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The Core Skills Trainer: A Set of Haptic Games for Practicing Key Clinical Skills

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Abstract. A new approach to teaching the skills used by health professionals during hands-on (palpation-based) examinations and procedures is reported, where students practice individual 'core' skills by playing haptic computer games. These core palpatory skills were identified through interviews and a survey of clinicians and include determining size, firmness, shape and moving and thinking in 3D. A learning environment using haptic force-feedback technology (The Core Skills Trainer) was created that consisted of a set of eight computer games, one game for each core skill. Concepts from computer gaming were used to help engage students in the learning process including acquiring points, losing lives, different levels of difficulty and high scores tables. Each game has three levels of difficulty to support progressive improvement and the player's ultimate task is to become proficient in all the core skills.

Key words: Clinical training, core skills, computer games, simulator.

1 Introduction

Hands-on skills are central to the clinical work of many health professionals who use their hands to examine patients (i.e. palpation). Simulators are now widely used to provide trainees with alternatives to practicing these palpatory skills on patients. Many simulators (physical and virtual reality) are procedure specific, i.e. designed for learning a particular clinical task or examination. An example of such a simulator is the veterinary trainer 'The Haptic Cow' [1]. While teaching the core curriculum with the cow, a more generic approach was sometimes adopted because a number of students' career aspirations were not in farm animal medicine, but rather equine or small animal practice. To make the training relevant the instructor would focus on the 'core' haptic skills (e.g. determining relative size or detecting differences in stiffness) that were applicable to other species and techniques, but were being learned in the context of the cow. A logical next step was proposed: the development of 'The Core Skills Trainer', a training tool for learning the palpatory skills that are the fundamental 'building blocks' for many palpation-based procedures and examinations. In human medicine, training for the component skills of minimally invasive surgery (MIS) has been provided [2] but a similar approach for palpation has not been undertaken. The Core Skills Trainer aimed to fill this niche, providing generic palpatory skills training (initially for veterinary education) in an engaging and enjoyable format: a set of haptic computer games, one for each core skill.

2 Identifying the Core Skills

The first step was to identify the core palpatory skills. A preliminary list was drawn up using information from the literature, including object properties explored through touch as researched by Weber [3], Lederman and Klatsky's exploratory procedures (EPs) [4] and from our own work with veterinarians [5]. A clinical perspective was established initially by interviewing doctors and veterinarians. They were asked to identify the core skills used when performing palpation-based examinations and procedures. The list was then refined and compiled into a survey sent to veterinarians. The recipients were asked to decide whether each skill was core to their clinical work and to provide examples of when the skill was used. At the end of the survey a free text section was provided for respondents to enter additional core skills not represented in the list.

Fifty-five veterinarians responded. Six of the eight provisional core skills were considered of clinical relevance by the majority of respondents (Fig. 1). Comments on the skills indicated that hand movements for certain techniques are restricted primarily to one dimension, e.g. pressing an object to assess stiffness, or could be in three dimensions, e.g. to find and identify structures. The skill of thinking in 3D was related to processing information gathered during complex tasks including palpating 'blind' (e.g. during an internal examination) and building a 3D mental image, say of the overall anatomy. In the free text section a further skill emerged, classified as 'detection of movement', e.g. a pulse.

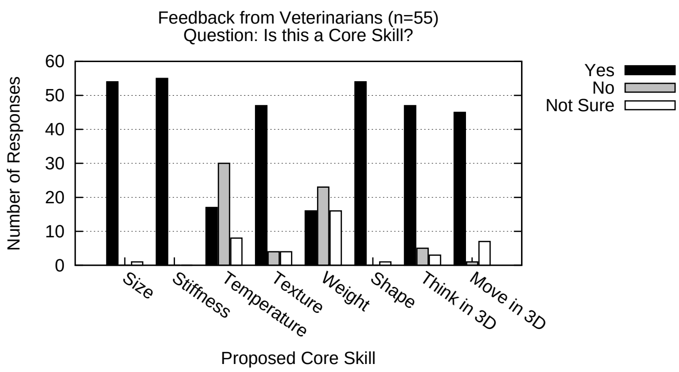

Fig. 1. Veterinarians' responses to a survey designed to identify core skills

3 Software Development

3.1 Requirements Overview

The Core Skills Trainer, a series of haptic computer games, was developed to enable trainee health professionals to practice the core skills identified by clinicians. A games environment was used to capitalize on the students' competitive nature and encourage them to practice and improve. A key requirement was that students should be able to use the trainer independently, so that its use was not limited by the need for a technician or tutor. A fundamental advantage of the core skills approach is that each skill is applicable to many different clinical procedures or tasks. Therefore, each game had to remain abstract from a specific clinical context. This also afforded greater freedom in terms of games design.

3.2 Design and Implementation

Based on the survey of clinicians, five games were developed, each focusing on a different haptic perception task (recognizing an object's stiffness, differentiating between objects based on size, identifying shapes, comparing textures and detecting movement). A further three games were created that incorporated aspects of 3D thinking and movement (two games focused on controlling force/pressure in a single dimension and one on movement around a 3D maze). The games were designed to be appealing, for example in one game, to teach the use of controlled pressure, the player's application of force controls the flight of an airplane. Objects including stars and bombs appear at different altitudes which need to be collected or avoided. In another game (the 'Texture Game') the player follows a path across a grid (Fig. 2; left) by feeling for the 'most textured' squares (texture is represented by dynamic and stick-slip friction). In this paper, the Texture Game will be used to illustrate the process by which all eight core skills games were developed. The challenge was to create fun game concepts, whilst ensuring that the skills taught were relevant to a range of clinical procedures. Veterinarians were regularly involved to help guide clinical relevance.

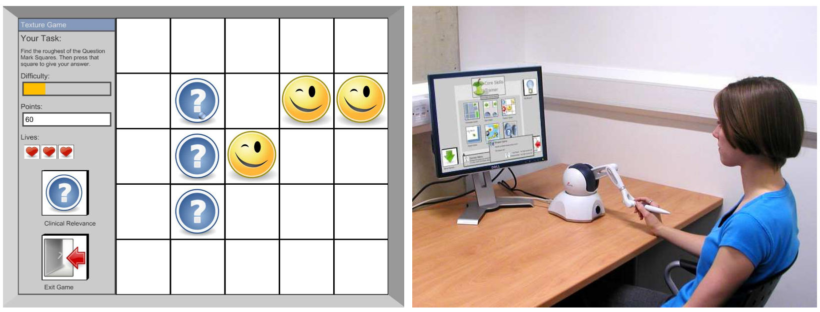

Fig. 2. The Texture Game (left), one of the eight core skills games developed and a student using The Core Skills Trainer (right)

Concepts from conventional computer games such as scoring points, losing lives and unlocking levels of increasing difficulty are used to engage the player and encourage competition. Each game has three levels of difficulty. The first and second levels present the same task, but the second is more difficult and should require repeated practice to complete. The third or 'expert' level adds an extra challenge (e.g. in the Texture Game the player feels the friction effect on a sphere rather than a flat surface). The games were designed to balance the use of psychophysics (to measure performance) with the gaming principals that the training should be fun and quick. For example, a psychophysical discrimination protocol is used as the basis for a game to teach size perception, however the number of questions is limited and the concepts of points and lives are added.

The Core Skills Trainer was implemented in C++ with H3DAPI [6] and uses a PHANToM Omni (Fig. 2; right). The Omni was chosen as a tradeoff between cost and performance. However, the software was designed to be independent of haptic device type, so that if a more suitable device became available, it could easily be supported. Preliminary user testing was conducted with each game to initially set difficulty levels. The expert level of the Texture Game was modified to use a psychophysical staircase algorithm to estimate a player's perceptual limit. Incorrect (less 'textured') spheres had a constant dynamic friction coefficient of 0.2 (as rendered by the HAPI God Object Renderer [6]), while the friction of the correct (most 'textured') sphere varied in steps of 0.03, decreasing after a correct answer and increasing after an incorrect answer. Three experienced haptic users participated and the resulting average Weber fraction of 34% was used to provisionally set the difficulty of the Texture Game.

A menu system was created to allow the players to access the games and view their overall progress. To enforce the idea that the skills are 'building blocks' for clinical practice and players need to acquire them all, an image of a clinician is gradually revealed as the player completes each game. To encourage the player to practice each skill equally, a game may become temporarily locked if it is played more often than the others. To avoid usability issues combining the use of a haptic device and a mouse, an interface was developed which used virtual haptic buttons, allowing the menus to be navigated using the haptic device.

Automated demonstrations are provided, during which the haptic device actively guides the student's hand through an example game (using PlaybackLib [7]). On-screen text and graphics explain key points during the demonstration.

3.3 User Testing

Development included an iterative process of user testing, involving student volunteers from the Royal Veterinary College (RVC), London. The goals were (a) to improve usability and (b) to refine the levels of difficulty. Each participant played 1-3 different games during a session lasting 30-60 mins and was instructed only to ask for assistance as a last resort. An observer made notes during the session and the participant answered a questionnaire immediately after using the trainer. Scores, lives and success rates were used to help assess the appropriateness of difficulty levels, which were revised during user testing.

3.4 Results

Fifty-nine veterinary students participated in the user testing and completed the questionnaire. When asked if they would like to use the trainer again, 91% answered ‘yes’, 7% ‘not sure’ and 2% ‘no’. Similarly, 88% would recommend it to others (12% answered ‘not sure’). Most found the haptic buttons easy to use giving a median rating of 9/10 for ease of use. Participants enjoyed the experience, giving a median score of 8/10 for fun. In a free text section, one participant remarked: “It is a new way of learning to listen to your sense of touch”. Participants gave a median rating of 8/10 (averaged for all games) when asked how appropriate they thought the level of difficulty was (i.e. not too hard or easy). However, during the course of user testing, the difficulty was adjusted in reaction to feedback and scores. Some participants commented that the clinical relevance of the skills was not immediately apparent. Also, at first some participants had difficulty operating the haptic device, particularly moving in 3D.

3.5 Refinements Based on User Testing

An interactive tutorial was developed to help players get used to the haptic device and practice moving in 3D. The tutorial introduced special features of the user interface (virtual haptic buttons and the haptic device guiding the hand during the automated demonstrations) and allowed the player to experience different haptic surface properties. Various aspects of the haptic buttons were refined to improve usability; the raised sides of the buttons were rendered smooth and sloped to prevent the haptic cursor catching and the surfaces of the buttons were assigned a high static friction to prevent the cursor from slipping. A ‘Skills Context’ button was added in each game to highlight the clinical relevance of the particular core skill. During user testing, qualitative and quantitative feedback (scores, lives and success rates) helped identify games and levels that were too easy or hard. Difficulty parameters (such as the differences between the friction coefficients in the Texture Game) were adjusted based on this feedback.

4 Discussion

A game-based haptic simulator was developed for trainee health professionals to practice core palpatory skills, which were identified by clinicians as being important in clinical practice. User testing conducted with veterinary students suggested that the trainer was easy and enjoyable to use and a number of refinements were implemented including more explanation of clinical context.

The skills used during palpation-based examinations and procedures are difficult to teach and learn because often the techniques are so familiar to the tutor that they become subconscious. Only by repeated practice can students learn to effectively ‘listen’ to their sense of touch. By ensuring that students can use the trainer without assistance, The Core Skills Trainer can be made available more frequently and so better support this kind of repeated and personal practice.

The core skills approach is appealing as the training is potentially relevant to a large number of different clinical procedures. The abstract games environment means that unlike many procedural simulators, no prior theoretical knowledge (e.g. anatomy) is required, so training can be provided earlier in the curriculum. However, it is not yet known how core skills learned in abstraction would transfer to more complex clinical procedures involving integrating several core skills and other knowledge. Further studies will help to establish how best to combine the core skills approach with training on procedural simulators and real patients. Veterinary and medical students are not currently selected on their manual or palpatory skills, so early exposure to training tools such as The Core Skills Trainer would help students identify skills they need to improve and offer a safe and appealing environment in which to practice. Students and teachers could track skills development using scores provided by The Core Skills Trainer.

The trainer is currently being used with students at the RVC to investigate how it can be incorporated into a curriculum, and preliminary feedback from both veterinarians and students is encouraging. Further studies will attempt to objectively assess the effectiveness of the training provided, beginning by examining learning effects within the games environment. Future work will also include the identification of other disciplines that could benefit from the trainer. The abstract nature of the core skills and their presentation in a games environment mean that adapting The Core Skills Trainer for other skills domains is feasible. Any profession where manual dexterity and haptic perception are important, such as human medicine, dentistry and physiotherapy, could potentially benefit from the trainer with modifications. More generally, a similar combination of game-based learning and haptics could be used to engage students in other areas of learning, not only manual and haptic perception skills training.

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