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 long-term retention of these skills. The obvious example is riding a bike, but other examples include the physician certified to perform a particular clinical skill; if long periods elapse without practise, 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.
More than a feeling

With training programmes in a wide variety of professions relying increasingly upon haptic technology, research at the Memorial University of Newfoundland aims to ensure their effect on motor skill learning is properly understood.

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, of 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:
INTELLIGENCE
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
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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.

the effects of haptic feedback on motor skill acquisition. Using Geomagic Touch devices and various different types of haptic feedbacks developed with Williams, Carnahan aims to find out how the acquisition and retention of motor skills over time is affected by the manipulation of augmented haptic feedback. With the device’s pen shaped stylus, participants perform a tracing task while their progress is shown on a computer screen. Connected to the motorised body, the stylus imitates the experience of putting a pen to paper on a hard surface and provides each participant with a different form of haptic feedback. One day after the task’s completion, tracing is performed again but this time without haptic feedback in order to see how each form of feedback has affected the user’s level of performance. “By comparing the performance of participants exposed to different forms of haptic feedback we will begin to understand which form of feedback is more effective for learning this skill,” explains Carnahan.

While studies are ongoing, it is clear 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 used.

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.