The Role of Mental Imagery Ability in Learning Clinical Skills: Development of the Clinical Skills Imagery Ability Questionnaire (CS-IAQ)

by

Yvonne Hui

A thesis submitted in conformity with the requirements for the degree of Master of Science

Institute of Medical Science
University of Toronto

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Abstract

The general aim of this thesis was to gain a better understanding of the use of mental imagery in 
health professions education, as well as the consideration of imagery ability. This was done 
through a scoping review and the development of a questionnaire to assess the ability to image 
clinical scenarios. An improvement in skill performance after mental imagery was reported in 
about half of the experimental research studies. In the development of the questionnaire, three of 
the resulting clusters of questions were shown to be able to differentiate participants with 
different levels of experience and all represented the motivational general category. Participants 
also reported a preference for a first person perspective when imaging, regardless of their level of 
training. Overall, the results of this thesis project were found to enhance the understanding of 
mental imagery use by health professionals as well as the effects of imagery ability.
Acknowledgments

I would like to express my gratitude to my supervisor Dr. Heather Carnahan for her expertise, patience, continual guidance and support throughout my whole graduate program and beyond. I would also like to thank the other members of my committee, Dr. Adam Dubrowski and Dr. Tim Welsh for their feedback and guidance.

Finally, I would like to thank Camille Williams and the members of the Wilson Centre for their unconditional support.
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Chapter 1
A Literature Review of the Use of Mental Imagery in Health Professions Education

1.0 Introduction

Changes in the delivery of patient care have made it challenging for students at any level to practice new skills on patients (Aggarwal & Darzi, 2006). Patient safety must be kept in mind when allowing students to practice new skills. Alternative methods that have been used in medical education to address these challenges include the use of simulators, clinical skills labs and the use of standardized patients. Concepts borrowed from the domain of Kinesiology and Psychology has been applied to study the teaching of clinical skills in medicine to improve these alternative methods (Dubrowski & Backstein, 2004; Dubrowski, Backstein, Abughaduma, Leidl, & Carnahan, 2005; Elliott, Grierson, Hayes, & Lyons, 2011). Another concept from that domain that should be given more attention, is the use of mental imagery to enhance the learning of technical skills. Mental imagery refers to the cognitive practice of a motor task without engaging in the physical movement involved with the task (Driskell, Copper, & Moran, 1994). Other terms have been used to describe this definition, such as mental practice, mental movements and motor imagery (Schuster et al., 2011). In this thesis, mental imagery will be used as the term to represent these other terms that may describe the cognitive practice of a motor task. It has been shown that mental imagery can be an effective alternative to physical practice when learning a motor skill in medicine (Arora et al., 2010). This can be due to the activation of the shared neural representation of performing the action itself when mentally simulating an action (Jeannerod, 1994; Jeannerod, 1999). Wohldmann, Healy, and Bourne (2008) examined the differences between mental imagery practice and physical practice using a typing task. In their study, they
found that mental practice was superior to physical practice and also led to more skill transfer. This was in part due to an interference effect caused by the physical practice of the new motor tasks impairing the old motor behaviours.

Mental imagery research is significant as it may be more cost effective and easier to facilitate as an alternative or adjunct to physical practice when teaching health professionals clinical skills. Mental imagery is a useful tool for athletes, but there may also be a great economical impact for health educators. Educators and skills labs used in health professions education are costly. Mental imagery, however, is a low cost resource and relatively inexpensive method of learning that may be used as an alternative or adjunct to physical practice. There may be a significant opportunity to reduce the costs associated with health professions education. In order to develop more effective training techniques that may utilize mental imagery, a better understanding of how mental imagery is used or taught in medical education is needed.

A scoping review of the literature was completed to gain a better understanding of the current use of mental imagery in health professions education. The purpose of the scoping review was also to look at the discussion of mental imagery ability in the literature. The purpose of this scoping review was not to evaluate the caliber of studies but to summarize the current literature on the use of mental imagery in health professions education.

The information summarized in the scoping review then helped to direct the second phase of the thesis, which involved the development of a questionnaire to assess the ability to image clinical skills. The questionnaire entitled the Clinical Skills Imagery Ability Questionnaire (CS-IAQ), was developed and the process of validation began, to specifically assess the use of imagery during the performance of clinical skills. Specifically, the questionnaire assessed an individual’s ability to form specific clinical images as well as the perspective of imagery used.
The categorization of mental imagery, mental imagery across disciplines and mental imagery in medical education will first be discussed.

1.1 The Categorization of Mental Imagery

Mental imagery can be explained in different ways depending on the type and form. Paivio (1985) described mental imagery by the purpose it served the individual. He categorized mental imagery according to four different purposes, which can be seen in Table 1. Mental imagery can serve a motivational purpose to increase physiological arousal and the associated emotions. Individuals who image the arousal of positive or negative emotions associated with general scenarios are using the motivational-general aspect of imagery. Those who image the arousal of responses to a specific goal or goal-oriented behaviours are serving the motivational-specific aspect of imagery. Mental imagery can also serve a cognitive purpose to directly practice behavioral skills. Individuals can use cognitive imagery specifically for the purpose of rehearsing motor skills. For a more general purpose such as the rehearsal of general strategies, individuals are serving the cognitive general aspect of imagery.
**Table 1.** The division of imagery into four different categories depending on the purpose it serves (adapted from Paivio, 1985)

<table>
<thead>
<tr>
<th>Imagery purpose</th>
<th>Motivational Function</th>
<th>Cognitive Function</th>
</tr>
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<tbody>
<tr>
<td>General Function</td>
<td>Imagery to increase physiological arousal and positive or negative emotions</td>
<td>Imagery of general strategies</td>
</tr>
<tr>
<td>Specific Function</td>
<td>Imagery of responses to goal or goal oriented behaviours</td>
<td>Imagery of specific motor skills</td>
</tr>
</tbody>
</table>

Alternatively mental imagery can also be examined according to the perspective of the images formed. When imaging, individuals can use a first person perspective as if they were performing the movements. A first person perspective is referred to as “internal” imagery. The other perspective that can be taken is the third person perspective. This perspective, referred to as “external” imagery is associated with the individual being a spectator. External imagery involves the individual watching themselves perform the movement from an outside view (Mahoney & Avener, 1977; Jeannerod, 1999). There are debates over which perspective produces the most positive results (Salmon et al., 1994; Hardy & Callow, 1999; Immenroth et al. 2007). However, the perspective chosen may be task specific or may simply be a matter of preference (Hall, 1997).
1.2 Mental Imagery Across Disciplines

Mental imagery has been looked at in the sports psychology arena to increase athletic performance and confidence (Rogers, 2006; Hall et al., 2009), in the business sector to improve job interviewing skills (Knudstrup, Segrest, & Hurley, 2003), and to aide in rehabilitation (Weiss et al., 1994). In a review by Rogers (2006), mental imagery was found to be used by runners, football players, gymnasts and in general exercise routines to improve performance. Schuster et al. (2011) reviewed motor imagery training elements in five different disciplines including: education, medicine, music, psychology and sports. In the review, the mental imagery training session was examined based on the physical, environmental, timing, task, learning, emotional and perspective aspects. The investigators also looked at the duration times and number of repetitions of the training sessions. They found mental imagery interventions that resulted in positive outcomes involved: motor focused activities, when live detailed acoustic instructions were provided, when sessions were supervised and when participants closed their eyes to image. Another component of the mental imagery training session that was examined in Schuster et al.’s (2011) review was the physical practice component. The authors described the beneficial effect of mental imagery when added to physical practice and compared the order of the mental imagery trial compared to the physical practice trial and whether mental imagery practice was more beneficial when added to or embedded into physical practice. They found that successful mental imagery interventions involved mental imagery trials that were added and performed after physical practice. The use of mental imagery as a technique to rehearse technical skills without physically performing the skills has been shown to have successful outcomes. It is also evident that the success of mental imagery can depend on a number of factors. Successful mental imagery training sessions were most prominent in the psychology literature (Schuster et al.,
2011). In the review, the total number of articles found for the discipline of psychology was 79 compared to the nine articles found in the discipline of education. All of the literature found in the discipline of education, involved participants in health professions. Comparing the number of articles found in the discipline of Psychology, this method of practice should be given more attention within the field of medical education.

1.3 Mental Imagery in Medical Education

In medical education, mental imagery is a technique that has been used to learn basic surgical skills (Sanders et al., 2004) and more advanced skills such as laparoscopic surgery (Arora et al., 2010; Arora et al., 2011). Another review has looked at the use of mental imagery to facilitate the transition of newly graduate registered nurses into practice (Boehm & Tse, 2013). There have also been studies looking at the use of mental imagery with dental students (Walsh, Hannebrink, & Heckman, 1984; Welk et al., 2007). The benefits of mental imagery in the learning of skills can be extended to all health professions where the performance of clinical skills is necessary and should not be limited to one health profession as shown in the above mentioned studies. Mental imagery in health profession’s education, however, has not been investigated in depth compared to the disciplines of psychology and medicine (Schuster et al., 2011).

Findings from a number of studies show the potential of mental imagery in training health care professionals. Arora et al. (2011) compared novice surgeons who underwent mental imagery training using a mental imagery script, to a control group who viewed an online lecture in addition to both groups receiving physical practice on a simulator. Arora et al. (2011) found that the mental imagery group improved their quality of laparoscopic performance on a virtual reality laparoscopic cholecystectomy compared to the control group as assessed by expert raters.
Komesu et al. (2009) similarly found gynecology residents who underwent mental imagery training to score higher in performance measures when compared to a control group who read a textbook. The study by Komesu et al. (2009), however, did not include a physical practice component.

While mental imagery has been shown to be effective in the above studies, there are examples in the literature where mental imagery did not lead to enhanced skill learning. Nursing students were divided into one of four groups: a control group, a mental imagery only group, a relaxation group and a combined mental imagery and relaxation group in Doheny’s (1993) study. The mental imagery group was instructed to imagine performing an intramuscular injection while the control group was given content on therapy techniques and the relaxation group was taught muscle relaxation techniques. There were no significant differences between the groups on performance scores of an intramuscular injection. The participants also reported actual physical practice as most helpful when learning a new skill and that mental imagery was most helpful when combined with physical practice. Hayter et al. (2013) and Mulla et al. (2012) found similar results in their studies with anaesthesia residents and medical students respectively.

It is unclear from the literature, what conclusions can be made regarding the effectives of mental imagery. What can account for the differences seen in the outcome of studies in the literature? An important consideration is the characteristics of the studies done in mental imagery. As seen in studies previously mentioned, many different characteristics can determine the effectiveness of mental imagery training. The method of mental imagery delivery, the inclusion of a mental imagery ability component, the clinical domain being examined, the skill involved, the inclusion of physical practice, the study population and the number of participants all affect the outcome of the studies and need to be considered. All of these characteristics can affect how successful the
mental imagery training session will be. Without considering these characteristics it is difficult to fully understand and make conclusions regarding mental imagery.

Another concept that may influence the effectiveness of mental imagery is an individual’s ability to image. It is important then, when investigating mental imagery to also consider imagery ability. In the reviews previously mentioned, mental imagery ability was not specifically considered in the analysis of the relevant literature (Schuster et al., 2011; Boehm & Tse, 2013).

1.4 The Scoping Review

According to the methodological framework developed by Arksey and O’Malley (2005), the purposes of a scoping review include: examining the extent, range and nature of research activity; determining the value of performing a full systematic review; summarizing and disseminating research findings; and identifying research gaps in the existing literature. Compared to systematic reviews, scoping reviews do not usually assess the quality of a study (Levac, Colquhoun, & O’Brien, 2010). The scoping review was, therefore, chosen in this study for the purposes laid out by Arksey and O’Malley and utilized the five stages of the methodological framework (Arksey & O’Malley, 2005; Levac et al., 2010). The five stages include:

1. Identification of the research question
2. Identification of relevant studies
3. Study Selection
4. Charting the data
5. Collating, summarizing and reporting the results.
1.4.1 Procedural Steps

After the formulation of research questions, the assistance of a librarian from the Hospital for Sick Children in Toronto, Canada, was used to develop a search strategy. The research questions included:

- What does the current research say about the use of mental imagery in medical education?
- Is it being taught/used?
- What skills are they being used for? Is it effective?

The search was run using the OvidSP search platform in the following databases: MEDLINE, EMBASE, EBM Reviews – Health Technology Assessment (HTA), PsycINFO, Eric; as well as the EBSCOHost search platform in the following database: CINAHL. Articles indexed as of January 31, 2013 were included. The search was repeated on December 2, 2013 to retrieve any articles that were published during the year. A combination of terms specific to each database was included in the search strategy and consisted of the broad terms:

i. Mental processes, or imagery, or mental practice, or imagination
ii. Medical education, or interdisciplinary education, or medical residency

All references were kept regardless of the year of publication. References were saved in an EndNote library and later imported into RefWorks, both bibliographic management systems. Duplicates were then removed using EndNote and RefWorks.

1.4.2 Identification of Relevant Studies

Inclusion and exclusion criteria were developed by two raters to select each reference.

References were included if they met all the inclusion criteria:

i. Populations/participants at any level: undergraduate, graduate, residents, fellows
ii. Any of the health professions: medicine, surgery, dentistry, occupational therapy, physiotherapy, nursing, chiropractic, respiratory therapy, veterinary medicine (all disciplines/settings)

iii. Explicit discussion of the use of some form of mental imagery (e.g. imagery scripts, think aloud techniques, imagery techniques) for learning or practicing some sort of skill

References were excluded if they met any of the exclusion criteria:

i. Use of mental imagery for rehabilitation (e.g. Teaching patients to use mental imagery for rehabilitation)

ii. Use of mental imagery for patient therapy (e.g. pain and anxiety management)

iii. Use of mental imagery for education not in health professions

Using the inclusion and exclusion criteria, one rater reviewed each reference independently to determine the relevance. Any references that were determined to be unclear were marked and later reviewed by the second rater to make the final decision. Decisions of both raters were then compared and if any decisions were still unclear, the full text article was retrieved to make a final consensus. The included published articles comprised experimental research studies, commentaries, reviews, and conference abstracts. A summary of this step can be found in Figure 1. Articles that were not in English were excluded from the final count due to the cost and resources involved with translation. Articles that were not found physically or online were also excluded from the final count.

A data charting spreadsheet developed by the two raters was then used to chart each full text article. Information was recorded including: first author, title, year of publication, journal, article type, method of mental imagery, whether mental imagery sessions were supervised, if a measure
of mental imagery ability was used, the clinical domain, the skill, if physical practice was involved, research type, the study population, the number of participants, the study location and settings, if mental imagery was successful compared to the control or another form of practice, key findings and main conclusions. The chart was filled out where applicable for each reference.
Figure 1. Summary of study selection step

Search Strategy = 1668 total abstracts
MEDLINE (299), EMBASE (539), EBM Reviews – Health Technology Assessment (HTA) (3), PsycINFO (237), Eric (146), CINAHL (444)

269 duplicates were removed using EndNote library

1399 unique abstracts reviewed. One rater reviewed all abstracts against inclusion and exclusion criteria to determine relevance (The second rater reviewed any abstracts that were determined to be unclear)

1323 abstracts were excluded as determined by the inclusion and exclusion criteria

76 abstracts determined to be relevant and pulled for full review and data charting

28 articles removed (Including: articles not in English, articles further determined to be irrelevant by one rater using the criteria, irretrievable articles and additional duplicates)

48 articles included in final analysis
1.4.3 Final analyses

After charting the final 48 articles, the data were analyzed, collated and summarized into a numerical summary. The purpose of the numerical summary was to describe the characteristics of the included articles including: the different types of research, the year of publication and the country of origin of each article (Levac et al., 2010).

A thematic analysis was then performed by one rater to identify any gaps in the literature, to make comparisons across the studies and to identify any contradictory findings. The thematic analysis is used in the scoping review as a step in collating, summarizing and reporting the results (Arksey & O’Malley, 2005). The first step of the thematic analysis was to categorize each article according to the article type. The emerging trends in the studies within each category were then extracted through the data charting process. Trends that were considered were derived from principles of mental imagery reported in the sports literature and included: the method of mental imagery delivery, the inclusion of a mental imagery ability component, the clinical domain, the skill involved, the inclusion of physical practice, the study population, the number of participants, the success of mental imagery, the key findings and the main conclusions. These trends were extracted and collated as applicable for each study.

1.4.4 Numerical Summary

The final analysis included 48 articles. Of the 48 articles, 25 were experimental research studies, 13 were commentaries, 8 were review articles, and 2 were published conference abstracts. The year of publication of the included articles can be seen in Figure 2. The country of origin of the articles is summarized in Figure 3.
Figure 2. The year of publication of articles
1.4.5 Thematic Analyses

The articles were divided into four categories according to the article type. The categories were articles that involved experimental research studies, articles that were considered commentaries, articles that involved reviews, and finally conference abstracts. The emerging trends of each category were then examined.

Figure 3. The distribution of articles across countries
1.4.6 Summary of Experimental Research Studies

The thematic analysis summary of experimental research studies was separated into studies that involved a measure of imagery ability and those that did not. The summary of studies that involved a measure of imagery ability can be found in Table 1. The summary of studies that did not involve a measure of imagery ability can be found in Table 2. Articles categorized under experimental research studies encompassed randomized controlled trials, pre-test and post-test study designs, post-test only studies, within subjects study designs and short research studies. All studies involved a method of imagery delivery, which has been collectively referred to as mental imagery. The methods of mental imagery delivery varied from mental imagery scripts, the use of visual cues internally and externally, mental rotation tasks with various objects, think aloud techniques, detailed descriptions of procedures, video demonstration and audio tapes. Sessions ranged in time from five to 90 minutes. The studies also varied in the amount of supervision given to participants during each session with some given 1-on-1 with physician, expert or psychologist supervision compared to other participants who were given independent practice. Interestingly, in study 9, participants reported actual practice as the most helpful form of practice and that mental imagery was most helpful when combined with physical practice. This is in line with literature found in the motor learning domain which suggest that physical practice is the preferred method of practice when available, however when physical practice is not available, mental imagery can be an effective method to augment learning (Hird, Landers, Thomas, & Horan, 1991; Allami, Paulignan, Brovelli, & Boussaoud, 2008; Schmidt & Lee, 2011).

There were 14 studies that included a mental imagery ability component. The studies involved surgeons, medical students, undergraduate students, graduate students, nursing students, medical residents and dental students. Of the 14 studies, eight studies reported mental imagery to be
successful in enhancing skill performance compared to a control or the standard protocol of practice [Studies 1, 3, 4, 5, 6, 8, 11, 13]. There were four studies that reported better imagers to have a better quality of performance [Studies 1, 2, 9, 13] and four studies that showed mental imagery ability improving with practice [Studies 1, 3, 10, 13]. Other studies used the mental imagery ability component as a randomization tool. In three studies, mental imagery was shown to be comparable to physical practice or the control condition [Studies 7, 8, 12]. Finally, in three studies, mental imagery was reported to either improve confidence, a participant’s readiness for the task or reduce the stress associated with the task [Studies 1, 4, 11]. Measures of mental imagery ability were done through different questionnaires and tests. These included a validated mental imagery questionnaire [Study 1, 4, 14], the cube test section of the Intelligence Structure Test 2000R (Study 2), mental rotation tasks (Study 3), the Movement Imagery Questionnaire – Revised (Study 5), the Revised Minnesota paper form board test to assess visuospatial cognitive ability (Study 6), the Betts Questionnaire upon Mental Imagery vividness [Study 7, 8, 10, 13], the revised Gordon test of visual imagery control [Study 8, 13], the Vividness of Movement Imagery questionnaire (Study 9), and other informal questionnaires [Studies 11, 12]. These questionnaires examined the imagery of general scenes and situations and most were not specific to health professions.

There were 11 studies that did not include a mental imagery ability component. These studies involved surgeons, medical students, nursing students, medical residents and dental students. Of the 11 studies, six studies reported mental imagery to be successful in enhancing skill performance compared to a control or the standard protocol of practice [Studies 15, 19, 20, 21, 24, 25]. In six studies, mental imagery was shown to be equal to physical practice or the control condition [Studies 15, 16, 19, 22, 23, 25]. Finally, in seven studies, mental imagery was reported
to either improve confidence, a participant’s readiness for the task or reduce the stress associated with the task [Studies 16, 18, 19, 20, 22, 23, 24].
Table 2. Thematic analysis summary of experimental research studies that included a measure of imagery ability

<table>
<thead>
<tr>
<th>First author</th>
<th>Measure of imagery ability?</th>
<th>Skill</th>
<th>Physical practice involved</th>
<th>Study population</th>
<th>N</th>
<th>Key findings (Was mental imagery successful?)</th>
</tr>
</thead>
</table>
| 1) Arora, S. | Validated MIQ done before performing each of 5 LCs (immediately after MI or control) | LC    | Yes on simulator           | Novice surgeons (no earlier experience with LC surgery, but observed >5 LCs) | 18 | • MI group were sig superior to control in quality of performance, all aspects of imagery, confidence and knowledge  
• sig (+) relationship between better imagery and quality of performance within each session  
• MI enhances quality of LC performance in novice surgeons (through the use of scientifically developed and validated script)  
• MI improves with practice |
<table>
<thead>
<tr>
<th>No.</th>
<th>Author(s)</th>
<th>Task Description</th>
<th>Practice</th>
<th>Participants</th>
<th>Number</th>
<th>Key Findings</th>
</tr>
</thead>
</table>
| 2)  | Jungmann, F. | Cube test section of the Intelligence Structure Test 2000R | Laparoscopic surgery (knot tying task) | med students with no prior laparoscopic simulator experience | 40 | • high scores on cube test correlated with faster performance, more precise movements  
• MI practice did not influence overall laparoscopic performance  
• learning effect reached a plateau after several reps which may have limited effect of MI |
| 3)  | Stransky, D. | Performance on mental rotation tasks | FLS tasks - peg transfer and circle cutting | Undergrad and grad students | 28 in study 1, 34 in study 2 | • full MRT training group performed sig better on MRT than MRT and FLS group and evidence of generalization of improvement in mental rotation ability  
• mental rotation training enhanced performance on certain FLS tasks, (cutting task) assumed to be dependent upon mental rotation, no sig difference in peg transfer  
• suggests mental rotation practice can improve surgical performance |
| 4) Arora, S. | Adapted MIQ, done before and after MI practice | LC | No | novice & experienced surgeons | 20 | • surgeons rely more on visual imagery than kinesthetic and cognitive imagery, both groups found MI useful  
 • greater degree of improvement was seen in novice surgeons, improved sig in their knowledge, confidence and imagery after MI training  
 • MIQ had internal consistency and construct validity  
 • expert surgeons had stronger imagery experiences than novices, MI significantly enhanced surgeons kinesthetic imagery and confidence |
|---|---|---|---|---|---|---|
| 5) Wright, C. | MIQ-R (prior to group assignment – but still random assignment) | Blood pressure measurement and aseptic technique | Yes, practice OSCEs | Nursing students (no previous imagery training) | 38 on blood pressure, 18 on aseptic | • MI group scored sig higher on blood pressure measurement, no difference in aseptic technique  
 • support use of PETTLEP model for blood pressure measurement skill, not for aseptic (blood pressure more highly skilled motor task)  
 • Aseptic procedure might be less psychomotor task so MI may not have been as effective |
| 6) Sanders, C. | Revised Minnesota paper form board test to assess visuospatial cognitive ability (match geometric object to different orientations) | Incision and suturing | Yes | Year 2 medical students | 64 | • MI seems to be superior to textbook study group in transfer to live surgery  
• skills of MI students improved whereas those who studied text declined for real surgery |
| 7) Klimek, CM. | Betts Questionnaire upon MI vividness of imagery scale - rated as high or low imaging ability then equally divided to treatment and control groups | Intramuscular injection | Yes | Year 2 nursing students (no experience) | 37 | • Use of visualization as supplement to video taped demo and PP is equally as effective as demo and PP alone |
| 8) Bucher, L. | Shortened form of Betts’ questionnaire upon MI (vividness) and revised Gordon test of visual imagery control were split at median (control) then divided according to level of MI | applying and removing sterile gloves | Yes, for some groups on top of MI and without | Year 2 nursing students (with no prior experience ) | 108 | • MI + PP was found to sig influence learning of novel psychomotor skill compared to MI alone, no other differences were found  
• PP participants did not perform sig better than subjects in MI |
9) Doheny, MO. | Vividness of movement imagery questionnaire to divide low and high imagers but still random assignment | Intramuscular injection | No, just 1 demo of skill | Year 2 nursing students | 95 |
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<tr>
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<td></td>
<td></td>
<td></td>
<td>• no sig difference between groups in performance scores but not all subjects complied</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>• high imagers consistently described using MI techniques along with actual practice to learn new skills and gave more acceptable injection performances</td>
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<td>• low imagers used memorization, practice and demonstration to learn new skills and gave less acceptable injections but only marginally sig</td>
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<td></td>
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<td>• acceptable performance was more common among high than low imagers regardless of treatment group</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>• subjects cited actual practice as most helpful when learning a skill and MI was most useful when combined with PP</td>
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<td></td>
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<td>• Ability to image does affect learning and performance of motor skills</td>
</tr>
</tbody>
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10) Eaton, S. | Short form of Betts Questionnaire upon MI vividness | N/A | No | Female sophomore nursing students | 60 |
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<td></td>
<td>• low imager group with MI showed considerable improvement in MI ability measured on QMI but mirrored by low imager relaxation group</td>
</tr>
</tbody>
</table>
- High imager group showed no difference after relaxation.

- MI ability was enhanced only after 2 brief practice sessions.

11) Immenroth, M.

At the end, MI group had to answer questionnaire to solicit view of MI

LC

Yes, allowed to perform a LC once before baseline procedure on simulator

Surgeons undertaking specialist training

98

- MI group were generally well able to MI performing procedure, and imagine from inner perspective, concentrated at nodal points and had favourable opinion about MI, predicted that it could have a very (+) long term effect and generalizable to other procedures. most wanted to use it in the future on their own

- MI effective in optimizing performance of surgeons undergoing training in LC, better outcomes than practical training or control on checklist

- MI results in greater improvement in cognitive aspects of a procedure (Checklist) than motor elements (Global Rating Scale)

12) Sanders, C.

Visualization abilities were considered

Incision and suturing under controlled time (8 minutes)

Yes, individual supervision by teaching physicians

Year 2 medical students

65

- PP only group appeared to gain more than the other groups, but 1 PP + 2 MI group only slightly lower in performance in the actual surgery. 2 PP + 1 MI was lower still, BUT no
<table>
<thead>
<tr>
<th>Patient</th>
<th>Test administered</th>
<th>Procedure</th>
<th>Group</th>
<th>Year</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>13) Walsh, MM.</td>
<td>Shortened form of Betts test of Imagery vividness and Gordon test of imagery control to level of MI, then random assignment</td>
<td>intraoral local anesthetic</td>
<td>Yes during clinical session</td>
<td>Year 2 dental hygiene students (no previous experience)</td>
<td>18</td>
</tr>
</tbody>
</table>

- After initial instruction and a session of monitored PP, MI rehearsal was as effective as PP in learning surgical skills by medical students.
- MI should not replace PP but it may supplement it.
- At post test, sig increase in mean scores for Gordon test within MI group.
- Sig correlations with both test for certain injections for performance improvement between first and final clinical evaluation scores for combined group.
- MI + PP improved students first attempts at administering local anesthetic.
- MI group almost doubled the degree of improvement of control in clinical performance of intraoral local anesthetic administration.
- Only MI group showed sig improvement in imagery control from pre - post test.
- High MI ability learned psychomotor.
| 14) Hayter, M. | modified MIQ after 20 min of MI or didactic (validated from Arora et al., 2010) | Laparoscopic splenectomy, Crisis resource management | No | Post graduate anesthesia trainees years 1-5 | 40 | • no sig correlation between overall global rating scores and scores on modified MIQ  
• 20 min of MI does not sig improve crisis resource management performance of simulated cardiac arrest, nor did it increase the participants' perceived readiness to participate in a crisis (MIQ scores)  
• crisis resource management based on non technical skills do not seem to improve with warm up using MI |
Table 3. Thematic analysis summary of experimental research studies that did not include a measure of imagery ability

**Acronyms:**
- VRS - virtual reality simulator
- MI - mental imagery
- sig - significant (ly)
- ATLS - Advanced Trauma Life Support
- CPR - Cardiopulmonary Resuscitation
- PP - physical practice

<table>
<thead>
<tr>
<th>First author</th>
<th>Skill</th>
<th>Physical practice involved</th>
<th>Study population</th>
<th>N</th>
<th>Key findings (Was mental imagery successful?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15) Eldred-Evans, D.</td>
<td>Laparoscopic task (circle cutting)</td>
<td>Yes - box trainer and/or VRS</td>
<td>med students (no prior laparoscopic training or experience)</td>
<td>64</td>
<td>• on box trainer: MI highest on all domains except speed, VRS improved (but not sig), box free poorest and slowest</td>
</tr>
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<td>• on VRS: VRS performed best across all domains, MI scored very well too just behind VRS, both showed sig improvement over control, box free behind in all domains, MI took longest, sig slower than control and box free</td>
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<td></td>
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<td>• suggests success of MI dependent on subject receiving a degree of tutored training to ensure skill is fixed in mind</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th></th>
<th>Study</th>
<th>Procedure Type</th>
<th>Pre-test Details</th>
<th>Novice Surgeons Details</th>
<th>N</th>
<th>Notes</th>
</tr>
</thead>
</table>
| 16) Geoffrion, R. | Vaginal hysterectomy | Pre-test vaginal hysterectomy (no practice) | Novice surgeons who had observed at least one but performed fewer than 5 vaginal hysterectomy on their own | 50 | • resident level had an effect for procedure specific scale (by raters) Jr. residents improved more compared to Sr. residents  
• did not demonstrate a sig improvement in surgical skills (rated on scale), both groups had similar but nonsig improvement from pretest to test after MI, no difference in time, blood loss or complications for both groups  
• residents self assessment of skill and confidence had sig improvement in MI group |
| 17) Mulla, M. | Laparoscopic surgery (circle cutting) | No | med students, no prior experience in laparoscopic surgery | 41 | • **Box trainer** assessment: MI was slowest even compared to control, low on precision, last on accuracy, last on performance  
• **VRS** assessment: MI was faster vs. control but not other groups, lowest for precision, lowest for accuracy, last on performance  
• MI as sole method showed poor results, not here to replace skills training, did not prove to be effective in novices learning a new skill  
• potential enhancing role of VRS vs. MI as adjunct to best training method (box + practice) found in this study |
| 18) Wetzel, CM. | simulated carotid endarterectomy (CEA) | Yes - surgical crisis simulation done before and after for Surgical residents who were able to perform CEA as primary surgeon, | | 16 | • sig effects on coping, stress levels, and communication skills, trend of improved technical skills and operative outcome was found  
• control group showed no sig changes in any variables of interest |
| intervention group | minimum 2 years residency and experience in vascular surgery | • strongest effect of stress management training was found in use of surgical coping strategies, qualitative data indicated high acceptability of training package, perceived benefits of improved technical and nontechnical skills

• combination of stress management training with technical and nontechnical skills training likely to be most effective

• both, booklet and MI of surgical procedures integrating strategic, emotional and kinesthetic imagery elements were rated as the most useful

| 19) Komesu, Y. | cystoscopy | No | Gynecology residents who had observed at least 1 cystoscopy and performed < 3 cystoscopies | 68 | • compared to reading a textbook with text and photos, MI group scored higher than control in performance

• no difference in competence, performing procedure independently and time to complete

• residents who did MI performed superiorly to residents who did not but not for second cystoscopy

• MI group complied more with intervention, residents favoured MI over reading, rated higher in helpfulness of preparation |
| 20) Welk, A. | crown preparation | Yes, baseline and in between on dental simulator | Second semester dental students (low level experience in tooth preparations) | 41 | • knowledge parameter showed greatest impact of MI, process parameter also sig  
• several practical exercise units should be completed alternately with MI  
• MI group felt much better prepared for the preparation with MI than with teaching method they used before and could imagine using MI again in the future independently |
| 21) Bathalon, S. | cricothyrotomy | Yes in kinesiology | First-year med students | 44 | • kinesiology + MI group found to be statistically different from control ATLS group in steps, fluidity and total (but not from kinesiology group)  
• asked participants to transition between physical act to mental image by going through procedure first with pen and paper then with fingers then without physical support which yielded positive results compared to control, cognitive task analysis, kinesiology and MI in teaching cricothyrotomy, improved short-term acquisition of this skill |
| 22) Speck, BJ. | Intramuscular injection in dorsogluteal muscle | Yes - 3 hours supervised practice using models | Baccalaureate nursing students | 26 | • subjects who used MI prior to first injection perceived their anxiety as lower than individuals who did not use it  
• time of injection performance not sig different for 2 groups but there was a difference  
• no difference for performance scores |
| 23) Bachman, K. | One rescuer CPR (ORCPR) | No (not formally but all nurses were CPR certified within the last year) | Registered nurses recertifying in CPR (all certified within the last year) | 22 | • MI superior to PP alone could not be addressed quantitatively in this study
• skill using MI was statistically well perceived by subjects and they found it interesting and helpful
• no sig differences in performance were demonstrated between the 2 groups and confounding variables not sig but MI did better on time to pass, number of trials to pass and number of critical errors |
| 24) Rakestraw, PG. | Pelvic examinations | Yes, prior to performance | Year 2 med students | 160 | • postmotor session and combined MI session were more effective than premotor MI
• MI using tapes found to be superior to traditional instructions for certain skills but observational ratings of skill performance were inconclusive
• actual patient practice was most helpful method of instruction, students rated MI helpful for preparation and more important than lectures or readings, acceptance of method was good |
| 25) Sanders, C. | venipuncture | Yes, 30 minutes on plastic arm | Year 2 med students | 60 | • difference between MI group and PP group not sig different
• both (+), PP (sig different) and MI (marginally sig) promoted improved performance on live venipuncture relative to control, differences slightly favoured (+) PP (sig different)
• repeated MI sessions might have more effect (only one in study) |
1.4.7 Summary of Commentaries

A scoping review is meant to be comprehensive (Arksey & O’Malley, 2005), thus commentaries were included to examine discussions of mental imagery in medical education. There were a total of 13 articles categorized as commentaries. The summary of articles that involved commentaries can be found in Table 3. Articles that were categorized under commentaries encompassed personal views, letters, editorial commentaries and opinions, commentaries, teaching tips, conference commentaries and reply to commentaries. The articles that discussed a method of mental imagery delivery included detailed imagery scripts, self-talk, relaxation, goal setting, high-fidelity computer-aided simulations, and mental imagery done in combination with physical practice [Articles 26, 28, 29, 30, 31, 32, 33]. Some commentaries also recommended that methods of imagery delivery should include more detailed scripts (Article 28); sessions that are controlled, structured and systematic (Article 29); simulations that mimic the task (Article 30), sessions that include details of the surgery including problem resolution (Article 31); sessions that are close in timing with physical practice sessions (Article 32); and prior task familiarization with the component parts of the task broken down with visual cues (Article 34).

The articles in the commentary category included three that mentioned a mental imagery ability component [Articles 28, 36 and 37]. Article 28 described how crucial it was for studies to include a measure of mental imagery in order to determine the quality of mental imagery. Articles 36 and 37 discussed the use of an adapted questionnaire that was developed, entitled the Mental Imagery Questionnaire (MIQ).

Around half of the commentaries suggested the use of mental imagery to prepare for clinical cases in some form [Articles 26, 27, 31, 32, 34, 35, 36]. Mental imagery was suggested to help
improve judgment and decision making skills (Article 26), as well as accelerating the learning curve for new trainees [Articles 26 and 31]. There were two commentaries, however, that cautioned the use of mental imagery either because it was inappropriate for the discussed task or the method of mental imagery that was used [Articles 28, 33]. Finally, there were four studies that made suggestions on how to improve the incorporation of mental imagery into medical education [Articles 29, 30, 37, 38]. It was suggested that medical education should look at the techniques applied in sports (Article 29), the supporting role of virtual reality simulators (Article 30), the role of imagery ability control through the use of questionnaires (Article 37) and the level of experience and affinity for virtual reality training of each participant (Article 38).
Table 4. Thematic analysis summary of commentaries

<table>
<thead>
<tr>
<th>First author</th>
<th>Clinical domain</th>
<th>Skill</th>
<th>Key findings</th>
</tr>
</thead>
</table>
| 26) Arora, S. | Surgery         | Surgery | • Randomized controlled trials have shown improvements in performance as well as reduction in stress and performance anxiety in practicing physicians and med students  
• routine use of MI could be incorporated into everyday clinical setting to prepare for cases (before task)  
• could also be helpful in judgment and decision making  
• MI could be used as an adjunct to physical or simulation based training in all specialties, may help accelerate learning curve, hinder skills decay and maximize valuable resources  
• incorporation of MI early could teach trainees how to maximize its benefits, improve acquisition and retention of skills and minimize deterioration of performance under stress  |
<p>| 27) Yardley, IE. | Surgery     | Surgery | • should allow for the mental preparation needed for elite performance before operation                                                      |</p>
<table>
<thead>
<tr>
<th>No.</th>
<th>Author(s)</th>
<th>Field</th>
<th>Subfield</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>28)</td>
<td>Moppet, I.</td>
<td>Anesthesia</td>
<td>Crisis Resource Management</td>
<td>• further studies required to test MI in anesthesia and other domains with focus on cognitive and behavioral skills</td>
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<tr>
<td></td>
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<td>• MI may be an inappropriate intervention for crisis management</td>
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<td></td>
<td>• also need to look at the appropriateness of MI for novices</td>
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<tr>
<td>29)</td>
<td>Gibney, EJ</td>
<td>Surgery</td>
<td>Surgery in general</td>
<td>• psychological techniques applied in sport could be helpful to look at for surgical training</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>• there are many similarities between sport and surgery, to acquire surgical skills requires lifelong acquisition of incremental skill enhancement through practice, experience and structured education, this is where sports psychological methods could help</td>
</tr>
<tr>
<td>30)</td>
<td>Mukherjee, S.</td>
<td>Surgery</td>
<td>Laparoscopic surgery</td>
<td>• supporting the role of VR simulators in surgical education</td>
</tr>
<tr>
<td>31)</td>
<td>Matsuda, T.</td>
<td>Surgery</td>
<td>Surgery</td>
<td>• need to prepare detailed MI scripts for all urologic laparoscopy surgeries to facilitate urologic laparoscopy trainees</td>
</tr>
<tr>
<td>32)</td>
<td>Caughey, AB.</td>
<td>Surgery</td>
<td>Surgery</td>
<td>• MI should be introduced but it cannot replace actual surgery, need to ensure trainees have adequate volume to achieve mastery of wide range of surgical skills</td>
</tr>
<tr>
<td>33)</td>
<td>Aggarwal, R.</td>
<td>Surgery</td>
<td>Surgery</td>
<td>• mental practice is broader domain of mental preparation, not everything constitutes as mental practice</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>• have to be careful when improvement shown in MI group, could just be due to increased motivation</td>
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</tr>
<tr>
<td>34</td>
<td>Rodriguez, L.</td>
<td>Nursing</td>
<td>Nursing skills</td>
<td>MI effective at many levels of skill learning, students should be given time to perform the skill, and should learn skill through observation first</td>
</tr>
<tr>
<td>35</td>
<td>Leung, EYL.</td>
<td>Surgery</td>
<td>Surgery</td>
<td>video MI recordings with or without scripts should be considered, should be standardized somehow</td>
</tr>
</tbody>
</table>
| 36 | Geoffrion, R. | Surgery - Obstetricians | vaginal hysterectomy | MIQ partially validated, not ready for widespread use, no pass/fail scores established  
- MI may not benefit novice  
- ongoing practice of MI may improve surgical performance as it improves self confidence and stress |
| 37 | Sevdalis, N. | Surgery - Obstetricians | vaginal hysterectomy | relationship between MI training and skilled performance is moderated by: imagery ability and imagery script compliance, MIQ could be used to control for imagery ability |
| 38 | Immenroth, M. | Surgery | Surgery | 2 most important issues of MI include level of experience and affinity to VR training, MI should be useful for novices and intermediates as well as advanced surgeons  
- novices could benefit because this kind of psychological rehearsal leads to improvement of cognitive tasks  
- even with VR studies, can't explain the extent surgeons who are educated with simulator mimic the internal observative an ideomotoric MI phases |
1.4.8 Summary of Review Articles

The articles in the review category consisted of formal literature reviews as well as informal reviews and discussions. The summary of articles in the review category can be found in Table 4. All eight articles discussed some method of mental imagery delivery including audio files, relaxation, prior learning, reflection, problem solving, procedure write ups, the use of hand movements, observation, the creation of context rich images and detailed scripts with cues.

There were three articles that included a mental imagery ability component [Studies 39, 42, 44]. Studies 39 and 42 discussed the need to include a measure or control of the variance in imagery ability within each individual. Study 44 considered an individual’s internal representation of objects as well as their ability to represent mentally in a three dimensional situation.

Mental imagery was discussed as a method to reduce the anxiety and stress associated with the procedure in two of the studies [Studies 39, 45]. There were two studies that emphasized the need to define the best regimen for mental imagery training sessions [Studies 40, 42]. Finally, studies 41 and 46 called for the need for more mental imagery research in the fields of surgery and more specifically, neurosurgery.
Table 5. Thematic analysis summary of reviews

<table>
<thead>
<tr>
<th>First author</th>
<th>Skill</th>
<th>Inclusion of physical practice</th>
<th>Study population</th>
<th>Key findings</th>
</tr>
</thead>
</table>
| 39) Boehm, LB. | Nursing skills | N/A                             | Student nurses and experienced nurses  | - MI was primarily used to reduce anxiety surrounding acquisition of new psychomotor skill  
- confounding variables such as: variance in vividness of ability across individuals needs to be measured or controlled and variance in personal preference (auditory, visual, tactile, or olfactory images) and variance in duration and frequency of intervention and amount of interest sustained by participant throughout sequence of sessions  
- in studies, individual ability to visualize cited as a strong indicator of efficacy of using guided imagery to improve skill performance  
- new graduate registered nurses transition is stressful, guided imagery and other techniques may reduce that stress and could be introduced earlier in career  
- also can be used for nursing students and experience nurses who require updating skills or nurses taking on new roles |
| 40) Hall, JC. | Surgery     | N/A                             | Surgeons                               | - there is a need to define best regimens to follow after workshops for maximizing skill retention and advancement |
• MI can be used in early stages of learning, diminishing the learning curve for a new procedure, transferring skills for established techniques, hindering the decay of skills and preoperation preparation for a complex procedure

• 3 general principles that apply to effective MI:
  o Conforms to general process of learning a motor skill (cognitive, associative, autonomous)
  o Make formal and explicit learning activates that are usually more implicit
  o Can be applied to any situation, but as automation is reached, it becomes a form of risk management (Novices: next steps, experts: key steps on selected occasions)

<table>
<thead>
<tr>
<th>Source</th>
<th>Discipline</th>
<th>Level</th>
<th>MI Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>41) Lang, N.</td>
<td>Surgery</td>
<td>N/A</td>
<td>Surgeons</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• MI may provide some training efficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• most surgical faculty are aware of MI but have not studied the role of MI extensively</td>
</tr>
<tr>
<td>42) Schuster, C.</td>
<td>Varied</td>
<td>Some</td>
<td>Nursing, Surgeons, Medical students, Chiropractic, dentistry, undergrad</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• found 9 interventions in education (mostly medicine), 7 had absolute change in improvement, 1 not stated and 1 decreased</td>
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<tr>
<td></td>
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<td></td>
<td>• 3 MITS elements showed both categories: position of participants during MITS (task specific and non task specific), instruction mode (life and pre-recorded) and perspective (internal and external)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• MI content focused on cognitive related task activities, MI mode not reported</td>
</tr>
</tbody>
</table>
| | | | • MI intervention duration and total MI time were < half of
those in average (+) MI interventions, but MITS duration was twice as long as in the average (+) MITS

- MITS adaptations were necessary to direct each step of surgical procedures
- important to evaluate MI ability of participants to determine whether they are able to perform MI, and it might change over intervention period
- assessments of MI ability used in 1 med education study with (+) results and in 1 study with no change or negative results

<table>
<thead>
<tr>
<th>Study</th>
<th>Specialization</th>
<th>MI Participation</th>
<th>MI Rank</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rogers, RG.</td>
<td>Surgery</td>
<td>Yes, MI done as preoperative preparation for each case</td>
<td>Surgeons</td>
<td>of 30 residents who participated in sessions, all have ranked MI as one of the most valuable parts of training during the 8 week rotation</td>
</tr>
<tr>
<td>DesCoteaux, JG.</td>
<td>Surgery</td>
<td>Yes, during which allows learner to be aware of the many other stimuli that reduce the amount of attention that can be devoted to imagery. Observation and practice are complementary ways of learning surgical technical</td>
<td>Surgeons</td>
<td>score on surgical skills correlated sig with complex visuospatial organization</td>
</tr>
</tbody>
</table>

- deterioration of pure motor ability with age, presumably compensated for by experience including mental abilities such as visuospatial representation of operative site and well established executive routines
- if executive routine is mastered, quality of performance
<table>
<thead>
<tr>
<th>Reference</th>
<th>Topic</th>
<th>Description</th>
<th>Relevance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contrades, S.</td>
<td>Cardiac, respiratory and neurological assessment, vaginal examination, foley catheterization, and nasogastric intubation</td>
<td>Yes, in skills lab</td>
<td>Nursing students</td>
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<tr>
<td>Marcus, H.</td>
<td>Neurosurgery</td>
<td>Should be included</td>
<td>Neurosurgeons</td>
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<tr>
<td></td>
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<td>• important to change one's practice in different situations</td>
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<td>• variations on mental thought process must also be practiced physically so surgeon can modify procedure for surgeon- or patient-specific needs</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• evidence in both surgical and nonsurgical disciplines suggest MI may be cost-effective and safe way of training novice surgeons</td>
</tr>
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<td></td>
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<td></td>
<td>• to date, no studies in MI have been conducted in neurosurgery, but outcomes of studies in laparoscopic surgery are encouraging</td>
</tr>
</tbody>
</table>
1.4.9 Summary of Conference Abstracts

There were two published conference abstracts, both presented at the 20th International Congress of the European Association for Endoscopic Surgery (EAES). The summary of the conference abstracts can be found in Table 5. Both studies were randomized controlled trials and had similar results. Significant improvements in specific technical skills after mental imagery were found for both studies. These abstracts have not been published in full and have not been captured elsewhere in the scoping review.

Table 6. Thematic analysis summary of conference abstracts

Acronyms: MI - mental imagery

<table>
<thead>
<tr>
<th>First author</th>
<th>Skill</th>
<th>Physical practice involved</th>
<th>Study population</th>
<th>N</th>
<th>Key findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>47) Sarker, SK.</td>
<td>laparoscopic right hemicolecotomy</td>
<td>Yes before and after MI</td>
<td>Junior surgeons</td>
<td>10</td>
<td>• significant improvement in specific technical skills in both groups with MI</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• no improvement in generic skills</td>
</tr>
<tr>
<td>48) Sarker, SK.</td>
<td>laparoscopic appendectomy</td>
<td>Yes before and after MI</td>
<td>Junior surgeons</td>
<td>14</td>
<td>• significant improvement in specific technical skills in both groups with MI, specifically the quality of operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• no improvement in generic skills</td>
</tr>
</tbody>
</table>
1.4.10 Overall Trends Found in the Literature

In order to make informed conclusions on mental imagery training, it is important to first understand the characteristics of mental imagery. By examining the characteristics of studies that showed skill improvement, a better understanding can be gained of the characteristics that make mental imagery effective. Thus, a scoping review was completed to gain a better perspective of the variety of research being done on mental imagery as well as some of the main findings in the context of health professions education. A second purpose of the scoping review was to look at the discussion and inclusion of mental imagery ability within the literature. Mental imagery research is important as there is a potential cost savings for health professions educators as well as increased opportunities for practice. This is especially evident in clinical settings when physical practice may not be available (Schmidt & Lee, 2011). Access to patients and simulation labs are limited to trainees so if mental imagery can be shown to be equivalent or better compared to physical practice or to no practice, the opportunities to practice can be significantly increased.

There have been previous reviews, which looked at imagery training in five different disciplines and specifically in nursing (Schuster et al., 2011; Boehm & Tse, 2013). In the systematic literature review by Schuster et al. (2011), the focus of the review was on the mental imagery training session. Although the mental imagery training session is an important factor to consider when designing training programs, the purpose of this scoping review was to look at other characteristics in addition to the method of delivery. The review by Boehm and Tse, (2013) focused primarily on newly graduated registered nurses. The current scoping review, however, investigated the medical education trends across all health care fields. By looking at the literature in a broader sense, the extent and nature of research in mental imagery as well as any missing
gaps could be identified. From this information, investigators then could determine the value of performing full systematic reviews. A summary of the research findings could also help direct future research by informing investigators of the necessary factors to consider when conducting mental imagery research. The results from this scoping review suggest future research should investigate the factors which affect the efficiency of mental imagery training including an individual’s imagery ability.

The results of the scoping review show a considerable amount of research published in the field of mental imagery within medical education. This is especially evident within the past seven years, where we see a majority of the articles being published. Looking at the distribution of research across the world, it is evident that there is a widespread dissemination of research activity. A majority of the research originated from the United Kingdom and the United States of America, with Canada and Germany just behind. Mental imagery in medical education has generated a number of research projects with half of the total articles comprising of experimental research studies. The second largest category of articles included commentaries published by different journals.

Within the category of experimental research studies just over half of the total studies reported an improvement in skill performance after mental imagery as compared to a control or an alternative form of practice. This was also seen in the commentaries, with half of the articles suggesting the use of mental imagery to prepare for clinical cases in some form. The two conference abstracts also reported significant improvements in technical skills after mental imagery. Another nine studies reported mental imagery practice being equivalent to physical practice, the control condition or an alternative form of practice. A number of studies described the use of the mental imagery technique to improve a trainee’s confidence, reduce stress and
anxiety, improve judgment and decision-making skills, and increase readiness for the task. With the variation in results seen in the success rate of mental imagery, it is hard to come to a conclusion on the effectiveness of mental imagery. This suggests that there may be a number of factors that are influencing the efficiency of mental imagery training. More research needs to be done to determine how these factors influence the efficiency of mental imagery training as well as how they interact with each other. The method of mental imagery delivery, the clinical domain being examined, the skill involved, the comparison of mental imagery to physical practice, the study population and the number of participants were all factors that varied in the included literature. These factors should be considered in future research as it is still unclear how these factors interact and influence mental imagery together or separately.

Another component that may be important to consider is an individual’s ability to image. Within the total number of articles, 20 considered an individual’s imagery ability. Individuals with a higher ability to image were shown to have a better quality of performance in four studies. It was also shown that mental imagery ability could be improved through mental imagery practice. Different imagery ability definitions were used including the vividness of images, the ability to control images, visual imagery, kinesthetic imagery, cognitive imagery, the affinity for virtual reality simulators and the ability to rotate different objects in the mind. The studies that included measures of mental imagery ability used many different forms of measurement. The methods of measurement included validated questionnaires, informal questionnaires and mental rotation tasks and tests. Many studies used questionnaires from the sports and psychology literature (Bucher, 1993; Klimek, 1995; Sanders, Sadoski, Walsum, Bramson, Wiprud & Fossum, 2008; Stransky, Wilcox & Dubrowski, 2010; Jungmann et al., 2011). The selection of questionnaires and assessments of mental imagery ability in these studies may not be the best indicators of mental imagery ability in a health professions context. Most of the assessments used, looked at
the imagery of general situations and may have been used beyond their intended scope. Paivio (1985) has stated the importance of selecting a measurement that is directly related to the specific task being examined. Hall et al. (1998) and Williams and Cumming (2011) described a similar need for specific instruments in the sports literature. An appropriate method of assessing an individual’s ability to image clinical skills is needed in order to study imagery ability in a health professions context.

Using the measurement of imagery ability, researchers will be able to investigate the impact of mental imagery practice on an individual’s ability to image. In the review by Schuster et al. (2011), the authors state the importance of evaluating mental imagery ability to determine an individual’s capability of performing the imagery task as well as to measure any change in ability over the intervention period. Imagery ability can be used as an indicator of how successful a mental imagery intervention is, the adherence to the intervention, and how an individual’s ability changes with time. The measure of imagery ability can also be used to compare individuals in different levels of training. This is further reiterated by the number of experimental studies that did include a measure of mental imagery ability. Therefore, the effectiveness of mental imagery practice may be determined by an individual’s ability to engage in the practice session. Identifying an individual’s imagery ability may help tailor teaching techniques to better suit the needs of each individual. An individual with difficulty controlling images may not benefit from techniques to improve the vividness or the realism of the images. These individuals may need help with practicing image manipulation. Individuals who have difficulty with simply forming images may benefit from techniques on how to form images of general scenes and situations before learning to control the images. By considering the individual differences in ability, investigators will gain a better appreciation for the different training needs of individuals to better tailor mental imagery training sessions.
1.4.11 Limitations of the Scoping Review

This scoping study was conducted according to the methodological framework developed by Arksey and O’Malley (2005). Although the methodology was followed as outlined, there were a number of limitations in the current study. A number of articles that were not in English or were not found were excluded from the final analysis. Secondly, only one rater reviewed each unique abstract. In order to reduce reviewer bias, both raters agreed upon a set inclusion and exclusion criteria to select each abstract. Furthermore, the second rater was used when any abstract was determined to be unclear. These steps were taken in order to reduce any potential bias from using one rater for the initial review.

Another limitation of this study was the search strategy used. The search strategy consisted of the use of literature databases and did not include any non peer-reviewed or non-indexed literature. Although, this may have resulted in the exclusion of relevant articles, the breadth of databases included in the final search should have reduced the impact of this limitation.

The inclusion of review articles and commentaries may have skewed the numerical summary and thematic analysis because some of these articles included the experimental studies already included in the scoping review. However, the purpose of this scoping review was to look at the breadth of contributions and thus a comprehensive approach was used.

1.5 Summary

A literature review in the form of a scoping review was conducted, which summarized the extent, range and research activity on the use of mental imagery in medical education. This
review enhanced the understanding of mental imagery ability by highlighting the results of studies which included an imagery ability component. Interest in the concept of mental imagery has been increasing throughout the years with a majority of the articles being published in the last seven years. The highest numbers of articles were published within the last year. Mental imagery is increasingly recognized as a valuable tool to use when teaching new health care trainees. It has been reported to be used in the training of both technical and non-technical skills.

Alongside mental imagery, the concept of mental imagery ability has also been investigated in just under half of the included articles. The significance of an individual’s imagery ability cannot be overlooked when using mental imagery. Imagery ability may determine the effectiveness of mental imagery practice. By determining an individual’s ability, practice sessions can then be individualized according to a trainee’s specific needs. Measures of mental imagery ability need to be developed and used to determine an individual’s ability. Several different measures of imagery ability were used in the reported studies. However, many of these measures were adapted from the psychology literature and may have been used out of context. To accurately measure imagery ability in the context of medical education appropriate measures need to be developed. The results of this scoping review will hopefully encourage further research and development in mental imagery, specifically its use in medical education. As previously mentioned, mental imagery research in medical education is important as there may be a significant opportunity to reduce costs and resources.
Chapter 2
General Aims and Hypotheses

2.0 The Validation Process

When developing a new instrument, there are many aspects of validity and reliability to consider. Construct validity refers to the degree an instrument measures what it intends to measure and consists of different types of validity. The correlation of the measures of a new instrument to similar instruments previously developed is known as convergent validity. A measure of a new instrument that is uncorrelated to an instrument that is not similar is known as discriminate validity (Trochim, 2000). Criterion validity is the ability of an instrument to predict performance on a measure; that is the instruments’ ability to differentiate two groups that are different (Schuwirth et al., 2011). The reliability of an instrument should also be considered. Reliability, the repeatability of measures, also consists of different types of reliability. Test-retest reliability is the consistency of a measure at two different times. Internal consistency measures the consistency of results across items of an instrument (Trochim, 2000). These aspects of validity and reliability are important to consider when developing a new instrument.

The validity process of an instrument, however, should not be viewed as a static process but an ongoing one, which involves the collection of data, analysis and refinement of the instrument (Schuwirth et al., 2011). As recommended by Schuwirth et al. (2011) instruments are never completely validated, but an ongoing process of collecting evidence in support of the arguments for validity. The recommendation also states that an instrument is never valid; instead it is always valid for something. This aspect of validity is also an important consideration when developing a new instrument.
2.1 Aims and Hypotheses

The general aim of this thesis project was to gain a better understanding of the use of mental imagery in health profession education as well as the consideration of mental imagery ability in the literature. In chapter one, this was done through a review of the current literature.

In chapter three of the thesis, using information from the review, a new instrument was developed to assess the ability to form clinical images as well as the perspective of imagery used. The development of the CS-IAQ offers an opportunity to increase the knowledge of imagery ability in health professions education. As mentioned in the previous section, the process of validation is ongoing (Schuwirth et al., 2011), thus the purpose of chapter three was to develop an initial version of the questionnaire and to begin the process of validation. This was done by examining the difference in novice and expert answers to items on the questionnaire.

In phase one of chapter three, items from the Sports Imagery Questionnaire (Hall et al., 1998), the Sports Imagery Ability Questionnaire (Williams & Cummings, 2011) and the adapted questionnaire from Arora et al.’s (2010) study were used to develop the initial content for the CS-IAQ. The initial collated list of items was distributed to a group of experts from kinesiology/sports psychology and a group of physicians from different disciplines. The experts rated each item in terms of relevance and wording. The items were then tested for content validity (Lynn, 1986) and subsequently reduced in length.

In phase two of chapter three, the most relevant items were identified and the questionnaire was further reduced in length. The second iteration of the questionnaire was distributed to a group of participants from various backgrounds and levels of training. Participants were asked to go through each scenario thoroughly and to image each question item before assigning a rating.
depending on how easy it was for them to image. A principal components analysis was used to reduce the large number of items into a smaller number of clusters. Items were discarded depending on whether they contributed to the unique predictive ability of the questionnaire. An initial assessment of construct validity was completed by assessing the questionnaires ability to differentiate between the higher skilled experts and the more novice participants. Each cluster was then interpreted and assigned a name depending on the purpose it served. This was done using the concepts from Paivio’s (1985) categorization of mental imagery and from the interpretation of factors from previous studies. At the conclusion of chapter three, a questionnaire was developed and the process of validation was initiated, that helped assess an individual’s ability to form specific clinical images as well as the perspective of imagery used. The opportunities for future research were also discussed.

The questionnaire is hypothesized to meet some initial criteria for construct validity if it is able to differentiate between higher skilled experts and the more novice participants. If the questionnaire is unable to differentiate between higher skilled experts and the more novice participants then it does meet the initial criteria for construct validity. This initial criterion for construct validity was chosen as the first step in the process of validation due to the dynamic nature of the process.
Chapter 3
Development of the Clinical Skills Imagery Ability Questionnaire

3.0 Introduction

The scoping review of the use of mental imagery in health professions education conducted in Chapter 1 revealed the growing presence of research in the field. Mental imagery is the cognitive practice of a motor task without the actual physical performance of the movement involved with the task (Driskell, Copper, & Moran, 1994). Having shown success in other fields (Rogers, 2006; Hall et al., 2009), this type of practice may be a valuable tool for health professions educators to use as an adjunct to physical practice when teaching clinical skills. The usefulness of mental imagery as an adjunct to physical practice may be particularly evident for surgical procedures that trainees have limited opportunities to practice due to issues related to patient safety or case complexity. The results from the studies found in the scoping review showed a variation in the success of mental imagery and it was difficult to make a conclusion on the effectiveness of mental imagery. This could have been due to the different characteristics of mental imagery that need to be considered when conducting research in this field. Some of the characteristics highlighted include the method of mental imagery delivery, the form of mental imagery, the skill involved, the comparison of mental imagery to physical practice, and an individual’s ability to image. The type of mental imagery and an individual’s ability to image will be examined further in this study.

3.0.1 The characteristics of mental imagery

When examining mental imagery, it is important to consider the type and form of mental imagery. The type of mental imagery refers to the perspective of the images formed. Images
formed and perceived from the perspective of an external observer, such as a spectator observing a movement is referred to as “external” imagery. Images formed and perceived from the perspective within the body performing the movement is referred to as “internal” imagery and also involves experiencing the kinesthetic feel of the movement itself (Mahoney & Avener, 1977; Jeannerod, 1999). Mental imagery can also be distinguished by the purpose it serves. Paivio (1985), categorized mental imagery into four categories: motivational-specific, motivational-general, cognitive-specific and cognitive-general. The motivational-specific purpose of imagery refers to the use of imagery for the arousal of responses related to the specific goal or goal-oriented behaviours. Motivational-general imagery refers to the arousal of emotions in general situations; this can include both positive and negative emotional responses. On the cognitive side, cognitive-specific imagery refers to the imagery of the performance of the certain skill whereas cognitive-general imagery refers to the imagery of the overall strategy while performing a skill (Paivio, 1985; Hall, Mack, Paivio & Hausenblas, 1998).

### 3.0.2 Mental Imagery Ability

Another significant characteristic of mental imagery that should be considered is that of imagery ability. Mental imagery ability can refer to how well images are formed in one’s mind, how vivid and realistic the images formed are and how well the images can be controlled (Roberts, Callow, Hardy, Markland, & Bringer, 2008). The differences in an individual’s ability to image may determine the effectiveness of mental imagery. Imagery techniques may be of little use to individuals with low imagery ability, whereas individuals with high imagery ability may find imagery techniques to be very effective (Hall, Buckolz & Fishburne, 1992). Arora et al. (2010) developed a mental imagery script, which consisted of a cognitive “walk through” of performing a laparoscopic cholecystectomy, and compared the imagery ability of surgeons of different levels.
before and after completing the script. It was found that the imagery ability of the surgeons improved after the mental imagery practice with novice surgeons showing a greater improvement. If imagery ability is something that can be taught and improved as shown in the study by Arora et al. (2010), then there is a potential significance in identifying the interaction between imagery ability and the use of imagery.

Individual differences in imagery ability may also be important for identifying the most effective training strategies. Determining an individual’s imagery ability can help tailor coaching techniques depending on which area the individual has difficulty with. Strategies can be taught on how to effectively bring images to one’s mind if the area of difficulty is in forming images, whereas difficulty with other aspects of imagery such as manipulating images calls for different coaching techniques.

In order to distinguish individual differences in their ability to image there has to be a method of assessing imagery ability. A method that has been used by researchers to study imagery has been in the form of questionnaires. Marks (1973) developed the Vividness of Visual Imagery Questionnaire (VVIQ) to assess the vividness of an individuals’ imagery. The Movement Imagery Questionnaire (MIQ; Hall, Pongrac, & Buckolz, 1985) was developed to assess the quality of images formed for physical movements. The Sport Imagery Questionnaire (SIQ) was developed to assess the frequency use of mental imagery in sports (Hall et al., 1998). More recently the Sport Imagery Ability Questionnaire (SIAQ) was developed to assess imagery ability in sports (Williams & Cumming, 2011). Many of the earlier questionnaires that were developed looked at imagery of certain scenes and situations (VVIQ) or general physical movements (MIQ). However, for studying movements in a specific context, these questionnaires have been used beyond their intended scope (Williams & Cumming, 2011).
There may be a need to develop an imagery questionnaire that is specific to the performance of clinical skills in a health professions context. It may not be adequate to use questionnaires that were developed in a sporting context as these questionnaires do not directly address the movements involved in a medical context. In the study described earlier by Arora et al. (2010), which found both novice and expert surgeon’s ability to image enhanced after imagery practice, an adapted version of a mental imagery questionnaire was used to assess the quality of the mental imagery experience. In their study, novice and expert participants were introduced to the concept of mental imagery before completing the questionnaire. After completion of the questionnaire, participants then went on to complete a mental imagery protocol consisting of learning a mental imagery script and rehearsal of a laparoscopic cholecystectomy using a talk-out loud technique. The questionnaire was then completed again after the mental imagery protocol. The selection of the questionnaire that was used in the study may not be the most ideal questionnaire to assess imagery ability because only three out of the eight items assessed the ease of visually and kinesthetically imaging the script and the vividness and clarity of the image.

In order to study imagery ability in a medical context, it is important to find a method of assessing both an individual’s imagery ability as well as the individual’s ability to image within the specific context. Paivio (1985) points out that “there is no single best measure of imagery ability because imagery skills are at least as varied as verbal skills, and the trick is to find one that is most directly related to the specific task under consideration” (p 27s). This point is further reiterated by Hall et al. (1998) and Williams and Cumming (2011), who suggests the need to develop instruments to measure imagery ability specific to an individual’s experiences in relation to sport experiences. The development of the SIQ by Hall et al. (1998) was used to look at imagery used specifically by athletes in sport related contexts. The SIAQ was developed to
specifically look at an athlete’s “ability” to generate images, compared to why they are imaging certain images (Williams & Cumming, 2011).

Thus, the purpose of the second phase of the thesis was to develop and start the validation process of a questionnaire specific to imagery used during the performance of clinical skills, the Clinical Skills Imagery ability Questionnaire (CS-IAQ). In the present study, the performance of clinical skills refers to any motor skills performed as part of a medical procedure. These can include and are not limited to surgical procedures, suturing, performing various patient exams, intubations and injections. The CS-IAQ will assess the self-reported ability to form specific clinical images in a medical context. Such a study will help us understand individual differences in imagery ability, which may be important for identifying effective teaching strategies. Mental imagery is an inexpensive and safe method of learning that has been shown to be useful in the sports literature (Rogers, 2006; Hall et al., 2009). However, this method of learning may not be beneficial to those with low or different imagery abilities, if not taught properly. Once those individuals have been identified as having low or a different imagery ability, different teaching strategies can be used to help them take advantage of this method of practice.

3.1 Methods

3.1.1 Phase 1 – Initial Item Generation

The first phase of this project involved developing a list of items for the new questionnaire. Items from the SIQ (30 items total) (Hall et al., 1998), SIAQ (16 items total) (Williams & Cummings, 2011) and the adapted questionnaire from Arora et al.’s (8 items total) (2010) study were collated and used as a starting point. These questionnaires were chosen as a starting point because they were developed to examine situations and movements in a specific context, similar
to the CS-IAQ. The SIQ and the SIAQ may not be appropriate when assessing movements specific to medical education, however, they are a good starting point since they still involve the assessment of movements. The fifty-four items were refined and reworded to fit within the context of medicine as suggested by Lynn (1986) in the third step of the developmental stage for the determination and quantification of content validity. This step involved rewording and refining the items into a usable form (Lynn, 1986). Two of the investigators analyzed each item together to determine the most suitable terms to fit in a medical context. For example, one item from the SIQ “I image each section of an event/game (e.g., offence vs. defence, fast vs. slow)” was changed to “I image each section of a procedure (e.g., approaching the patient, setting up the equipment, performing the procedure).” The questionnaire was then distributed via SurveyMonkey (http://www.surveymonkey.com) to seven experts with a kinesiology/sport psychology background and 15 physicians from different disciplines including various surgical specialties, gastroenterology, respirology, internal medicine, anesthesiology and family medicine. For the initial pool of 22 experts, faculty members within the appropriate departments at the University of Toronto were recruited. Experts were invited to participate who were representative from the domain of kinesiology/sport psychology and from the appropriate clinical domains. The concept of mental imagery and its role in learning clinical skills was borrowed from the domain of sports. Thus, the selection of experts from the domain of kinesiology/sport psychology was used to ensure the appropriate application of this concept. The names of these individuals were obtained from a public domain website listing all faculty members within the appropriate departments at the University of Toronto as well as their faculty appointments. The selection criteria for the expert panel were faculty members in leadership positions (e.g. faculty members with associate professor faculty appointments, clinician scientists, known experts in the field and department chairs). Identified potential participants
were initially contacted via email by the investigator. The email contained a synopsis of the study purposes and a description of the proposed methodology. The email also contained contact information, which prospective participants could use if they had any questions regarding the proposed study.

It was made very clear to all participants that their participation in the proposed study was completely voluntary. Phase 1 of the project received approval from the Health Sciences Research Ethics Board at the University of Toronto and participants provided voluntary informed consent before participating. The inclusion of more than 10 experts was determined to be sufficient to establish the content validity of the questionnaire according to Lynn (1986). In order to establish content validity beyond the 0.05 level of significance, 8 out of 10 experts need to agree on an item. The inclusion of more than five experts allows for a modest amount of disagreement (Lynn, 1986; Polit, Beck, & Owen, 2007). The inclusion of more than 10 experts also fit the feasibility of the study. A definition of mental imagery as well as the scope of the study was given to the experts. The experts were then asked to read through each item and assess the content in terms of relevance in reflecting imagery ability in a medical context on a 4 point rating scale (1= not relevant; 2= unable to assess relevance without item revision or item is in need of such revision that it would no longer be relevant; 3= relevant but needs minor alteration; 4= very relevant and succinct) (Lynn, 1986). The experts were also given the opportunity to suggest revisions to items as well as recommend any new relevant items they felt should be included in the questionnaire. A full list of the items that were distributed to each expert can be found in Table 1.
**Table 1.** The final list of items distributed to each expert

<table>
<thead>
<tr>
<th>1.</th>
<th>I image the atmosphere of successfully performing a procedure (e.g., the excitement that follows)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>I image myself giving 100% to the procedure.</td>
</tr>
<tr>
<td>3.</td>
<td>I image both the positive and negative emotions I feel while doing the procedure.</td>
</tr>
<tr>
<td>4.</td>
<td>I image my skills improving.</td>
</tr>
<tr>
<td>5.</td>
<td>I image alternative strategies in case my plan/strategy fails.</td>
</tr>
<tr>
<td>6.</td>
<td>I image myself handling the arousal and excitement associated with my procedure.</td>
</tr>
<tr>
<td>7.</td>
<td>I image myself appearing self-confident in front of my patients.</td>
</tr>
<tr>
<td>8.</td>
<td>I image myself appearing self-confident in front of my peers.</td>
</tr>
<tr>
<td>10.</td>
<td>I image my peers making comments on my good performance.</td>
</tr>
<tr>
<td>11.</td>
<td>I image each section of a procedure (e.g., approaching the patient, setting up the equipment, performing the procedure).</td>
</tr>
<tr>
<td>12.</td>
<td>I image myself being in control during difficult situations.</td>
</tr>
<tr>
<td>13.</td>
<td>I can change an image of a skill in my mind.</td>
</tr>
<tr>
<td>14.</td>
<td>I image the stress and anxiety associated with the procedure.</td>
</tr>
<tr>
<td>15.</td>
<td>I image executing entire procedures/plans/strategies just the way I want them to happen.</td>
</tr>
<tr>
<td>16.</td>
<td>I image myself being mentally tough.</td>
</tr>
<tr>
<td>17.</td>
<td>I image the positive feelings associated with performing a procedure.</td>
</tr>
<tr>
<td>18.</td>
<td>I image myself to be focused during a challenging situation.</td>
</tr>
<tr>
<td>19.</td>
<td>When learning a new skill, I imagine myself performing it perfectly.</td>
</tr>
<tr>
<td>20.</td>
<td>I imagine myself successfully following my plan (the steps to take).</td>
</tr>
<tr>
<td>21.</td>
<td>I image myself working successfully through tough situations (e.g., a complication, patient...</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>22.</td>
<td>I image giving 100% effort even when things are not going well.</td>
</tr>
<tr>
<td>23.</td>
<td>I image refining a particular skill.</td>
</tr>
<tr>
<td>24.</td>
<td>I image the anticipation and excitement associated with the procedure</td>
</tr>
<tr>
<td>25.</td>
<td>I image improving a particular skill.</td>
</tr>
<tr>
<td>26.</td>
<td>I image staying positive after a setback.</td>
</tr>
<tr>
<td>27.</td>
<td>I image creating a new strategy/plan.</td>
</tr>
<tr>
<td>28.</td>
<td>I image myself succeeding.</td>
</tr>
<tr>
<td>29.</td>
<td>I image myself remaining confident in a difficult situation.</td>
</tr>
<tr>
<td>30.</td>
<td>I make up new plans for the execution of movements/strategies for completing the procedure in my head.</td>
</tr>
<tr>
<td>31.</td>
<td>I can consistently control the image of a procedural skill.</td>
</tr>
<tr>
<td>32.</td>
<td>When imaging a particular skill, I consistently perform it perfectly in my mind.</td>
</tr>
<tr>
<td>33.</td>
<td>When I image myself performing, I feel myself getting psyched up.</td>
</tr>
<tr>
<td>34.</td>
<td>I can easily make corrections to procedural skills in my head.</td>
</tr>
<tr>
<td>35.</td>
<td>Before attempting a particular skill, I can easily imagine myself performing it perfectly.</td>
</tr>
<tr>
<td>36.</td>
<td>When I image myself performing a procedure, I feel anxious.</td>
</tr>
<tr>
<td>37.</td>
<td>I can easily ‘see’ myself performing the procedure.</td>
</tr>
<tr>
<td>38.</td>
<td>The images of the procedure in my mind are vivid and clear.</td>
</tr>
<tr>
<td>39.</td>
<td>I can easily ‘feel’ myself performing the procedure.</td>
</tr>
<tr>
<td>40.</td>
<td>Mental imagery is helpful in preparing myself to perform a procedure</td>
</tr>
</tbody>
</table>
| 41. | When experiencing the above images, did you generally see yourself from an **outside view** (i.e., from a 3rd person perspective, as if watching yourself perform the procedure on video tape) or from an **inside view** (i.e., from a 1st person perspective, as if you are actually inside
3.1.1.1 Phase 1 – Content Validity Index

Content validity is defined by Lynn (1986) as the determination of the relevance of items of an instrument using a two-stage judgment process. The two-stage judgment process includes:

1. The developmental stage
2. Judgment-Quantification stage

The first stage of the judgment process includes the generation and refinement of a list of items into a usable form. The second stage of the judgment process requires the agreement of a number of experts on the content validity of the items, which is accomplished by the index of content validity (CVI). The determination of the CVI is recommended as an appropriate indicator and was also selected for its ease of use and understandability (Polit, Beck, & Owen, 2007). The CVI for each item was determined by dividing the number of experts who rated the item a 3 or 4 by the total number of experts involved in the rating process. Items with CVI’s above 0.90 were determined to be valid (Lynn, 1986). Items with CVI’s below 0.90 were discarded or revised according to suggestions made by the experts. Items were also removed that were determined to be ambiguous or repetitive. A total of 13 experts completed the questionnaire from the initial pool of 22. A list of each item with the resulting CVI can be found in Table 2. Items that were kept from phase 1 are in bold.
Table 2. The list of items with the resulting CVI

<table>
<thead>
<tr>
<th>Question</th>
<th>CVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 1</td>
<td>0.77</td>
</tr>
<tr>
<td>Item 2</td>
<td>0.85</td>
</tr>
<tr>
<td><strong>Item 3</strong></td>
<td><strong>0.92</strong></td>
</tr>
<tr>
<td>Item 4</td>
<td>1.00</td>
</tr>
<tr>
<td><strong>Item 5</strong></td>
<td><strong>1.00</strong></td>
</tr>
<tr>
<td>Item 6</td>
<td>0.85</td>
</tr>
<tr>
<td><strong>Item 7</strong></td>
<td><strong>1.00</strong></td>
</tr>
<tr>
<td>Item 8</td>
<td>0.92</td>
</tr>
<tr>
<td>Item 9</td>
<td>0.92</td>
</tr>
<tr>
<td>Item 10</td>
<td>0.85</td>
</tr>
<tr>
<td><strong>Item 11</strong></td>
<td><strong>1.00</strong></td>
</tr>
<tr>
<td>Item 12</td>
<td>1.00</td>
</tr>
<tr>
<td>Item 13</td>
<td>0.77</td>
</tr>
<tr>
<td><strong>Item 14</strong></td>
<td><strong>0.92</strong></td>
</tr>
<tr>
<td><strong>Item 15</strong></td>
<td><strong>1.00</strong></td>
</tr>
<tr>
<td><strong>Item 16</strong></td>
<td><strong>1.00</strong></td>
</tr>
<tr>
<td>Item 17</td>
<td>0.92</td>
</tr>
<tr>
<td><strong>Item 18</strong></td>
<td><strong>0.92</strong></td>
</tr>
<tr>
<td><strong>Item 19</strong></td>
<td><strong>0.92</strong></td>
</tr>
<tr>
<td>Item 20</td>
<td>0.92</td>
</tr>
<tr>
<td><strong>Item 21</strong></td>
<td><strong>0.92</strong></td>
</tr>
<tr>
<td>Item 22</td>
<td>0.85</td>
</tr>
<tr>
<td>Item 23</td>
<td>1.00</td>
</tr>
<tr>
<td>Item 24</td>
<td>0.77</td>
</tr>
<tr>
<td><strong>Item 25</strong></td>
<td><strong>1.00</strong></td>
</tr>
<tr>
<td>Item 26</td>
<td>0.85</td>
</tr>
</tbody>
</table>
3.1.2 Phase 2 – Item Reduction

The selected items from Phase 1 were then used to create the final questionnaire (Figure 1) for Phase 2. This phase involved identifying only the most relevant items from the list generated in the first phase so the test could be reduced in length. Another objective of phase 2 was to test the construct validity of the questionnaire. The sample to complete the questionnaire included individuals with a range of clinical experience; it is assumed that highly experienced individuals will also be better at using imagery than individuals who are novices (Hall et al., 1998; Williams & Cumming, 2011). If the questionnaire has construct validity, the higher skilled experts should
be able to image better thus score higher on the questionnaire compared to the more novice participants. The second iteration of the questionnaire was distributed to a group of participants via SurveyMonkey (http://www.surveymonkey.com). It was made very clear to all participants that their participation in the proposed study was completely voluntary. Phase 2 of the project received approval from the Health Sciences Research Ethics Board at the University of Toronto and the Health Research Ethics Board at the Health Research Ethics Authority of Newfoundland & Labrador. Participants provided voluntary informed consent before participating. A definition of mental imagery, the scope of the study and examples of the use of mental imagery in medicine were given. Participants were then asked to image each question item with their eyes closed, and then rate how easy it was to image that scenario. For example, the participants were asked to imagine the emotions they feel while doing the procedure, then with respect to that, how easy was it for them to image that? It was suggested that the term ‘imagine’ would be an easier term for people to understand while going through the questionnaire. Ratings were made based on the 7 point Likert scale used by Williams and Cummings, (2011) in the development of the SIAQ (1-very hard to image to 7- very easy to image). A second 7 point Likert agreement scale was also used for the items that didn’t fit the ease of imaging scale (1 - strongly disagree to 7 – strongly agree).
Figure 1. The questionnaire distributed to participants in Phase 2

Development of the Clinical Skills Imagery Ability Questionnaire (CS-IAQ) – Phase 2

Age: ___

Sex: ___

Please indicate your area of "specialty":

☐ N/A – Medical student year 3
☐ N/A – Medical student year 4
☐ Surgery
☐ Internal Medicine
☐ Family Medicine
☐ Obstetrics and Gynecology
☐ Urology
☐ Emergency Medicine
☐ Critical Care Medicine
☐ Anesthesia
☐ Pediatrics
☐ Other (please specify): ___

What is your current level of training/position/title?

☐ Medical Student
☐ Resident
☐ Fellow
☐ Practicing Physician
☐ Other (please specify): ___

What year of training are you in at your current level/how long have you been in practice?

☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☐ 6
☐ 7
☐ 8
☐ 9
Which procedure/s do you perform most often?

How long have you been performing this/these procedure/s?

The main goal of this questionnaire is to understand the imagery ability of different individuals with respect to the procedures they perform most often.

For each question, please image each question scenario and then provide a rating to the best of your ability. Go through each scenario thoroughly and take your time.

For questions 1-18 please follow the ease of imaging scale. With respect to the procedures you perform most often, how easy is it for you to image the following?

|-----------------------|-----------------|---------------------------|-------------------------------|--------------------------|-----------------|----------------------|

1. I imagine the emotions I feel while doing the procedure. ☐ ☐ ☐ ☐ ☐ ☐ ☐

2. I imagine my technical skills improving. ☐ ☐ ☐ ☐ ☐ ☐ ☐

3. I imagine alternative strategies in case things don’t go according to my plan/strategy. ☐ ☐ ☐ ☐ ☐ ☐ ☐

4. I imagine myself being self-confident in front of my patients. ☐ ☐ ☐ ☐ ☐ ☐ ☐

5. I imagine myself being self-confident in front of my peers. ☐ ☐ ☐ ☐ ☐ ☐ ☐

6. I imagine myself being self-confident in front of my supervisors. ☐ ☐ ☐ ☐ ☐ ☐ ☐

7. I imagine each section of a procedure (e.g., approaching the patient, setting up the equipment, performing the
8. I imagine myself being in control during difficult situations.

9. I imagine the stress and anxiety associated with the procedure.

10. I imagine executing entire procedures/plans/strategies just the way I want them to happen.

11. I imagine myself being mentally tough (i.e., to a patient adverse event or to feedback/criticisms).

12. I imagine myself being focused during a challenging situation.

13. When learning a new skill, I imagine myself performing it perfectly.

14. I imagine myself working successfully through difficult situations (e.g., a complication, patient complaint, etc.).

15. I imagine improving a particular skill.

16. I imagine myself creating a clinical strategy/plan.

17. I imagine myself succeeding in the outcome of the procedure.

18. I imagine myself remaining confident in a difficult situation.

For each question, please imagine each question scenario and then provide a rating to the best of your ability. Go through each scenario thoroughly and take your time.

For questions 19-26 please follow the level of agreement scale. With respect to the procedures you perform most often, how much do you agree with each statement?

|----------------------|-------------|----------------------|----------------------------------------|------------------|---------|-----------------|
19. When imagining a particular skill, I consistently perform it correctly in my mind.

20. I can easily make corrections to procedural skills in my head.

21. Before attempting a particular skill, I can easily imagine myself performing it perfectly.

22. When I imagine myself performing a procedure, I feel anxious.

23. I can easily ‘see’ myself performing the procedure from an outside view (i.e., from a 3rd person perspective, as if watching myself perform the procedure on video tape).

24. The images of the procedure in my mind are vivid and clear.

25. I can easily ‘feel’ myself performing the procedure (i.e., from a 1st person perspective, as if I was actually inside myself performing and seeing the action through my own eyes).

26. Mental imagery is helpful in preparing myself to perform a procedure.

27. When experiencing the above images, did you generally see yourself from an outside view (i.e., from a 3rd person perspective, as if watching yourself perform the procedure on video tape) or from an inside view (i.e., from a 1st person perspective, as if you were actually inside yourself performing and seeing the action through your own eyes)? Please select a response from 1 to 7.

28. Additional comments:
3.1.2.1 Phase 2 – Participants

Participants in phase 2 included medical students in years 3 and 4, residents, fellows and practitioners from various disciplinary backgrounds including surgery, internal medicine, family medicine, obstetrics and gynecology, urology, emergency medicine, critical care medicine, anesthesia and pediatrics. It has been suggested that certain characteristics may influence imagery ability, specifically that imagery ability correlates positively with the level of performance (Hall et al., 1998; Williams & Cumming, 2011). The highly skilled experts then should be able to image better, thus score higher on the questionnaire compared to the more novice participants. In order to test the construct validity of the questionnaire it is necessary to include a wide range of participants and have a representation of all skill levels in the participant pool. Although Tabachnick and Fidell (2007) have suggested at least 300 participants for a factor analysis, the practicality of the study allows for 50 to 100 participants. The factors that are being examined in this study have been previously defined by Paivio, (1985). De Winter et al. (2009) have suggested that when a small number of factors are involved or if the factors are well defined, that small sample sizes can yield reliable solutions. Thus, 50 to 100 participants was deemed a sufficient sample size in order to represent the constructs in this study (De Winter, Dodou, & Wieringa, 2009).

3.1.2.2 Phase 2 – Factor Analysis and Principal Components Analysis

The main purpose of the factor analysis or a principal components analysis was to reduce the large number of items to a smaller number of clusters. This type of analysis was chosen in order to reduce the questionnaire in length and to examine any relationships that may be observed between the 26 question items. Upon completion of the questionnaire, a principle component
analysis was carried out to see if the items produced a pattern of correlation that would allow them to be divided into clusters (Tabachnick & Fidell, 2007). The items in one cluster would be similar to one another but different from items in other clusters. Items were either kept or discarded depending on whether they contributed any unique predictive ability of the questionnaire. At the conclusion of the principle components analysis, a final questionnaire with a reduced number of items was produced as well as the division of the items into the different constructs they represent.

An oblique principal component cluster analysis was performed to divide the 26 questions into 5 disjoint clusters. Random initializations with a maximum of 20 replications were completed to assure confidence in the results. The $R^2$ within each cluster and the next closest cluster was then calculated to see how well the items loaded onto their own cluster and how well they loaded onto the next closest cluster. The item with the lowest $1-R^2$ ratio for each cluster indicates the most representative item for that cluster. Two of the most representative items were selected from each cluster and the final outcome was calculated based on the mean value of the two items. Question 27 assessed the type of imagery perspective used by each individual, compared to the other questions which assessed an individual’s imagery ability. Question 27 was therefore, determined to be different and was treated as a separate outcome.

The 5 scores from each cluster and the score from Question 27 was then used to conduct the formal analysis. A generalized estimation equation (GEE) approach was used to analyze the repeated measures ANOVA. A correlation matrix was used to account for the correlation among the 6 scores within the same subject. An unstructured correlation matrix was chosen. Post-hoc tests were done after seeing a significant overall effect. The Sidak method was used to adjust for the multiple comparisons.
SAS v9.3 and PROC VARCLUS, PROC MIXED with REPEATED statement was used for all the analysis.

3.2 Results

3.2.1 Demographics

The survey was started by 99 participants and completed by 69 participants. Of the 69 participants, 57 came from the University of Toronto network in Toronto, Ontario, Canada and 12 came from Memorial University in St. John’s, Newfoundland, Canada. The average age of participants was 35, with a minimum age of 25 and a maximum age of 74. There were 37 males and 32 females in the participant group. The distribution of participants across different specialties in all levels can be found in Table 3. Four participants marked their specialty as other and indicated radiology, gynecologic oncology, gastroenterology and gerontology as their specialty. Some of the procedures that were listed included: caesarian sections, intubations, immunizations, biopsies, intravenous insertions, various surgical procedures, intrauterine device insertions, wound closures, lumbar punctures, suturing, vaginal examinations, papanicolaou tests, paracentesis, physical exams, injections, anesthetic procedures, central line placements, vaginal deliveries, incisions and drainages, epidurals, thoracentesis, fracture reductions, casting, chest tube insertions, catheter insertions, and other various procedures.
Table 3. The number of participants by specialty in all levels

<table>
<thead>
<tr>
<th>Specialty</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A - Medical Student Year 3</td>
<td>3</td>
</tr>
<tr>
<td>N/A - Medical Student Year 4</td>
<td>1</td>
</tr>
<tr>
<td>Surgery</td>
<td>16</td>
</tr>
<tr>
<td>Internal Medicine</td>
<td>5</td>
</tr>
<tr>
<td>Family Medicine</td>
<td>18</td>
</tr>
<tr>
<td>Obstetrics and Gynecology</td>
<td>3</td>
</tr>
<tr>
<td>Emergency Medicine</td>
<td>7</td>
</tr>
<tr>
<td>Anesthesia</td>
<td>8</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
</tr>
</tbody>
</table>

3.2.2 Oblique principal component cluster analysis

The results from the oblique principal component cluster analysis can be found in Table 4. The $1-R^2$ ratio represents the $(1-R^2_{own})/(1-R^2_{nearest})$ ratio and was used to determine which items were the most representative of each cluster. Low values of $1-R^2$ ratios signify good clustering. $R^2$ loadings with the item’s own cluster of greater than 0.55 are considered good (Items 8, 19); $R^2$ loadings with the item’s own cluster of greater than 0.63 are considered very good (Items 1, 7, 9, 18, 25); and $R^2$ loadings with the item’s own cluster of greater than 0.71 are considered excellent (Items 5, 6, 21) (Comrey & Lee, 1992; Tabachnick & Fidell, 2007). $R^2$ loadings with the item’s next cluster should be less than 0.32 to be considered poor (Comrey & Lee, 1992; Tabachnick & Fidell, 2007). All of the items chosen to be representative of their own cluster have $R^2$ loadings with the item’s next cluster of less than or around 0.34. The resulting cluster
and question items from the oblique principal component cluster analysis can be found in Table 5.

**Table 4.** The $R^2$ and $1-R^2$ values from the oblique principal component cluster analysis

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Variable</th>
<th>$R^2$</th>
<th>Next Closest</th>
<th>Next Closest</th>
<th>$1-R^{**2}$ Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1</td>
<td>Q2</td>
<td>0.57</td>
<td>0.28</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q13</td>
<td>0.62</td>
<td>0.34</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q19*</td>
<td>0.57</td>
<td>0.19</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q20</td>
<td>0.62</td>
<td>0.41</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q21*</td>
<td>0.79</td>
<td>0.35</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q23</td>
<td>0.27</td>
<td>0.16</td>
<td>0.87</td>
<td></td>
</tr>
<tr>
<td>Cluster 2</td>
<td>Q3</td>
<td>0.45</td>
<td>0.23</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q8*</td>
<td>0.61</td>
<td>0.35</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q11</td>
<td>0.49</td>
<td>0.31</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q12</td>
<td>0.48</td>
<td>0.27</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q14</td>
<td>0.47</td>
<td>0.21</td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q16</td>
<td>0.44</td>
<td>0.28</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q17</td>
<td>0.56</td>
<td>0.33</td>
<td>0.65</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q18*</td>
<td>0.67</td>
<td>0.29</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Cluster 3</td>
<td>Q1*</td>
<td>0.65</td>
<td>0.13</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q9*</td>
<td>0.68</td>
<td>0.09</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q22</td>
<td>0.39</td>
<td>0.07</td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>Cluster 4</td>
<td>Q4</td>
<td>0.75</td>
<td>0.24</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q5*</td>
<td>0.86</td>
<td>0.31</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q6*</td>
<td>0.81</td>
<td>0.29</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Cluster 5</td>
<td>Q7*</td>
<td>0.66</td>
<td>0.31</td>
<td>0.49</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q10</td>
<td>0.56</td>
<td>0.48</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q15</td>
<td>0.55</td>
<td>0.33</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q24</td>
<td>0.70</td>
<td>0.51</td>
<td>0.60</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q25*</td>
<td>0.64</td>
<td>0.29</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q26</td>
<td>0.54</td>
<td>0.19</td>
<td>0.56</td>
<td></td>
</tr>
</tbody>
</table>

* Represents the items with the lowest $1-R^2$ ratio for each cluster
Table 5. The resulting question items and cluster divisions

<table>
<thead>
<tr>
<th>Clusters</th>
<th>Question Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1</td>
<td>19. When imagining a particular skill, I consistently perform it correctly in my mind.</td>
</tr>
<tr>
<td></td>
<td>21. Before attempting a particular skill, I can easily imagine myself performing it perfectly.</td>
</tr>
<tr>
<td>Cluster 2</td>
<td>8. I imagine myself being in control during difficult situations.</td>
</tr>
<tr>
<td></td>
<td>18. I imagine myself remaining confident in a difficult situation.</td>
</tr>
<tr>
<td>Cluster 3</td>
<td>1. I imagine the emotions I feel while doing the procedure.</td>
</tr>
<tr>
<td></td>
<td>9. I imagine the stress and anxiety associated with the procedure.</td>
</tr>
<tr>
<td>Cluster 4</td>
<td>5. I imagine myself being self-confident in front of my peers.</td>
</tr>
<tr>
<td></td>
<td>6. I imagine myself being self-confident in front of my supervisors.</td>
</tr>
<tr>
<td>Cluster 5</td>
<td>7. I imagine each section of a procedure (e.g., approaching the patient, setting up the equipment, performing the procedure).</td>
</tr>
<tr>
<td></td>
<td>25. I can easily ‘feel’ myself performing the procedure (i.e., from a 1st person perspective, as if I was actually inside myself performing and seeing the action through my own eyes).</td>
</tr>
</tbody>
</table>
| Stand alone question | 27. When experiencing the above images, did you generally see yourself from an **outside view** (i.e., from a 3rd person perspective, as if watching yourself perform the procedure on video tape) or from an **inside view** (i.e., from a 1st person perspective, as if you are actually inside
3.2.3 Mean Scores

The mean scores, standard deviations, and minimum and maximum values for each cluster can be found in Table 6. The mean scores were calculated from the average score of the 2 most representative question items from each cluster except for question 27 which was calculated from 1 score.

Table 6. Mean scores of the 2 question items most representative of each cluster

<table>
<thead>
<tr>
<th>Clusters</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1</td>
<td>69</td>
<td>5.34</td>
<td>1.09</td>
<td>2.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Cluster 2</td>
<td>69</td>
<td>5.33</td>
<td>0.97</td>
<td>2.50</td>
<td>7.00</td>
</tr>
<tr>
<td>Cluster 3</td>
<td>69</td>
<td>4.78</td>
<td>1.29</td>
<td>2.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Cluster 4</td>
<td>69</td>
<td>5.20</td>
<td>1.04</td>
<td>2.50</td>
<td>7.00</td>
</tr>
<tr>
<td>Cluster 5</td>
<td>69</td>
<td>5.43</td>
<td>1.17</td>
<td>1.50</td>
<td>7.00</td>
</tr>
<tr>
<td>Question 27</td>
<td>69</td>
<td>2.71</td>
<td>1.46</td>
<td>1.00</td>
<td>7.00</td>
</tr>
</tbody>
</table>
3.2.4 Correlation

The correlation among the 6 clusters can be found in Table 7. Values close to zero indicate no linear relationship between the variables (Tabachnick & Fidell, 2007). Cluster 1 and 2, cluster 1 and 5, cluster 2 and 4, and cluster 2 and 5 show a medium correlation with values ranging from 0.43 to 0.53.

Table 7. The correlation matrix to show the correlation among the 6 clusters

<table>
<thead>
<tr>
<th></th>
<th>Cluster 1</th>
<th>Cluster 2</th>
<th>Cluster 3</th>
<th>Cluster 4</th>
<th>Cluster 5</th>
<th>Question 27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster 2</td>
<td>0.43</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster 3</td>
<td>0.14</td>
<td>0.29</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster 4</td>
<td>0.29</td>
<td>0.53</td>
<td>0.22</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster 5</td>
<td>0.48</td>
<td>0.52</td>
<td>0.33</td>
<td>0.33</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Question 27</td>
<td>0.04</td>
<td>-0.02</td>
<td>-0.01</td>
<td>0.05</td>
<td>-0.14</td>
<td>1.00</td>
</tr>
</tbody>
</table>

N = 69

3.2.5 Years Performing Procedures

Participants were asked to indicate which procedures they performed most often as well as how long they have been performing the indicated procedures. Using the years the participants spent performing the procedures as a continuous variable, an ANOVA was completed to see if there was a difference in scores between participants in terms of experience in years. A generalized estimation equation (GEE) approach was used to analyze the repeated measures ANOVA. There
was a significant overall effect of experience in years on item scores, $F(6, 69) = 386.95$, $p < 0.001$. Post-hoc t-tests were done after seeing a significant overall effect. The results from the analysis can be found in Table 8. Clusters 2, 3 and 4 scores were found to be significantly different by year performing the procedures ($p < 0.05$).

**Table 8.** Comparisons of scores between participants with different years of experience

| Effect     | Variable | Estimate | Standard Error | DF  | t Value | Pr > |t|   |
|------------|----------|----------|----------------|-----|---------|------|----|
| Years*Cluster | Cluster 1 | 0.01830  | 0.01291        | 69  | 1.42    | 0.1609 |
| Years*Cluster | Cluster 2 | 0.02544  | 0.01128        | 69  | 2.26    | 0.0273* |
| Years*Cluster | Cluster 3 | 0.03412  | 0.01495        | 69  | 2.28    | 0.0256* |
| Years*Cluster | Cluster 4 | 0.03534  | 0.01179        | 69  | 3.00    | 0.0038* |
| Years*Cluster | Cluster 5 | 0.01196  | 0.01396        | 69  | 0.86    | 0.3947  |
| Years*Cluster | Cluster 6 | -0.02161 | 0.01731        | 69  | -1.25   | 0.2162  |

* Indicates significance ($p < 0.05$)

### 3.2.6 Level of Training

Participants were asked to indicate their current level of training, position or title (medical student, resident, fellow, or practicing physician). An ANOVA was completed to examine the difference in scores between participants in different training levels. A generalized estimation equation (GEE) approach was used to analyze the repeated measures ANOVA. There was a
significant overall effect of different training levels on item scores, $F(5, 69) = 20.91$, $p < 0.001$.

Post-hoc t-tests were done after seeing a significant overall effect and a Sidak correction was used to adjust for the multiple comparisons. Differences were found for Cluster 4 as seen in Table 9. Only Cluster 4 scores were found to be significantly different by level of training when comparing medical students with residents, medical students with fellows and medical students and practicing physicians ($p < 0.0125$). This can be seen graphically in Figure 2. Although there was an improvement of scores seen as the level of training increased, only the progression from medical student to resident, fellow and practicing physician showed a significant difference.
Table 9. Comparisons of scores between participants in different training levels

<table>
<thead>
<tr>
<th>Cluster and level of training</th>
<th>Estimate</th>
<th>StdErr</th>
<th>DF</th>
<th>tValue</th>
<th>Probt</th>
<th>Alpha</th>
<th>Lower</th>
<th>Upper</th>
<th>Adjusted p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 4 1 vs. 2</td>
<td>-1.6596</td>
<td>0.5044</td>
<td>69</td>
<td>-3.29</td>
<td>0.0016*</td>
<td>0.0125</td>
<td>-2.9539</td>
<td>-0.3652</td>
<td>0.006346</td>
</tr>
<tr>
<td>Cluster 4 1 vs. 3</td>
<td>-1.8333</td>
<td>0.6252</td>
<td>69</td>
<td>-2.93</td>
<td>0.0046*</td>
<td>0.0125</td>
<td>-3.4375</td>
<td>-0.2292</td>
<td>0.018187</td>
</tr>
<tr>
<td>Cluster 4 1 vs. 4</td>
<td>-2.2000</td>
<td>0.5450</td>
<td>69</td>
<td>-4.04</td>
<td>0.0001*</td>
<td>0.0125</td>
<td>-3.5985</td>
<td>-0.8015</td>
<td>0.000560</td>
</tr>
</tbody>
</table>

* Indicates significance (p < 0.0125)

1 - Medical student
2 - Resident
3 - Fellow
4 - Practicing Physician
* Indicates significant difference in scores (p < 0.0125)

**Figure 2.** Cluster 4 average scores for participants in different levels of training

**3.2.7 Type of Imagery Perspective**

Participants were asked to select a perspective they commonly had when they were imaging the question scenarios for Question 27. Perspectives varied on a spectrum from an inside first person perspective to an outside third person perspective. The results of Question 27 by level of training can be seen in Figure 3. The scores between participants in different levels of training did not differ significantly. As seen in Figure 3 participants were more likely to adopt a first person perspective when imaging the question scenarios.
3.2.8 Item Reduction Results

An objective of Phase 2 was to identify only the most relevant items from the first phase so the final questionnaire can be reduced in length. One method of identifying the most relevant items was to test the construct validity of the items. The questionnaire’s ability to differentiate between participants with different levels of experience was examined. It is assumed that participants with more experience would be able to image better compared to participants with less experience (Hall et al., 1998; Williams & Cumming, 2011). The more experienced participants should then be able to score higher compared to participants with less experience. Clusters 2, 3 and 4 were found to differentiate participants based on years performing procedures and Cluster 4 was able to differentiate participants based on their level of training. Specifically, Cluster 4

![Figure 3. Question 27 scores by level of training](image-url)
was able to differentiate between participants who were medical students compared to residents, fellows and practicing physicians. These three clusters and the corresponding question items shown to be able to differentiate participants with different levels of experience represented the final questionnaire. Question 27 was also included in the final questionnaire as it provides information on the type of imagery perspective used by each individual and was determined to be relevant in Phase 1. The final list of items can be found in Table 10.

**Table 10. The final list of question items and cluster divisions**

<table>
<thead>
<tr>
<th>Clusters</th>
<th>Question Item</th>
</tr>
</thead>
</table>
| **Cluster 2**| 8. I imagine myself being in control during difficult situations.  
18. I imagine myself remaining confident in a difficult situation.                                                                                       |
| **Cluster 3**| 1. I imagine the emotions I feel while doing the procedure.  
9. I imagine the stress and anxiety associated with the procedure.                                                                                     |
| **Cluster 4**| 5. I imagine myself being self-confident in front of my peers.  
6. I imagine myself being self-confident in front of my supervisors.                                                                                   |
| **Stand alone question** | 27. When experiencing the above images, did you generally see yourself from an outside view (i.e., from a 3rd person perspective, as if watching yourself perform the procedure on video tape) or from an inside view (i.e., from a 1st person perspective, as if you are actually inside yourself performing and seeing the action through your own eyes)? |
3.3 Discussion

The main objective of this study was to develop and begin the process of validation of the CS-IAQ to be used during clinical skills performance in a clinical setting. Specifically, the questionnaire was developed to assess an individual’s self-reported ability to form specific clinical images in a medical context. This type of questionnaire was necessary in order to gain a better understanding of the type of mental imagery used by individuals as well as individual differences in imagery ability. Mental imagery is a cost effective and safe method of practice that has been shown to be effective in other disciplines (Schuster et al., 2011). By understanding individual differences in imagery ability, mental imagery can be better taught by specifying the teaching strategies used according to individual needs. An initial list of items was developed using items from the SIQ (Hall et al., 1998), SIAQ (Williams & Cummings, 2011) and the adapted questionnaire from Arora et al.’s (2010) study. The relevance of the items were then determined using a group of experts in Phase 1. With the selected items from Phase 1, the questionnaire was then distributed to participants with various levels of training in various disciplines of medicine to examine the construct validity of the questionnaire.

3.3.1 Determination of the Final Items

An oblique principal component cluster analysis was completed to reduce the large number of items into a smaller number of meaningful clusters and to examine any relationships between the 26 question items. After the cluster analysis was performed, the 26 question items from Phase 2 were divided into 5 clusters. The two most representative items from each cluster was then selected. Two items were selected from each cluster in order to reduce the questionnaire in length. Each cluster was appropriately represented by the two items that were selected. All items
selected had good to excellent loadings with their own cluster and poor loadings with the item’s next cluster (Comrey & Lee, 1992; Tabachnick & Fidell, 2007). The construct validity of the clusters was then examined by their ability to differentiate between participants with different levels of experience. Clusters 2, 3 and 4 were found to be able to differentiate participants according to the number of years they had spent performing procedures and Cluster 4 was able to differentiate participants based on their level of training. These three clusters and the two question items contained within each cluster were therefore, included in the final questionnaire.

3.3.2 Interpretation of Clusters

As described by Tabachnick and Fidell (2007) “To interpret a factor, one tries to understand the underlying dimension that unifies the group of variables loading on it” (p 649). The SIQ developed by Hall et al. (1998) was based off of Paivio’s (1985) categorization of mental imagery into the four categories: motivational-specific, motivational-general, cognitive-specific and cognitive-general. Hall et al. (1998) also separated the motivational-general category into two factors: arousal imagery and mastery of one’s motivation states. The SIAQ developed by Williams and Cumming (2011) used the SIQ to develop the initial items for the questionnaire. Similar to the SIQ, the SIAQ also adopted a five factor model which included: skill, strategy, goal, affect and mastery images. Because items from both the SIQ and SIAQ were used to develop the items for the CS-IAQ, the interpretation of the resulting clusters should show a similar pattern to the factors in the former two questionnaires.

Reviewing the resulting clusters, the question items within Cluster 2 “I imagine myself being in control during difficult situations” and “I imagine myself remaining confident in a difficult situation” are similar to the question items under the category of motivational general mastery from the SIQ and the category mastery images from the SIAQ. According to Paivio’s (1985)
categorization of mental imagery, motivational general items refer to the level of physiological stimulation and the affect or emotions associated with the stimulation. Hall et al.’s (1998) interpretation of the motivational general mastery aspect is the mastery of one’s motivational state such as their self-confidence or mental toughness. On the other hand, Williams and Cumming’s (2011) interpretation of mastery images is associated with maintaining a correct mental state during difficult situations. Because the items contained within Cluster 2 involve being in control or remaining confident during difficult situations, it was given the label “mastery during difficult situations”.

The question items within Cluster 3 “I imagine the emotions I feel while doing the procedure” and “I imagine the stress and anxiety associated with the procedure” are similar to the question items under the category of motivational general arousal imagery from the SIQ and the category affect images from the SIAQ. Similar to Cluster 2, these items also fall under Paivio’s (1985) categorization of motivational general items. Hall et al.’s (1998) category of motivational general arousal imagery refers imagery associated with arousal and emotions. Williams and Cumming’s (2011) category of affect images refers to images associated with the feelings and emotions related with sports. The items within Cluster 3 involve imaging the emotions associated with performance of the procedure and were given the label “emotions during procedures”.

Finally, the question items within Cluster 4 “I imagine myself being self-confident in front of my peers” and “I imagine myself being self-confident in front of my supervisors” are similar to the question items under the category of motivational general mastery from the SIQ. There were no similarities to any questions items from the SIAQ. These items again, fall under Paivio’s (1985) categorization of motivational general items. Because the items within Cluster 4 involve being
self confident, similar to Hall et al.’s (1998) interpretation of the motivational general mastery category, it was given the label “mastery of self confidence”.

All three of the resulting clusters represented the motivational general category (Paivio, 1985). There were no representations in the cognitive side of skill performance and the motivational specific category. In the study by Salmon, Hall and Haslam (1994) of the use of imagery, the soccer players did use imagery to practice certain skills but they used it mostly to motivate them before games and practices. This is aligned with the findings from Hall et al.’s (1998) study, in which athletes were found to use imagery for motivational general mastery purposes most often and more so compared to cognitive purposes. Hall et al (1998) explains this finding by the greater use of imagery by athletes for competition compared to for practice. During practice, athletes are concentrating on learning and improving their skills, which can be accomplished through cognitive imaging. However, during competition athletes are more concerned with a good performance, which can be enhanced by motivational imaging. At the competition stage, cognitive imaging may not be as useful because it is too late to learn the skill. This theory can be compared to trainees who may be learning a clinical skill in surgery. It is common for trainees to practice a skill with a real patient and because of the risks involved with patient safety, this could be viewed as a high stake situation similar to an athlete’s competition. Although trainees may still be learning the skill they must be cognizant of their performance as well. A bad performance of a skill could mean putting the patient’s safety at risk. Similar to athlete’s then, surgical trainees may employ the use of motivational imagery over cognitive imagery for the purpose of performance improvement.
From the final three clusters, Cluster 2 - mastery during difficult situations and Cluster 4 - mastery of self-confidence were found to have a medium correlation. This correlation is not surprising because both these clusters fall under the motivational general mastery category.

3.3.3 Imagery Perspective

Question 27 asked participants if they generally saw themselves from a third or first person perspective when experiencing each image. There were no significant differences between participants in different levels of training in regards to perspective. Most participants saw themselves through a first person perspective when imaging the question items. Salmon et al. (1994) found a similar preference for an internal perspective with soccer players. In the study by Immenroth et al. (2007) looking at mental training in surgical education, surgeons were asked how well they could imagine the inner perspective of laparoscopic cholecystectomy. Surgeons reported to be well able to image from an inner perspective. However, Hardy and Callow (1999) concluded that external imagery was more effective than internal imagery for tasks which relied on form, from three different experiments. The different findings in these studies can be attributed to the task examined in each study. The most effective imagery perspective may depend on the task at hand (Hall, 1997). Hall (1997) also points to the possibility that there is no superior perspective but the perspective chosen may be a matter of preference.

3.3.4 Limitations

There were a number of limitations in this study, despite the efforts made to reduce them. One of the biggest limitations in this study is the sample size. A large sample size is important to ensure correlations are reliably calculated (Tabachnick & Fidell, 2007). Comrey and Lee (1992) provided a guideline for sample sizes with 50 being very poor, 100 as poor, 200 as fair, 300 as
good, 500 as very good and 1000 as excellent. Generally, having at least 300 participants is a comfortable number for a factor analysis, however, the appropriate sample size also depends on the number of factors. For a smaller number of factors, a smaller sample size is appropriate. In some cases, 50-100 participants is a sufficient sample size to show the correlations in a study (Tabachnick & Fidell, 2007; De Winter et al., 2009). There were several strategies employed to increase the sample size for this study but the practicality of the study only allowed for 69 participants. One of the strategies to increase the sample size included recruitment from two separate Universities. Recruitment of participants occurred at the University of Toronto and at Memorial University. The survey was distributed online through email correspondence to reach a larger number of participants and access to the survey was made convenient with the use of website links. Participants were also recruited from various disciplinary backgrounds and from various levels of training.

Another limitation in the study is the absence of supervision while the participants completed the questionnaire. Participants were asked to image each question scenario before they provided a rating. Because there was no direct supervision of the participants, there is no guarantee that each participant would image each scenario before they completed the question. To reduce the impact of this limitation there was no set time limit to complete the questionnaire allowing the participant to go through each scenario thoroughly. Detailed instructions were also provided to assist the participants. Finally, participants were asked to indicate the procedure they performed most often to encourage the participants to image each scenario. This was done to make sure participants had a specific clinical skill they were thinking about before they completed each scenario.
The recommendation to only retain three of the clusters for the final questionnaire was also a limitation of this study. The three clusters were chosen due to the ability of the items in the clusters to differentiate between individuals with different levels of training. As a result, only the motivational function of imagery was represented in the final questionnaire. Participants with more experience are assumed to be able to image better compared to participants with less experience (Hall et al., 1998; Williams & Cumming, 2011). Although the process of validation is ongoing, this method was chosen as one way to look at the validity of the questionnaire. The process of validation was limited by the feasibility of the study, however, future studies should look at different types of validity to examine the inclusion of other clusters.

3.3.5 Conclusions and Future Directions

A questionnaire was developed to assess an individual’s ability to form specific clinical images. The perspective of mental imagery used by an individual was also examined. Researchers in the sports and psychology domain have studied imagery in the past through the use of questionnaires. Several different questionnaires have been developed to study the vividness of visual imagery and the imagery of general movements (Marks, 1973; Hall et al., 1985). Questionnaires have also been developed more specific to sport related movements. Currently, there are no validated questionnaires specific to the performance of clinical skills in a health professions context. It is important to have an instrument to measure imagery ability specific to an individual’s unique experiences (Paivio, 1985; Hall et al., 1998; Williams & Cumming, 2011). The development of the CS-IAQ will allow a better understanding of the use of imagery in a medical context. Mental imagery may be a simple and cost effective method to increase practice opportunities for trainees in healthcare. This is particularly important for clinical procedures that trainees have limited opportunities to practice. With a better understanding of
how imagery ability differs between individuals, health professions educators can improve and tailor the way they teach this skill. For individuals with low imagery ability, more attention can be given to teaching these individuals how to image. Individuals who have high imagery ability can be taught other imagery skills such as how to control the image. Because imagery ability has been found to improve with practice (Walsh, Hannebrink & Heckman, 1984; Eaton & Evans, 1986; Stransky, Wilcox & Dubrowski, 2010; Arora et al., 2011), educators can take advantage of this alternative form of practice. Although there were limitations in the present study, the development of the CS-IAQ is a good starting point to increase the understanding of mental imagery in health professions education. The CS-IAQ provides researchers with an instrument that can help measure an individual’s imagery ability. Specifically, it can help measure an individual’s self-reported ability to image mastery during difficult situations, emotions during procedures and mastery of self-confidence. Along with these motivational general aspects, the CS-IAQ can also indicate the type of imagery used.

The CS-IAQ offers an opportunity to increase the knowledge of mental imagery within different health professions. However, there is still a lot of work to be done. Firstly, the process of validation is ongoing and was only partially examined in this study. The final questionnaire needs to be further examined with new samples. The questionnaire should also be compared to previous imagery questionnaires that have been well established. Questionnaires developed in the psychology and sports domain should be used to further the validation process of the CS-IAQ.

Future research should also examine the different forms of imagery, specifically the use of cognitive imagery and motivational imagery. The different forms of imagery serve different purposes and this may depend on the setting (Paivio, 1985, Hall et al., 1998). In this study, only
motivational imagery was represented in the final questionnaire. The results may be different if imagery was looked at in different practice settings, specifically in low risk compared to high-risk settings (Hall et al., 1998). In low risk settings, such as practice in a surgical skills lab, cognitive imagery may be more beneficial because the focus is on learning and improving skills. In high-risk settings, such as practice in the operating room, motivational imagery may be more beneficial because focus is on the overall performance. The different forms of imagery used in different settings should be further investigated to increase the understanding of the purposes of imagery. By understanding the specific benefits of each form of imagery in different settings, educators can then select the form of imagery to teach according to the setting.

Individual differences in the type of perspective used when imaging should also be examined. Hall (1997) suggests the possibility that the chosen perspective may be a matter of preference and may not differ between individuals in different competitive levels. Although differences in the perspective used was not detected in this study, it would be interesting to see if this finding is replicated in future studies.

The development of the CS-IAQ will hopefully encourage investigators to increase the research of mental imagery in the field of health professions education. Future investigators will hopefully view the CS-IAQ as a valuable instrument to include in their research of mental imagery.
Chapter 4
General Discussion

The overall purpose of this thesis project was to increase the understanding of mental imagery use by health professionals as well as the mental imagery ability in health professions education. A questionnaire was developed to assess the imagery ability to form clinical images as well as the perspective used to image. The development of this instrument addresses the need of an appropriate tool to assess imagery ability of health professionals performing their clinical duties. This questionnaire also offers a measurement of imagery ability that can be used to track the progression of trainees.

In chapter one a scoping review was completed to summarize the relevant literature on mental imagery in health professions education. The scoping review also looked at the considerations of imagery ability in the studies. The review was completed using a search strategy across multiple databases to ensure all relevant articles were found. All articles were then chosen against a set criterion. Once articles were gathered, the relevant information was charted using a data charting spreadsheet developed by two raters. The data chart was analyzed and summarized into a numerical summary. A thematic analysis was also performed to organize the data and to make comparisons across the studies. This was done by categorizing each article according to the article type. Emerging trends from each category were extracted through the data charting process.

A majority of the research published in the field of mental imagery within health professions education occurred within the past seven years. The majority of research was from the United Kingdom, the United States of America, Canada and Germany. Looking at the different
categories of research, experimental research studies had the biggest number of articles. Following experimental research studies were commentaries, review articles and conference abstracts, consecutively. An improvement in skill performance after mental imagery as compared to a control or an alternative form of practice was reported in about half of the experimental research studies and commentaries. Mental imagery was found to have the same results as physical practice, the control condition or an alternative form of practice. Many of the studies also reported the use of imagery techniques to improve the readiness for a task and to reduce stress and anxiety. Imagery ability was shown to improve after imagery practice. In four of the studies, individuals identified as having a higher ability to image were found to have a better quality of performance. Measures of imagery ability were determined through validated questionnaires, informal questionnaires and mental rotation tasks and tests. Most of the measures used, measured the ability to image general situations and movements and not movements associated with clinical procedures.

In chapter two, the CS-IAQ was developed to measure the ability to image procedures in a clinical setting. In the first phase of the project, a list of items was developed using the SIQ (Hall et al., 1998), SIAQ (Williams & Cummings, 2011) and the adapted questionnaire from Arora et al.’s (2010). The list of items was then distributed to a group of experts to identify the most relevant items to form the questionnaire for phase two. In the second phase of the project, the questionnaire was distributed to participants with various levels of experience in various disciplines of medicine. The construct validity of the questionnaire was examined by its ability to differentiate the imagery abilities of participants in different levels of training. Higher skilled experts should be able to image better, thus score higher on the questionnaire compared to the more novice participants according to trends seen in the sports literature (Hall et al., 1998; Williams & Cumming, 2011).
An oblique principal component cluster analysis was completed and the 26 question items were divided into five clusters with two of the most representative items in each cluster. Only three of the clusters were able to differentiate participants based on their level of experience. The three clusters were interpreted and labeled as “mastery during difficult situations”, “emotions during procedures”, and “mastery of self confidence”. All three of the resulting clusters represented the motivational general category (Paivio, 1985). Participants reported a first person perspective when imaging the question items regardless of their level of training.

4.1 Application of the CS-IAQ and Future Directions

The CS-IAQ could be a tool considered by researchers who want to investigate mental imagery ability in a health professions context. These researchers may include physician scientists, health professions educators, medical education scientists, psychologists and kinesiologists. Medical education scientists and educators can use the CS-IAQ to identify individuals with low imagery ability and provide them with guidance on how to use imagery. With practice, these individuals can improve their ability to image. The CS-IAQ can also be used to identify individuals with high imagery ability to further examine how these individuals use imagery and the frequency of use. For investigations of imagery interventions, the CS-IAQ can be used to track progression and improvement of imagery ability. If the purpose of the intervention is to improve imagery ability, the questionnaire can be used as an indication of the success of the intervention.

The CS-IAQ can be integrated into mental imagery research in medical education. The CS-IAQ measures the self-reported ability to image clinical scenarios and may be a more appropriate instrument to use compared to the instruments which measure the ability to image general situations or movements. For each question scenario, participants were asked to rate how easy it
was to image each item with respect to the procedures they performed most often. By allowing the participant to specify the procedures they perform most often, the questionnaire can be used across health professions. The purpose of the second phase of the thesis in chapter 3, was to develop a general questionnaire that can be used in a medical context. However, future research can continue to develop more focused questionnaires depending on the population of interest.

Similar to the Imagery Use Questionnaire for Soccer Players developed by Salmon et al. (1994) as a sport specific questionnaire, the CS-IAQ can be further specialized. Surgical educators may look to develop a more focused questionnaire for surgical skills; nursing educators may want to develop a questionnaire to look specifically at nursing skills; and physiotherapist educators may want a questionnaire for patient manipulation skills. The CS-IAQ could be used as a guideline or a starting point in the development of these questionnaires.

The process of validation of the CS-IAQ has only began and more work needs to be done. Although the resulting sample size was appropriate in this study (Tabachnick & Fidell, 2007; De Winter et al., 2009) a larger sample size would ensure correlations are reliably calculated (Tabachnick & Fidell, 2007). Previous imagery questionnaires that have been established and validated should also be compared to the CS-IAQ. Future research should test the reliability of the study. Specifically, they should examine the forms of imagery represented in the final questionnaire. In this study, only the motivational category of imagery was represented or shown to have construct validity. Further research should be done to see if this is replicable with a new sample. It would be interesting to see if the motivational category continues to be the only category represented. It is possible that the cognitive category may be more represented in a population, which focuses more on learning and improving skills. This can be investigated by comparing the results across disciplines and medical specialties.
4.2 Mental Imagery Ability and Observational learning

Recent research by Lawrence, Callow and Roberts (2013) looked at the effect of imagery ability on the relationship between observational learning and performance. Observational learning can refer to watching someone else or one’s self perform a task, which is referred to as self-modeling. The authors divided participants into four groups: a high imagery ability and observational learning group, a low imagery ability and observational learning group, a high imagery ability control and a low imagery ability control. All participants then watched a video of a gymnastic routine and immediately performed a pre-test. Participants in the observational learning group participated in an observational learning intervention which included watching the video clip everyday for two weeks. All groups then returned for a post test. The authors found that the participants who underwent the observational learning intervention increased their performance pre test to post test. More specifically, the participants with higher levels of imagery ability performed significantly better than the participants with low imagery ability. The authors further concluded that the effectiveness of observational learning is moderated by the ability of the participants to produce a vivid image. It was hypothesized that the visuo-spatial replications of the task, which support the execution of motor performance, were developed faster in participants with high imagery ability.

Observational learning is a method of learning used widely in medical education, from live demonstrations in the operating room and the patient’s bedside to video demonstrations in the skills lab. Any factor that may increase the effectiveness of observational learning could improve the learning of many different procedures. The results from Lawrence et al.’s (2013) study show a promising relationship between observational learning and mental imagery ability. There are many opportunities to improve the learning of clinical skills, if the effectiveness of observational
learning is moderated by an individual’s imagery ability. In their study, participants with higher levels of imagery ability performed significantly better than the participants with low imagery ability after an observational learning intervention (Lawrence et al., 2013). Improving imagery ability could improve the effectiveness of observational learning and imagery ability has been shown to improve with imagery practice (Walsh et al., 1984; Eaton & Evans, 1986; Stransky et al., 2010; Arora et al., 2011). Educators could then use the CS-IAQ to identify individuals with low imagery ability and have them partake in a mental imagery intervention to improve their imagery ability. The CS-IAQ could also be used as a measurement of their progression throughout the mental imagery intervention. Improving mental imagery ability could mean a more efficient and effective method of teaching clinical skills through observational learning. This is significant as the opportunities for physical practice becomes limited in medical education due to issues related to patient safety or case complexity. The use of mental imagery interventions may be a cost effective and safe solution to this problem.

4.3 General Conclusions

This thesis project enhanced the understanding of mental imagery use by health professionals as well as the effects of imagery ability. This was accomplished through a scoping review, which summarized the extent, range and research activity on the use of mental imagery in medical education. As well as the development of the CS-IAQ to assess the ability to form clinical images and the perspective used to image. The CS-IAQ provides future investigators with an instrument to assess imagery ability of health professionals performing their clinical procedures. The questionnaire also offers a measurement of the success of mental imagery interventions, a guideline for the development of more discipline specific questionnaires and a tool to enhance the understanding of the relationship between imagery ability and observational learning.
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