes in themselves without others having to explain:

As described in the previous discussion about changes in physicality and posture, many of the habitual tendencies that people present with feel totally 'normal' for them, despite sometimes being detrimental to efficient, effective movement. The participants were often asked, throughout this training study, to refer back to 'how it feels', to encourage them to keep 'checking in' with their body and its felt experience. As described earlier, some participants described the experience of taking part in the assisted facilitation exercise and how it helped them to how their body felt. On further questioning, the participant explained that they were paying more attention than usual to their body's felt experience. Baars useful metaphor about 'spotlight of attention' is useful here; they are shining their 'spotlight of attention' on what is happening in their bodies (Baars, 1997).

It is important to acknowledge that the feeling sense that participants use can be misleading due to the potential lack of synchrony between body schema and body image (chapter 4 of this thesis). Excess tension and habitual physical tendencies in movement and posture can feel normal, so people don't usually notice them, despite these movement patterns and habits being detrimental to movement potential. Awareness of the duelling body maps can potentially offer a mechanism for enabling change.

This was highlighted many times during the training study. Many participants could see in others what they couldn't feel in themselves, when analysing their own movement patterns and presenting postures. It was helpful to be working within a group environment and to be observing each other as this helped with participants' understandings and how they interpreted information about themselves. The training was designed to bring participants into touch with their body schema, by improving proprioception and this manifested in the participants reporting enhanced awareness:

> In discussion post session, the general agreement regarding enhanced body awareness was widely shared and much remarked on.
>
> Hopkinson, 2010.

Such an experience of enhanced awareness is described by participant D:

> My ankles felt so strange on the wobble board. I don't think they have ever had to work so hard. I could feel lots of sensations firing as my feet wobbled to keep me upright. I felt structures I have never felt before at work.
>
> Study participant D, 2010.

Participant D is describing a common experience on the wobble board, which highlights the increase in stimulation and information coming to the hypothalamus; this information has an increased likelihood of rising to consciousness as it is a new experience. This means that habits cannot so easily be ignored when the centre of gravity is displaced. As the wobble board experience is such a dynamic one - never the same twice - even when a participant is used to being on the board, the moment they slip into 'autopilot' and stop paying attention, the board will bring them back into the present moment.

It is hard to analyse objectively how effective the training study and the wobble board work was at 'bringing people into touch with their body schema'. Some participants reported that their awareness was enhanced (observations 49, 50, 51and 57 from table 12), and external observers noted changes in the physical habits of individuals when on the board (as described earlier). These are all fairly subjective claims, and it would seem to be beyond the scope of this particular research study to be able to confirm whether or not the wobble board training is directly responsible. It is more helpful to look at tangible changes in participants and at how knowledge of proprioception and body schema can help to inform participants' understanding of their bodies and how they work.

It is worth mentioning again the result or 'benefit' identified by so many throughout the training study – enhanced awareness. Many training modalities within theatre work to enhance a performer's self-awareness. By exploring proprioception – our mechanism for this very awareness - and body schema we can become more knowledgeable about the systems at work in somatic awareness. Understanding that one's felt sense may not always be accurate is very useful for performers engaged in processes of change.

Increased physical responsiveness:

The starting point for Peter Brook's actor training is responsiveness, and for Brook, such responsiveness is developed physically through the body (Marshall and Williams in Hodge, 2000:179). It is a desirable quality for a performer, especially when they work with others. Responsiveness and receptivity are important qualities as they allow more successful physical relationships to be developed when working with other performers. Responsiveness was cultivated during this training study by training proprioception, and working with body schema.

Improved responsiveness was observed and recorded by the external observers, particularly when watching the group undertake the assisted facilitation exercise and impulse exercise on the wobble boards (observations 23 and 64 from tables 12 and 13). These exercises involve one participant on the wobble board with eyes open at first, and one partner (building up to more people when ready) offering them facilitations and impulses to different body parts. The facilitator must be careful not to overload the partner on the board as too much stimuli can be detrimental and lead to a de-sensitisation. At the start of the work, it is advised that the facilitator offers a touch or impulse to their partner, and allows them to come back to an upright position on the board before proceeding with more touch. The touches engaged should be of varying intensity, depth and speeds to vary the sensations received.

Wobble board work can provide an effective way into being open to receive stimuli and allowing the resulting impulses flow through the body without blocking as the normal excessive tensions and habitual physical tendencies may not exist to be able to block them. Participants found it easier to allow impulses to flow through the body (observation 17 from table 12). Developing this further leads to training responsiveness, and the work was found to speed up the introduction to using contact improvisation as a training modality for performers.

Improved proprioception assists contact improvisers as it gives them more accuracy with their movement within the moment (observation 65 from table 13). It also helps to reinforce a more accurate body schema, as it involves a lot of touch and facilitation of different body parts. This in turn supports them to be more reactive to their partners and other performers and enjoy more accurate limb placement which is important for safety during improvised lifts and weight transfer. It supports a deeper understanding between the two (or more) performers and allows the performer to extend into new physical repertoires.

For an example of how improved proprioception can lead to enhanced performance, please refer to the DVD.

Proprioception in Action: Clip Six: Moving Towards Performance.

Description: This clip shows 2 performers at the end of the training period, moving from wobble boards into working with contact improvisation.

This was observed clearly during the training study. The difference between the quality of work on day one and the last day was marked, and identified by the external observers and the participants (Hopkinson, 2010, Engineer, 2010). The improvement in skill level demonstrated in the contact improvisation work manifested as smoother weight transfers between performers, sharper reaction times allowing the performers to work faster and more bravely, and daring physical work, demonstrated by lifts and compromising of balance to go to positions that had not been previously observed (observations 67, 68 and 69 from table 13). The overall effect was that the work was smoother, and more exciting. The participants backed up the external observers findings by their own experiences:

> The contact work really came alive after the wobble board work. It felt forced at first and I was trying to think of things to do, and I was trying to make connections with other people, that weren't always acted upon. Some were blocked or caught people by surprise. As the training progressed, we all started to engage differently with the work. It became more fluid and I felt more at one with my partner. I also got lifted where usually I am frightened to come off the floor.
>
> Study participant F, 2010.

The wobble board training and assisted facilitation seemed to directly affect the participants' capacity to respond and react to stimuli from others. Being on the wobble board limits the blocking of impulses, as it is easier for them to flow with the movement of the board. It was noted that these exercises helped participants be more open to stimuli, the resultant impulses, and facilitation from their partners. The wobble boards supported the training of responsiveness as well as proprioception.

Being present and 'in the moment':

As described, the wobble board insists that the user is present and has their awareness fixed on their physical experience. They need to react to their newly compromised balance to stay upright. This makes it easier to concentrate on the 'feeling of what happens', as Damasio (2006) would say, or to 'taste the sensations' as Yoshi Oida[19] would say. Participants reported being able to 'get into the zone' ready for work:

> I felt quite addicted to getting on the wobble board. It was tiring at first but it seemed to give you energy back as well. When we were asked to get off, I wanted to get straight back on. I felt really energised and alive, and it felt like

[19] The researcher worked with Yoshi Oida during Physical Fest in 2007 in Liverpool and throughout the week long workshop, he would ask the participants, to 'taste the sensations' in their bodies during each exercise. It is a useful term for asking people to pay more attention to their proprioceptive awareness.

> a great way to get ready for performance or training. It helped me get into the zone and leave my problems at the door.
>
> Study participant D, 2010

This was again a common experience. Some participants admitted to finding it hard usually to concentrate in workshops and the wobble boards helped them feel more focused, concentrated and 'in the moment' (observation 33 from table 12).

Increased energy:

Each exercise of the wobble board training was recorded as giving energy (observations 35, 42 and 61 from tables 12 and 13). The biggest change in energy was experienced in exercises on the wobble board whereby participants were overloaded with information and stimuli (observation 61 from table 13). The exercise that was most profound for so many participants was the ball overload exercise, where one participant is on the wobble board, whilst the whole group throw balls at them. The aim is to pitch your throw just out of their reach so as to challenge their balance and reactions (and therefore proprioception) as much as possible. Firstly, from external observation, it was interesting to see that the participants on the wobble boards caught far more balls than they or the observers expected them to catch. Secondly, they caught more balls that seemed as though they may be out of reach than they or the observers expected (observation 62 from table 13). They also made more multiple catches (when more than one ball is thrown and caught at the same time) than they and the observers expected. Thirdly, no-one fell off the board, despite going to catch balls that were deliberately being pitched to be just out of reach. The participants found this exercise harnessed a large amount of energy:

> I felt like I could do anything after that game. Every part of me felt so energised and alive and superhuman! I felt so ready to work.
>
> Study participant F, 2010.

Others described similar bursts of energy and a readiness to step into performance or training. This exercise was developed to include stepping off the board, and moving round the space catching numerous balls flying from all directions, to keeping hold of the energy and taking it into speech from pre learnt short sections of text. It was found that with cultivation, this energy can be taken forwards into creative work usefully:

> The discovery of ease during overload was marked on the fifth day of training, as was the development of the energy and connections found during the exercise into the following improvisations.
>
> Hopkinson, 2010

The overload part of the exercise can be related back to what we bring to conscious awareness and what stays below consciousness. As explained previously by Dr. Don Weed, humans have a billion bits of information that come in every second to the thalamus (the filter in the brain). From this massive amount of raw data, the thalamus filters less than a hundred of these bits per second for our recognition (Weed, 2007:71). Things that we don't need to pay attention to, we don't, to allow room for those things we do need to attend to. This is the reason why we often don't pay much attention to our moving bodies, because we don't need to on a day to day basis. This lack of awareness regarding our moving bodies is underlined as a problem for physical performers. This overload exercise involves a lot of information being literally 'thrown' at the body and the body having to react to not get hit and not to fall off the board. Sensations are heightened, reactions are faster, and the bodily experience is forced into the forefront of the performer's experience.

Applications for these study results:

This study is useful for practitioners who train physical performers. It may provide a framework for introducing proprioceptive training to their own methods of training or elements of the training may be useful to their own practice. It is also useful for physical performers who want to know more about the scientific underpinnings of their training and supports them to adopt safe practice within their physical work.

Concluding comments and areas for further research:

This study validates further research into the benefits of proprioceptive training for physical performers. It has provided a rationale for proprioceptive training to be an effective addition to a training programme for physical performers, and the practice has been informed by scientific theory. The benefits incurred by the participants of this present study are desirable for physical performers and are an example of safe physical practice.

Further investigation into the benefits of proprioceptive training for physical performers would be recommended as a result of this pilot study. Ideally, measuring proprioception at other body sites would make an interesting study. Futhermore, this study has provided a model of investigation into proprioceptive training that may be useful to other researchers who may wish to make lines of enquiry into the field.

The study also provides a methodology for evaluating efficacy of practice. Research into theatre and actor training has not in the past sought to provide quantitative research alongside the more familiar qualitative research often found in the actor training field. This study demonstrates that the two forms of research are mutually beneficial and can work together to strengthen rationale for training and provide a way to evaluate practice to ascertain if certain interventions are working as planned.

Limitations:

The present study used simple testing mechanisms in which to test proprioception. These tests are commonly used by physiotherapists in a clinical setting to test baseline measures of proprioception and any improvements post treatment or exercise intervention. Most scientific studies testing proprioception in their subjects use more complex, expensive equipment which will be more illustrative of the multi-faceted nature of proprioception. The more expensive approach to testing will be more rigorous also, as more accurate results can be garnered. The downside of using such equipment is that the studies are not easily replicated unless the researchers have access to the equipment and the budgets that allow the work at that level, hence why the decision to provide a low-fi, but thorough mechanism of testing. Other proprioceptive tests that could have been used include measuring position sense, and proprioceptive joint reflexes, but these tests need clinical training so were not used for the same reason, as the study was designed to be repeatable for artists, not just other physiotherapists. As the measurements were all taken by the researcher, there is a potential source of human error, which could have affected results also.

Chapter 8:1 Conclusion.

This practice led research thesis set out to cross epistemological boundaries by bringing the scientific research, theory and discourse around proprioception to the context of physical performer training, where previously this has not been done. The thesis synthesised theories and definitions of proprioception to provide a clear and comprehensive overview and proposes its relevance and importance in the training of actors and other physical performers. It hypothesised that proprioception in physical performers could be improved with specialised, focussed training and that these improvements would bring about enhanced performance.

The lack of a clear definition for proprioception and other related terms explored within the multi- disciplinary literature review highlights misunderstandings and misuse of language used to describe these concepts. As a result, a clear definition is articulated and presented, derived from physiotherapist Barry Stillman’s essay on proprioception. The definition used explains that proprioception is that part of the nervous system which provides sense of the spatial and mechanical status of the musculoskeletal framework: it is responsible for serving motor control and facilitating reflex defence of individual joints against falls, and it serves body image, and the development of motor control when learning new skills (Stillman, 2002:676).

An important benefit of increased proprioception is enhanced body awareness. Grotowski, Wangh, Pagneux, and Zarrilli, (Wangh, 2000, Zarrilli, 2002, Potter, 2002, Murray and Keefe,2007), amongst others all underline enhanced awareness as a key concern for actor training, and provide clear examples of the practitioners prioritising capabilities that proprioception serves. This enhanced bodily awareness is much sought after within the field of performance training as it allows trainees a deeper understanding and engagement with their bodies, and allows them a resultant advanced capacity for improving psychophysical potential and fluency. With enhanced awareness, performers are more able to identify physical habitual tendencies and make adjustments towards more desirable ways of moving, that will allow them to expand their movement repertoire and potential. The enhanced awareness also allows performers to describe postural changes in themselves without others having to explain from an external viewpoint. Developing this important part of physical performer training in more depth, this thesis also maps the links between proprioception and closely related terms body schema and body image. Body schema is a postural representation of the body in the brain (Gallagher, 2005:19), updated by proprioception, which is the major source of information for the normal functioning of body schema (Ziemke *et al*, 2007:279). Body schema and body image as terms are often used interchangeably, despite them being distinct (albeit closely related) systems. Gallagher explains the difference, stating that, 'body image is a system of perceptions, attitudes and beliefs pertaining to one's own body' (Gallagher, 2005:233). Body schema should update body image but this isn't always the case, as deeply ingrained belief systems about our bodies can be highly resistant to change. This results in our body schema (body proper) and our body image being incongruent, where our belief networks prevent us from tuning in to our proprioceptive awareness and body schemas. Priority can be given to the belief networks in body image, which can lead to inaccuracies between what we believe is happening with our bodies and what is actually happening.

This model of proprioception, body schema and body image is offered as a physiological model to explain why sometimes people are unaware of physical habits and tendencies that can hold them back, limit their movement repertoire and/or cause them pain. Attending to proprioceptive training, and therefore body schema can bring about opportunities to make changes in physicality and the way we move. Even being aware as performers that what we perceive about our bodies may not actually be what is going on can be useful. Excess tension and habitual tendencies in movement and in posture can feel normal, so performers don't notice them, despite these movement patterns and habits being potentially detrimental to their repertoire of movement. Somatic training to enable performers to focus on their habits is commonplace in dance training. As Virginia Wilmerding from IAMDS notes, dancers need to be 'aware of their art form and the potential problems that can arise from maladaptive technique' (Geber and Wilson, 2010:51). During the research studies, the focus on habitual tendencies, explored within the context of proprioception, body schema and body image allowed the participants to develop awareness of inefficient movement patterns and to explore ways of moving that were not inhibited by excessive tension or habits. Awareness of the potentially duelling nature of the body schema and the body image can offer a mechanism for enabling desirable change and further raising awareness. Many actor training methodologies seek to enhance awareness in trainees, but they don't question the integrity of the mechanism through which trainees have awareness. They don't consider that the felt sense can be inaccurate, thanks to the interplay between proprioception, body schema and body image. The research presented here demonstrates that the felt sense may not always provide accurate information, and that it is beneficial to support the integrity of the proprioceptive mechanism to ensure the reliability of the somatic feedback on which the performer relies. Proprioceptive training of the kind developed and discussed in this thesis can serve such a purpose.

The fact that proprioception can be improved through training has been well documented within the sports science fields and is starting to filter into dance educational and training programmes also. As far as the author is aware, there are no studies pertaining to proprioception within the theatre world apart from the two studies contained in this thesis. The sports and dance fields have used such research to help tailor focussed training and therefore enhance performance of athletes and dancers. This thesis hopes to provide theatre practitioners who train physical performers with an examination of a core physiological foundation for the training, giving information in order to affect potential change in designing theatre training methodology and/or provide a rationale for pedagogy of training.

This practice led research thesis demonstrates that proprioception can be improved in physical performers, by participating in focussed proprioceptive and sensorimotor training and demonstrates a range of benefits appropriate to performers. A methodology for training proprioception is described, outlining both specific exercises and approaches that can be used, alongside more general examples of other training that will concurrently train proprioception, such as sensorimotor training and psychophysical training.

Improved proprioception is shown to provide many benefits to physical performers to enhance their levels of performance. Enhanced proprioception leads to improved balance, which allows the performer to enjoy more confidence when moving out of their base of support and to enjoy a wider range of movement potentials. Improved balance also leads to a decreased incidence of injury. An improvement in proprioception leads to increased muscular control, resultant postural control and increased accuracy of limb positioning and movement. This is because increased proprioception allows even more accuracy in the information it provides with respect to the position and movement of limbs in relation to each other and the space and environment around them. This facet of proprioception also brings an increase in coordination due to more successful interplay of limbs working together. An improvement in proprioceptive acuity results in quicker reaction times. This can involve quicker reactions to sudden changes in environment that present a risk of injury (a sudden, unexpected unstable surface), quicker reactions to physical cues between physical performers, and quicker reactions to other forms of external stimuli (a ball flying at the performer at high speed). Quicker reactions can also lead to decreased risk of injury as well as more successful interactions between physical performers when working together on stage, for example, when taking part in contact improvisation or when devising choreography and/or other physical scores.

All these benefits listed above arising from enhancements in proprioception are highly pertinent to the physical performer. These benefits can greatly impact in performance, as they allow for quicker mastery of new choreography and other physical movement patterns and skills, more precision in the delivery of choreography or physical scores required of the performer, less likelihood of injury, safer physical practice in the rehearsal studio and safer physical collaborations with other performers. The benefits in performance of improved proprioception can also manifest in improvements in qualities desired by physical performers such as responsiveness, and the ability to play, devise and improvise with playful, flexible and malleable bodies.

A major aim of this thesis is to cross epistemological boundaries and introduce the science and practice of proprioceptive training to the arts world. The thesis aims to provide a physiological underpinning to the proprioceptive training practice explored. As Evans underlines, ‘the production of physically or psychophysically efficient actors is a complex process that requires the delivery and acquisition of sophisticated body knowledge’ (Evans, 2009:68). This thesis aims to deliver a deeper, more sophisticated knowledge of the physiological, anatomical and neuroscientific processes of the body for physical performers working within theatre. Those working within sports and dance fields have benefitted greatly from scientific research and approaches when designing training programmes for athletes and dancers. Writing for IADMS, dancer researchers Geber and Wilson explain how 'introductions of science into dance education has clarified and illuminated important principles in dance pedagogy' (Geber and Wilson, 2010:50).

Despite the benefits of scientific approaches, literature and research studies accrued by dancers, athletes and those working to train them, there is no such approach existing in theatre for training physical performers. As noted earlier, there is very little research demonstrating the efficacy of training modalities or methodologies within theatre (Evans, 2009:2). This thesis addresses this gap in research through the two studies investigating whether proprioception could be improved in physical performers working with a theatre context and how any improvements would manifest.

Study One demonstrates that proprioception can be improved with focussed, proprioceptive training using wobble boards. A training approach is described with exercises outlined and the training programme is shown to yield results showing a positive, statistically significant correlation between the training programme and levels of proprioceptive acuity. Study One also provides a methodology that can be simply reproduced by artists and practitioners, with no need for expensive equipment or scientific training. The study shows that the training actually worked to fulfil its aims and objectives, and that the training design worked.

Study Two sought to combine the quantitative approach of Study One with a qualitative approach, to examine the 'insights of relational understandings produced through experience' (Nelson, 2006:19) of the participants. The two approaches work well together as one demonstrates the efficacy of the training whilst the other analyses the benefits of the training experientially. Study Two demonstrates that the tailored proprioceptive training outlined does significantly improve levels of proprioception in physical performers, and also uses methods such as interviews, filming and journal logs to investigate how the benefits of improved proprioception manifest in the participants.

Summary of Contributions to original knowledge:

- A clear and comprehensive definition of the term proprioception has been provided for the theatre field for the first time, and has been demonstrated to be of interest to physical performers and highly pertinent to those practitioners in theatre who train physical performers.
- Proprioception has been demonstrated to be an accurate and comprehensive model for a core physiological foundation for physical performance training. It has also been shown that proprioception can be measured and therefore improvements can be documented.
- The functions that proprioception performs that are relevant to physical performers in theatre have been clearly outlined.
- The terrain has been mapped between proprioception and the related science and neuroscience pertaining to body maps, body schema and body image, in which a useful model pertaining to accuracy of body awareness has been posited.
- A methodology for improving proprioception in physical performers has been examined and outlined.
- The research has demonstrated that proprioception can be improved in physical performers.
- Improved proprioception has been shown to bring many desirable benefits to physical performers including enhanced awareness, balance, neuromuscular control, postural control, speed of reactions, and accuracy of limb placement and therefore enhanced accuracy of movement. These enhancements brought about an improvement in contact improvisation and responsiveness. Improved proprioception also decreases incidence of injury and can prolong performative life span.

Areas for further research:

This thesis has demonstrated that proprioception is a core sense for the physical performer and that it deserves consideration when designing training physical training for performers. The understanding around proprioception, body schema, body image and body awareness will develop as the developments occur within the relevant scientific fields. Those working within dance training research are benefitting from paying a closer attention to developments in the relevant science, and are adapting their training to gain the maximum enhancements in performance. Physical performer training within a theatre context should be treated with the same rigour and care for health, well being and longevity of performative lifespan that is found in dance training, so that physical performers in theatre can enjoy the same benefits.

This thesis has raised the issue of whether body schema and proprioceptive information can always be brought to consciousness or not. Drawing from Gallagher (2005:22) and Head (1920:606), it was explained that body schemas are usually outside central consciousness, but that they provide information about posture and movement that sometimes rises into consciousness (Head in Gallagher, 2005:22). This thesis concluded that the pertinent point here was not the debate over whether or not body schema can be brought to consciousness, but that body schema can be trained to work even more effectively for us, by training proprioception. This is another example of how developments in the science, and the subsequent links to consciousness and awareness will further support our understandings in the theatre field, which will in turn impact upon and inform practice. It is beyond the scope of this thesis to address the gaps in research pertaining to the neuroscience around these issues, but it can highlight areas of discrepancies, confusion, debate, and clarity.

Advances in knowledge are developing fast, and proving accessible to the dance field, thanks to organisations like IAMDS. If the knowledge is embedded within the field of theatre training, time will be needed to ascertain if training proprioception makes the differences to performative lifespan and decreases incidence of injuries sustained, as the research in dance and sports science have indicated. If the benefits of the proprioceptive training prove to be of interest to other practitioners within the field of theatre, it will be easier to locate this research more clearly within the field. The indication at this stage is that this research deserves more space, time and practice to ascertain how useful it will be in the field of physical performance training for theatre. More research into how proprioception can support those practitioners who train physical performers in theatre, and those working in related fields of enhancing awareness is indicated.

The crossing of epistemological boundaries to examine information within new contexts and to further knowledge in theatre research has also been indicated in this practice led thesis. The training methodology outlined in this thesis may improve levels of proprioception in physical performers, and support improvement in physical skill and psychophysical fluency. The examination into proprioception undertaken in this thesis offers a core physiological foundation for physical actor training.

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APPENDICES:

Appendix One: GLOSSARY.

B

Body Awareness: Body awareness is, at its simplest, the bringing of attention to the body and its felt experience.

Body Schema: Our brains are constantly updated with information about the position of our bodies. This information comes from an on-line, real time representation of the body position that has been termed ‘body schema ((Shenton *et al*, 2004:19).

Body Maps: Body maps were first posited by surgeon and brain researcher Wilder Penfield in the 1940s, as a way of talking about the way in which the body is mentally represented within the brain.

C

Cardiopulmonary Function: is the interrelationship between the workings of the heart and lung organs. Blood flow needs to be regulated between the two organs, primarily by the pulmonary artery. During exercise, the heart needs to beat faster and more strongly to provide the body with appropriate oxygen.

Cerebral Cortex: The outermost layer of the cerebral hemispheres of the brain, responsible for all forms of conscious experience, including perception, emotion and planning.

F

Frontal Lobe: One of the four divisions of each hemisphere of the cerebral cortex. Others are parietal, occipital and temporal). Responsible for controlling movement.

H

Homeostasis: is a property of cells, tissues and organisms that allows the maintenance and regulation of the stability and consistency needed to function properly. It is a healthy state that is constantly maintained by adjustments of biochemical and physiological pathways.

K

Kinaesthesia: Kinaesthesia is a term often used interchangeably with proprioception. Kinaesthesia was defined by pathologist Henry Bastian last century as the sensations which arise from movement (Stillman, 2002:667). Therefore kinaesthesia is often used to mean the 'feeling of movement'.

M

Mechanoreceptors: are sensory receptors which enable us to detect touch and monitor the position of our muscles, bones and joints, providing information for the propriceptive sense.

Mindfullness: is an awareness of the present moment that is cultivated by paying attention on purpose to the things that usually are not noticed (Kabat-Zinn, 2005).

Motor: The word 'motor' when used in context of motor control, motor learning and motor programme, literally means 'movement'.

Motor control: is that sub discipline of human movement studies concerned with understanding the processes responsible for the acquisition, performance and retention of motor skills (Abernethy *et al*, 2005:197).

Motor Learning: deals with motor control changes that occur as a consequence of practice (or adaptation), focusing literally on how motor skills are learned and on the changes in performance, retention, and control mechanisms that accompany skill acquisition (Abernethy *et al*, 2005:197).

Motor Neuron: A neuron that carries information from the central nervous system to the muscle.

Motor Programme: Is a sequence of co-ordinated movements. Signals transmitted through efferent and afferent pathways allow the central nervous system to anticipate, plan or guide movement.

Motor Skills: are those goal directed actions that require movement of the whole body, a limb, or a muscle in order to be successfully performed.

Musculoskeletal framework: The framework encompassing the muscles, bones, joints, and related structures, such as the tendons and connective tissue, that function in the movement of body parts and organs.

N

Neurons: Nerve cells which are specialised so that they can transmit information through the body. They are characterised by long fibrous projections called axons, and shorter projections called dendrites.

Neuromuscular Control: the unconscious motor efferent response to afferent sensory (proprioceptive) information. Afferent proprioceptive feedback results from impulses transmitted by mechanoreceptors to the central nervous system (CNS), relaying information about joint position and joint movement sense.

P

Parietal Neurons: are not concerned with identifying things in terms of their names, identities or meanings. Rather, they are concerned with the composition of space and the body's relationship to its surroundings (Blakeslee and Blakeslee, 2007:38).

Parietal Lobe: One of the four subdivisions of each hemisphere of the cerebral cortex (others are frontal, occipital and temporal. Creates our understanding of where we are in the world and how we relate to it, by playing a central role in sensory processes, attention and language.

Peripersonal Space: the space immediately surrounding our bodies.

Phenomenology: is predominantly concerned with human experience. It is an approach that concentrates on the study of consciousness and direct experience.

Pre Reflective Awareness: The awareness we have before we do any reflecting on our experience. Any reflective awareness is only possible because there is a pre-reflective awareness.

Proprioception: is the sense that gives us information about the location, movement and posture of our bodies in space.

Psychophysical Training: Training psychophysically refers to training that supports the trainee in operating out of a unified mind and body.

Physiological: The characteristics of normal functioning of the body.

R

Recessive Motor Programme: When these motor programmes are learnt, they can become recessive, meaning that we no longer have to pay as much attention to completing the programme, unless there is a reason for it to spring into consciousness again, for example, whilst losing balance.

Reflex Defence Mechanism: 'Reflex defence of individual joints' against, for example, falls, refers to our 'saving mechanism' against injury, seen most acutely when our ankles make appropriate adjustments after encountering an unexpected obstacle when walking.

S

Sensorimotor: The sensorimotor system describes the ‘sensory, motor, and central integration and processing components involved in maintaining joint homeostasis during bodily movements’ (Reimann and Lephart, 2002:72).

Somatosensory Cortex: is an area of the brain that processes the information derived from systems in the body that are sensitive to touch. The somatosensory system is very refined and sensitive and allows us to experience a wide range of sensations.

T

Temporal Lobe: One of the four major subdivisions of each hemisphere of the cerebral cortex (others are occipital, frontal and parietal). Has a role in auditory perception, speech and visual perception.

Thalamus: is part of the forebrain. It consists of masses of nerve tissue. It is the key relay station for sensory information flowing into the brain. It acts as a ‘filter’, filtering out only information of particular importance from the masses of raw data signals entering the brain.. It plays a central part in relaying sensory information.

V

Vestibular Cortex: Vestibular Cortex: is the portion of the cerebrum which responds to input from the vestibular system.

Vestibular System: is the sensory system that provides the leading contribution about movement and sense of balance.

Appendix Two:

Statistical Analysis of Results for Study One and Two.

Statistical Testing for Group, Study One.

	1 Foot EO	1 Foot EC	Stance EO	Stance EC	Pink EO1	Pink EO2	Pink EO3	Black EO1	Black EO2	Black EO3
A	50	6	34	8	15	46	58	24	42	65
B	120	120	120	42	47	45	88	90	120	120
C	74	42	52	12	6	5	12	56	47	36
D	120	120	120	88	4	6	5	72	32	43
E	120	16	89	7	120	120	120	120	120	120
F	120	67	120	12	70	37	97	120	120	120
G	97	13	78	24	120	120	120	120	120	120
H	88	34	70	11	50	35	65	120	109	98
I	120	120	70	23	43	61	98	120	120	120
J	120	102	120	72	12	6	42	120	98	112
A	120	110	89	45	98	110	120	120	120	120
B	120	120	120	108	120	120	120	120	120	120
C	120	120	120	120	89	57	93	111	117	120
D	120	120	120	120	73	80	106	120	113	94
E	120	79	120	55	120	120	120	120	120	120
F	120	120	120	103	120	120	120	120	120	120
G	120	95	120	120	120	120	120	120	120	120
H	120	78	120	58	120	120	120	120	120	120
I	120	120	120	98	120	120	120	120	120	120
J	120	120	120	120	42	78	94	120	82	120
	0.0295731	0.002618	0.0036185	1.488E-05	0.0002767	0.0001507	0.001443	0.02997	0.0470979	0.024338
						combined	0.000161		combined	0.028296

Statistical Testing for Group, Study Two.

Baseline Proprioceptive Tests:

		1 Foot EO	1 Foot EC	Stance EO	Stance EC
Pre	A	120	120	57	43
	B	120	120	120	52
	C	120	120	120	20
	D	120	120	120	96
	E	120	17.7	109	8.92
	F	120	120	120	17
	G	120	13	120	33
	H	120	120	120	29
	I	120	120	70	23
	J	120	102	120	100
Post	A	120	120	120	73
	B	120	120	120	86
	C	120	120	120	45
	D	120	120	120	120
	E	120	120	120	65
	F	120	120	120	120
	G	120	120	120	120
	H	120	120	120	120
	I	120	120	120	44
	J	120	120	120	120
		n/a	0.066632	0.0661563	0.000516

Exercise Group Wobble Board Results for Statistical Analysis, Study Two.

Eyes Open:

	Pink EO1	Pink EO2	Pink EO3	Black EO1	Black EO2	Black EO3	Wood EO1	Wood EO2	Wood EO3
	7	35	120	120	120	120	0.9	2	2.3
	31	32	108	90	120	120	2.4	3.1	3.2
	6	82	120	120	120	120	0.7	1	2
	120	120	120	120	120	120	0.8	1.4	2.1
Pre	2	2.5	3	18	48	53	0.5	0.5	0.5
	11	31	106	120	120	120	0.6	0.8	1
	120	120	120	120	120	120	1	1	1
	50	35	120	120	120	120	1	1	1
	61	101	103	120	120	120	0.5	1	0.5
	5	11	10	120	120	120	1.4	1.5	1
	5	120	120	120	120	120	1.5	2	2.4
	120	120	120	120	120	120	3.2	3.1	3.2
	120	120	120	120	120	120	1.5	2	2.5
	120	120	120	120	120	120	1.5	2	1.5
	120	120	120	120	120	120	1.5	2	1.3
	120	120	120	120	120	120	1.1	1.7	12
	120	120	120	120	120	120	1.8	1.6	3
	120	120	120	120	120	120	2	1.5	3
	120	120	120	120	120	120	1.4	2.3	6
	5	11	10	120	120	120	1.8	2.5	2.5
	0.003905	0.0027239	0.097539	0.116167	0.1717182	0.171718	4.516E-07	0.0005709	0.0350166
		combined	0.003518		combined	0.14359		combined	0.0049812

Exercise Group Wobble Board Results for Statistical Analysis, Study Two.

Eyes Closed:

	Pink EC1	Pink EC2	Pink EC3	Black EC1	Black EC2	Black EC3	Wood EC1	Wood EC2	Wood EC3
	2.2	3.8	5	6	6.6	13	0.9	1.9	2
	3.3	4.2	4.8	3.2	10.4	12	1.5	1.7	1.5
	3	3	5	4	4	5	0.9	1.9	2.4
PRE-STUDY	4.2	4.5	15.8	24	28	36	0.5	1	1.8
	1.5	1.5	2	2	3	4	0.2	0.2	0.2
	1.8	1.9	2	3	4	11	0.9	1	1.6
	2.8	4.5	5	5	18	32	0.8	0.5	0.5
	5	5	10	6	6	12	0.5	1	1.5
	2.5	3	7	3	3.5	15	1.5	1	1.5
	2.3	3.2	2.2	3.2	3.2	4.9	0.5	0.5	1
	2.5	7.4	9	60	50	59	1.7	1.6	2.3
	3.8	4.5	6	10	30	14	1.5	2	1.5
	8	7	9	102	100	90	2.5	2	2.5
POST – STUDY	11.5	9	18	120	120	120	1	1.5	2
	3.2	5	6	15	20	22	1	1	1.1
	3	6	8	8	9	10.5	1.3	1	1.6
	6.2	4.6	10.9	10.9	22	24	2.7	1.5	2
	4	7	17	12	15	22	1.5	2	2.7
	3	3.5	8	46	34	35	1.5	1	2.5
	5	6.5	4.8	71	78	54	1	0.5	1.2
	0.011641	0.000501	0.000127	0.004543	0.003633	0.009572	0.0020722	0.0225427	0.0065553
		combined	4.26E-05		combined	0.005088		combined	0.0020283

Appendix Three:
Sample Consent and Release Form for both studies.

University of Huddersfield. Performing Arts Dept.

Practical Proprioception Researcher: Laura Haughey

You have applied to take part in a research study entitled, ‘Practical Proprioception’, which is a training programme designed to improve your levels of propriception. Proprioception is the sense that gives us information about the location, movement and postural of our bodies in space. It is the bodily sense that enables us to know where and how our limbs are positioned in relation to each other.

The research study will take each participant through a psychophysical training process designed to improve levels of propriception. To test the hypothesis under exploration in my phd thesis, namely that ‘proprioception can be improved in the physical performer’, your baseline measurements of your starting level of proprioception will be taken. Then you will undertake the training process, before taking your resultant measurements of your level of proprioception post study. These measurements will be explored and discussed within the thesis.

Throughout the study, you will be filmed and photographic evidence will be gathered. You will also have your photo taken pre study and post study to allow any postural changes to be noted during the study. These photos will be discussed as part of the results section within the thesis. The video footage will be made into short DVD excerpts which will be presented alongside the thesis. This footage will be used however best serves the researcher and may in the future be presented online on the worldwide web.

Please sign below to show you have understood what will be required of you during this study and that you provide informed consent for your data, measurements, photographs and moving image to be used to help present the results of this study.

I confirm I have read and understand the information above and have had the opportunity to ask questions which have been answered fully.

.... Date ....

I understand that my participation is voluntary and I am free to withdraw at any time without giving any reason.. Date......................................

I provide informed consent for my still and moving image to be used as part of this research study.. Date..............................

I provide informed consent for my data and measurement to be used, reported and discussed as part of this research study.

.... Date..............................