The Transfer of Anticipation Skill Across Sports

A thesis submitted in fulfillment of the requirements for the degree of

Doctor of Philosophy

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DECLARATION

I, Simon Michel Rosalie, do hereby declare that:

a) except where due acknowledgement has been made, the work is that of the candidate alone;

b) the work has not been submitted previously, in whole or in part, to qualify for any other academic award;

c) the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program;

d) any editorial work, paid or unpaid, carried out by a third party is acknowledged;

e) ethics procedures and guidelines have been followed.

Signed: Date:
ACKNOWLEDGEMENTS

‘Do not pray for an easy life, pray for the strength to endure a difficult one’

Bruce Lee

Sir Isaac Newton is famously quoted as saying that “If I have seen further it is by standing on the shoulders of giants.” (Letter to Robert Hooke, February 5, 1675). While I may not have seen further, I have certainly stood on the shoulders of giants. To all of you who have guided and supported me on this journey whether knowingly or unwittingly, I extend my deepest gratitude.

As a remote student, for all intents and purposes, this journey has been a lonely one both professionally and personally. Although there are a number of colleagues, peers and supervisors that have guided me along the way, the undoubted light at the end of my academic tunnel is Sean Müller. Despite the trials and tribulations that have beset my candidature, some due to circumstance, some due to indulging in fight training in the AM hours (closer to midnight than to the light of dawn), and in no small part to my renown stubbornness, Sean has stood beside me, an advocate, a mate, a guide and a travelling companion along each step of the way for the past four years. I salute you. I also wish to thank Bruce Abernethy whose off the cuff suggestion (or perhaps not) created a complex, difficult and rewarding project out of a jaded anatomist’s search for something more. My gratitude also goes out to Stephen Bird and the staff and students of the Discipline of Exercise Sciences, RMIT University.

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‘Empty your mind, be formless, shapeless-like water. Now you put water into a cup, it becomes the cup, you put water into a bottle, it becomes the bottle, you put it in a teapot, it becomes the teapot. Now water can flow or it can crash. Be water, my friend’

Bruce Lee
LIST OF PUBLICATIONS AND PRESENTATIONS RELEVANT TO THE THESIS

PUBLICATIONS

Chapter 2

This paper outlines a model and aspects of the experimental design used to examine transfer in this thesis.

Chapter 4

Chapter 5

PRESENTATIONS


Rosalie, S. M. (2011, November). The transfer of anticipation skill across sports [PowerPoint slides]. Final PhD Oration presented to academics from RMIT University, Murdoch University and Victoria University.
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SUMMARY OF THE RESEARCH

Constant environmental variation forces the adaptation of previously learned behaviors to suit instantaneous performance constraints through the transfer of learning. Researchers remain divided over whether the transfer of learning is facilitated by similarities between learning and transfer (performance) domains, per identical elements theory, or principles abstracted with learning and applied in transfer, per general principle theory. Uncertainty regarding the mechanisms underlying the transfer of learning is most marked with respect to complex perceptual-motor behaviors, owing to the absence of research that examines the transfer of critical perceptual-motor skills, such as visual anticipation, in natural skill settings. Effective visual anticipation is based on the capability to extract visual information from the variable immediate environment to guide anticipation of forthcoming events and constrain motor skills. The importance of anticipation to successful perceptual-motor behavior is accentuated when the time available to perceive a stimulus and execute a movement response is limited, such as in fast paced sports. The purpose of the research in this thesis was to determine whether identical elements theory or general principle theory predicts the transfer of visual anticipation across domains and motor skill tasks in natural skill settings. Three experiments were undertaken in order to establish if the degree of similarity between domains (sports) predicts transfer of visual anticipation, or whether expertise in a time stressed domain (sport) facilitates the transfer of anticipation to similar and dissimilar transfer domains. Following a general introduction that outlines the rationale for the research in the thesis (Chapter 1); subsequent chapters present reviews of relevant
SUMMARY OF THE RESEARCH

literature (Chapters 2 & 3), the experiments (Chapters 4 & 5) and conclusions/implications of the research (Chapter 6).

Chapter 2 reviews relevant literature on transfer of perceptual-motor skill learning and presents a preliminary model outlining mechanisms that underlie transfer of perceptual-motor skill learning in sport and everyday tasks. Perceptual-motor behavior is motivated by performance demands and evolves over time to increase the probability of success through adaptation. Performance demands occurring at the time of the event create a unique transfer domain that specifies a range of potentially successful actions. Transfer is described as comprising of anticipatory subconscious and conscious mechanisms. The model also outlines how transfer occurs across a continuum, which is dependent upon the expertise of the individual and contextual variables occurring at the incidence of transfer.

Chapter 3 reviews the literature on visual anticipation in sport. Researchers have proposed that greater integration of existing theories could resolve key topics in motor control and learning. Investigation of information pick-up for anticipation has focused predominantly upon striking sports with little research addressing combat and contact sports. In Chapter 3, an integrated theoretical framework for investigation of anticipation in sport is presented combining traditional motor control theories, Anticipatory Behavioral Control, two visual system theory and transfer of learning theory. Through this framework, existing findings are evaluated and unanswered questions highlighted. Application of this framework to a broad spectrum of sports could lead to a fuller understanding of mechanisms of expert anticipation.

Previous research (reviewed in Chapter 3) has predominantly examined visual anticipation across large-scale expertise differences in sport. The first experiment of this
Summary of the Research

The thesis (Chapter 4) examined small-scale expertise differences in the pick-up of visual information to guide anticipation and motor skills by comparing the capabilities of expert and near-expert karate athletes and novices to block attacks using an in-situ temporal occlusion paradigm. Participants stood facing a karate opponent and then attempted to block attacks (kicks & punches), whilst their vision of attacks was occluded: (i) prior to onset of opponent motion, (ii) after preparatory head movement, and (iii) after initiation of the attacking motion. A no occlusion control condition provided complete vision of attacks. Results revealed small-scale expertise differences in the capability to pick-up visual information to guide anticipation and motor skills, whereby experts but not near-experts or novices were capable of utilizing both static and dynamic cues occurring prior to and throughout an opponent’s attacking motion to guide defensive responses. The finding that both static and dynamic sources can provide meaningful visual information to guide anticipation and motor skills further the understanding of expertise in biological motion perception and motor skill performance.

The first experiment of this thesis provided evidence of small-scale expertise differences in the capability of karate athletes to pick-up visual information to guide anticipation and motor skills. The second and third experiments of this thesis (reported in Chapter 5) were related and designed to examine the predictions of identical elements theory, general principle theory and aspects of the model outlined in Chapter 2 for the transfer of anticipation skill between domains using karate athletes as the transfer groups. Results revealed that non-domain experts and near-experts are as capable of using visual information to anticipate and guide motor skill responses as domain experts and near-experts in similar and dissimilar transfer domains. The findings suggest that transfer of anticipation skill is based upon expertise and an understanding of
fundamental principles of motor skills, but may be supported by similarities between stimulus and response elements in the learning and transfer domains when such similarities occur.
REFERENCES


Bryant, R. (n.d.). *Notes on using 433MHz UHF R/C Link with Plato Glasses* (Unpublished manufacturer’s technical documentation), The University of Queensland, Australia.


REFERENCES


Hoffmann, J. (1993). *Vorhersage und erkenntnis: Die Funktion von antizipationen in der menschlichen verhaltenssteuerung und wahrnehmung (Anticipation and
REFERENCES


REFERENCES


REFERENCES


