Could you outline the primary objectives of your current project? Why has this initiative been established?

My goal is to understand how we can facilitate the acquisition of motor skills and learn more about the mechanisms of their long-term retention. The obvious example is riding a bike, but others include the capacity of the physician certified to perform a particular clinical skill. If long periods elapse without practice, can the physician still be considered competent? Of particular interest is the role of touch, or haptics, during acquisition, and the long-term retention of manual skills for months and even years after they have initially been learned.

In what ways does your research on human kinetics in zero gravity build on your haptics work?

I have a programme of basic research that examines theoretical aspects of motor control and learning using simple tasks that we can measure very accurately in a laboratory environment. We also take these established principles of motor control and learning and apply them to various real life problems. These can range from an astronaut troubleshooting in space to a surgeon conducting an operation in theatre or a dentist repairing a tooth. Thus, my work in zero gravity environments is just one application of my interest in haptics.

Can you discuss how your current research is progressing?

Our experiments are part of an ongoing programme. The long-term goal of my research is to understand the process of motor skill learning in humans; I hope to understand more about how touch feedback can facilitate motor learning in the immediate future. One of the projects will continue to explore the parameters of haptic feedback that lead to optimal learning, where issues such as bandwidth and frequency of feedback will be investigated. A coinciding project will exploit a new instrument developed within the programme and used to measure gastroenterology performance in a bid to assess both learning and forgetting curves. Additionally, this project aims to identify individuals failing to keep pace with their peers in order to develop individualised training programmes for them.

What kind of skilled hand movement have you specifically been studying? Can you provide some examples?

The skills people learn in our laboratory are simple reaching and grasping movements, but individuals may also be required to learn a tracing task while manipulating a robot arm. Studying these types of skills is fascinating because there are well established ways to measure or quantify how these movements are performed. However, we are very interested...
in studying more realistic or intricate skills that are performed in complex environments. For example, we have studied how the use of gloves, which impairs haptics, influences a worker’s ability to perform. We have also investigated how the miniaturisation of hearing aids impacts the ability of older individuals to control these devices. Much of our research programme has been directed at understanding how to facilitate the learning and performance of clinical skills. We have examined how surgeons learn to suture or drill bones, how nurses learn to give injections and how the physician, or nurse, learns to perform a colonoscopy.

How have collaborations with your students helped with your research programme?

My graduate students are amazing and are critical to the success of all of my projects. I have only highlighted the work of two doctoral students, Camille Williams and Catharine Walsh, but I have a large number of students under my supervision, all of whom are conducting significant work in this field. What makes our group so interesting is the varied backgrounds of my graduate students, which include kinesiology, physiotherapy, occupational therapy, medicine, surgery and engineering.

To what extent has financial backing from the Natural Sciences and Engineering Research Council of Canada (NSERC) helped you to achieve your goals?

My research programme has been continuously funded by NSERC since 1991. These grants have supported the core basis of my research and provided a framework that has allowed me to apply for other supplementary funds to sustain the more applied research projects. Without financial backing for fundamental research none of our applied work could have taken place. I believe strong fundamental and theoretical work is necessary for good applied research to take place.

THE ACQUISITION OF motor skills is a process almost every human will experience in his/her lifetime, without even giving it much thought. Whether as a recreational activity or as a professional necessity such skills are generally learned by practice, practice, and more practice. Advances in haptic technology have expedited the proliferation of devices orientated around haptic feedback, augmenting human interaction in the training techniques of a wide range of professions where the complexity of skills are as diverse as the skillsets themselves. Such examples include simple reaching manoeuvres for laboratory work, or more dextrous movements for carrying out clinical procedures, such as a colonoscopy.

It is evident, however, that the concepts underpinning these training methods are not as well understood as previously thought. There remain important issues regarding the mechanisms of how best the acquisition of motor skills can be facilitated, their long-term retention, and what causes a skill to be forgotten. With an ever greater reliance on haptic technologies, there is an increasingly urgent need to answer these fundamental questions.

Dr Heather Carnahan is Professor and Dean of the School of Human Kinetics and Recreation at the Memorial University of Newfoundland (MUN) in Canada, a recent appointment in a prestigious career that has included, among others, a previously held post as interim Vice President of Education at Women’s College Hospital (WCH), Toronto. Carnahan’s ongoing efforts to further uncover the processes of motor skill learning in humans could have major benefits for reducing costs in time, money and injury experienced in many work environments reliant on practical skills.

GUIDING MOVEMENTS

As fundamental components in the acquisition of motor skills, it is vital to understand how amounts of practice, and the way in which different types of available sensory feedback are applied, contribute to how skills are retained as well as acquired. It is commonly accepted that the process of forgetting is comparable to that of learning but Carnahan’s research indicates it is not a simple mirror image of progression and regression. Rather than being governed by the amount of practice received, it appears that an individual’s level of performance at the end of practice is a more effective method for estimating the loss of a motor skill. If this process can be grasped more fully, the research proposed by Carnahan is likely to bring changes in many areas where the maintenance of certain skills is inextricably linked to human safety, such as those of pilots or health professionals.

Preceding such investigations, Carnahan’s collaboration with Camille Williams, a postgraduate clinical and biomedical engineer currently with the University of Toronto’s Graduate Department of Rehabilitation Science explores the other side of the learning coin:
INTRODUCTION

TOUCH PERCEPTION AND THE CONTROL OF MOVEMENT

OBJECTIVES

• To understand how the acquisition of motor skills can be facilitated
• To investigate the mechanisms of long-term retention of these skills

KEY COLLABORATORS

Catharine Walsh, MD, MEd, FRCP, Institute of Medical Science, University of Toronto
Camille Williams, BASc, MHSc, Graduate Department of Rehabilitation Science, University of Toronto

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HEATHER CARNAHAN obtained her PhD in kinesiology from the University of Waterloo, Canada, and continued to complete an NSERC postdoctoral fellowship in psychology at Western University, Canada. She later became a professor in the Faculty of Medicine at the University of Toronto, Canada, where she also served as the interim Vice President of Education at Women’s College Hospital, and was Director of the Centre for Ambulatory Care Education. She currently serves as Professor and Dean of the School of Human Kinetics and Recreation at Memorial University of Newfoundland in Canada.

While studies are ongoing, it is clear that the restriction of movements via assistive haptic feedback need to be mitigated to benefit the learning process. Overly strict haptic assistance contributes to the overdependence on its guidance, leading Carnahan and Williams to open up the field of enquiries yet further. To what extent, for example, do errors play a role in learning, motivation and attention? Is haptic feedback that promotes a positive impact on a user’s performance more conducive to learning than haptic feedback which has a negative impact? In order to explore these issues, Carnahan hopes it will be viable to take her studies out of the lab and into settings more applicable to the contexts of her research.

FEEDBACK AT THE FINAL FRONTIER

If haptic devices are to have a firm place in teaching then Carnahan’s research programme is crucial to understanding the concepts underpinning the use of haptic feedback. But what of those students and patients currently receiving training or neurorehabilitation with haptic devices? Catharine Walsh, a postgraduate paediatric gastroenterologist, works with Carnahan to address the lack of reliable tools for assessing the proficiency of clinical procedures. In particular, Walsh focuses on the development and validation of a gastrointestinal endoscopy competency assessment tool for use in colonoscopy. Developing such tools is vital as there are currently no widely accepted measures of endoscopic competency being implemented. Using Delphi methodology, a panel of gastroenterologists, surgeons and endoscopy managers participated in rounds of surveys, curtailing numerous checklist items and global ratings by consensus to a short list that created an evaluation instrument known as the Gastrointestinal Endoscopy Competency Assessment Tool (GIECAT). By repeatedly reviewing the responses until a consensus is achieved, the Delphi method has resulted in a validated measure of competency, specific to endoscopic procedures, that is relevant to practice across different institutions.

Though many questions are only beginning to be formulated around the use of haptic feedback, let alone explored, Carnahan’s research programme has already helped elucidate some of the key issues surrounding their use. The relevance of Carnahan’s research to innovations in all kinds of work settings is encapsulated by recent studies carried out in collaboration with the German Aerospace Centre (DLR). Carnahan conducted and participated in flight-simulated zero gravity tests to see how an exaggerated, complex environment like space can affect the learning of relatively simple motor skills. It is hoped that groundbreaking research of this sort will benefit the likes of healthcare providers who in the future, as extended trips into space become ever more likely, will need to administer high levels of care over long periods in zero gravity. It is in more terrestrial environments, however, that the benefits of Carnahan’s work can readily be felt.

It is now clear that individuals receiving these methods of training should experience simulations where feedback is most appropriate: “In most cases it is important that the haptic feedback that learners experience during training closely resemble the haptic feedback available during real performance,” Carnahan illustrates. Haptics are undoubtedly a vital component of skilled motor performance and haptic technology will continue to augment the human experience in a growing number of scenarios. It is vital that research like this ensures they remain efficient and effective methods for teaching.