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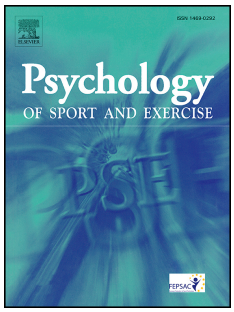

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Abstract

The ability to perform movement imagery has been shown to influence motor performance and learning in sports and rehabilitation. Self-report questionnaires have been developed to assess movement imagery ability in adults, such as the Movement Imagery Questionnaire 3 (MIQ-3); however, there is a dearth of developmentally appropriate measures for use with children. To address this gap, the focus of this research was to develop an imagery ability questionnaire for children. This process involved adaptation of the MIQ-3 via: i) cognitive interviewing with twenty children, ii) validation with 206 children by examining its factor structure via multitrait-multimethod confirmatory factor analysis, and iii) examination of test-retest reliability with 23 children. The findings of Study 1 led to changes to the wording of the questionnaire and modifications of the instructions to successfully adapt the MIQ-3 for children aged 7-12 years. The validation undertaken in Study 2 found that a correlated-traits correlated-uniqueness model provided the best fit to the data. Finally, test-retest reliabilities varied from fair (for external visual imagery) to substantial (for kinesthetic imagery). With respect to ease of imaging, no significant gender or age-group differences were noted. However, significant difference were found among the three imagery modalities ($p < .001$), with external visual imagery rated as easiest to image and kinesthetic imagery rated as the most difficult. Taken together, findings support the use of the MIQ-C for examining movement imagery ability with children.

Key words: imagery ability, scale development, ease of imaging

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Development and validation of the Movement Imagery Questionnaire for Children (MIQ-C)

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The ability to represent action in the mind, i.e., create a mental image, has been found to be important for the development, performance, and learning of motor tasks (Guillot & Collet, 2008). Mental imagery is increasingly used as an intervention strategy to enhance performance in sports as well as recovery in motor task performance in rehabilitation (Cummings & Williams, 2012). It is hypothesized that the mental imagery of action provides a window into how a person represents action in the brain for effective action planning (Gabbard, Caçola, & Bobbio, 2011; Skoura, Vinter, & Papaxanthis, 2005).

The mental performance of an action, without physical execution of the movement (Jeannerod & Decety, 1995), is a complex and multi-faceted construct (Hall & Martin, 1997; White & Hardy, 1995). Vealey and Greenleaf (2001) describe imagery as using all senses to create or re-create an experience in the absence of external stimuli. While imagery is recognized as being a polysensory experience, the most common modalities considered in sports and rehabilitation research are visual and kinesthetic. The kinesthetic component refers to how the person “feels” the movement and involves the internal awareness of the position and movements of the parts of the body, as well as the force and effort perceived during movement. The visual component, on the other hand, refers to the representation of what the individual ‘sees' (such as space, size, and amplitude) (Callow & Waters, 2005). Mental imaging of action can also involve different perspectives: internal (or first person) perspective or external (or third person) perspective (White & Hardy, 1995). When one images a movement as if one is actually doing the movement, this is referred to as using an internal perspective (Jeannerod, 1995; McAvinue & Robertson, 2008). One can use an internal perspective within the kinesthetic and/or within the visual modality. The external perspective, however, refers to seeing oneself doing the movement as if watching oneself on television or a video (Jeannerod, 1995; McAvinue& Robertson, 2008) and so usually involves the visual modality rather than the kinesthetic modality. Jeannerod (1995) uses the

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term motor imagery when referring to images "experienced from within" (p. 1419), i.e., of the first person and involving mostly kinesthetic representation. As such, while a motor representation is described as containing both kinesthetic and visual aspects of an action, it is generally understood that these are from an internal perspective (Jeannerod, 1995; McAvinue & Robertson, 2008; Roberts, Callow, Hardy, Markland, & Bringer, 2008). Movement imagery, on the other hand, seems to include both external and internal perspectives (McAvinue & Robertson, 2008). Although, recent research points out that imagined movement from both first and third person perspective may involve the same representations (Anquetil & Jeannerod, 2007), thus indicating that the distinction between first and third person perspectives needs for further investigation . For this paper, the term movement imagery will be used to encompass all perspectives and modalities of imagery.

All individuals are able to create and use images; however, some are better at this than others. This ability to form the image and the quality of the image constructed is known as imagery ability. It determines the extent to which imagery is used by an individual and so influences the degree of success obtained through these interventions (Cummings & Williams, 2012). In their review of the literature, Guillot and Collet (2008) stated that there is a strong association between movement imagery ability and motor performance and learning. Research suggests that imagery ability can be improved with training so as to benefit motor performance and learning (Cumming & Williams, 2013; McAvinue & Robertson, 2009). As such, improving movement imagery ability may be beneficial for individuals who demonstrate a weakness in this area, such as children with coordination difficulties (Gabbard & Bobbio, 2011). To be able to assess whether improving movement imagery ability could have such benefits, however, one needs to have a measurement tool that assesses this ability. Although, several measures exist for adults, few have been devised for use with children.

Measuring movement imagery ability in children

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Movement imagery has not been so widely studied with children as it has been with adults. While we know that children have the ability to create and use movement imagery (Gabbard, 2009), to date, we really know very little about the imagery capabilities of children. What we do know of imagery ability in children has been investigated using three main paradigms: mental rotation, mental chronometry, and self-report questionnaires (Heremans, Helsen, & Feys, 2008; McAvinue & Robertson, 2008).

Mental rotation is an implicit measure of imagery ability whereby subjects unconsciously make a decision regarding a visually presented stimulus as accurately and quickly as possible (McAvinue & Robertson, 2008). For example, if shown a hand oriented at different angles on a computer screen the subject must indicate if it is a right or a left hand. With adult subjects, it was found that there is a linear relationship between amount of rotation and reaction times (Estes, 1998). Using the mental rotation paradigm, Estes (1998), and Funk, Brugger, and Wilkening (2005) found that children as young as 6 years can mentally rotate visually presented objects, and that subjects aged 14 had results comparable to adults indicating that this ability improves with age.

With mental chronometry and self-report questionnaires, the subjects are asked to consciously image performing a movement, and are therefore known as explicit measures of imagery ability (Jeannerod, 1995). Mental chronometry is a strategy used to compare real and imagined movement times (e.g., imagining reaching for an object vs actually reaching for it). Better movement imagery ability is inferred by the similarity in movement times (McAvinue & Robertson, 2008). A study that used mental chronometry with children and adults found that, when compared to adults, all children imaged their movements with shorter durations than they executed them. This suggests that although children can perform movement imagery, imagery ability is not completely developed in children aged 6-10 years (Skoura et al., 2009). This finding is further supported by results from Molina, Tijus, and

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Jouen (2008), where no correlation was found between real and imagined movement durations in children aged 5 years, thus indicative of a lack of imagery ability. Similar results using mental chronometry were found by Deconinck, Spitaels, Fias, and Lenoir (2009), and Caeyenberghs, Wilson, van Roon, Swinnen, and Smits-Engelsman (2009).

The results of these studies indicate that movement imagery ability appears to develop between the ages of 7-12 years (Caeyenberghs, Tsoupas, Wilson, & Smits-Engelsman, 2009) and that these changes look like they coincide with the development of cognitive processes implicated in motor representation and necessary for the programming and execution of action (Molina et al., 2008). There seems to be consensus among researchers that motor imagery ability improves with age and experience due to the refinement of internal models (Caeyenberghs et al., 2009; Skoura et al., 2009).

Evidently, methods measuring temporal congruence between imaged and actual times, such as mental rotation and mental chronometry, provide important information on the characteristics of imagery ability related to timing, such as duration and speed. These measures focus primarily on a global movement rather than providing details of ongoing mental process and so do not capture the richness of the imagery experience, nor do they specify imagery perspectives being used, thereby failing to provide information on the vividness, or perspective used (Collet, Guillot, Lebon, MacIntyre, & Morgan, 2011; Heremans et al., 2008). While other methods, such as mental chronometry or mental rotation, are fairly objective ways to test imagery ability, the use of a questionnaire is a task-independent method for measuring movement imagery ability. Unlike these other methods, self-report movement imagery questionnaires provide information on ease of generation of imagery and its vividness with respect to the imagery perspective being used, thus addressing some of the weaknesses identified with mental chronometry and mental rotation (Williams, Cumming, Ntoumanis, Nordin-Bates, Ramsey, & Hall 2012).

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Though several movement imagery ability questionnaires measures exist, these have been validated only with adults. To date, no movement imagery ability questionnaire exists that has been developed for use with children. Considering the likely developmental changes that occur with imagery ability in children, an important first step in understanding its influence in children's motor performance and learning would be to develop a movement imagery ability measure for children.

Both Isaac and Marks (1994) and Taktek, Zinsser, and St-John (2008) used the Vividness of Movement Imagery Questionnaire (VMIQ), developed for adults, with children. Using this questionnaire with participants from 7 to 50+ years of age, Isaac and Marks found significant developmental changes in imagery ability in both children and adults. Furthermore, children with poor movement control were also noted to be poor imagers, with 42 percent reporting that they could not image at all. Due to the fact that a questionnaire destined for adults was used, the validity of these results need to be interpreted with reservation. Generally, using and adult questionnaire with children is problematic by virtue of the fact that children may not understand all the words and concepts, and therefore may not properly understand what the questionnaire is asking (Stadulis, MacCracken, Eidson, & Severance, 2002). As such, it cannot be properly concluded whether the developmental differences found or the communicated inability to imager, are really due to developmental differences in movement imagery ability or language ability. This issue is further illustrated by Taktek et al. (2008) when they investigated the association between imagery ability, via the VMIQ, and motor task performance in children. They found no correlation and attributed this absence of a correlation to the fact that the questionnaire was not validated for use with children. In fact, the children expressed having difficulties with i) the complexity of the rating scale, ii) the length of the questionnaire procedure , and iii) evaluating the clarity and vividness of their images in response to the different items (Taktek et al., 2008). These

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reported difficulties illustrate some of the conceptual and linguistic problems that can occur with using an adult questionnaire with children (Stadulis et al., 2002). As such, the main objective of our research was to develop and validate an imagery ability questionnaire for use with children.

The movement imagery questionnaire

A person's ability to image movement may vary depending on the imagery modality adopted. Indeed, visual and kinesthetic imagery appear to activate distinct parts of the brain and develop differently (Guillot, Collet, Nguyen, Malouin, Richards, & Doyon, 2009). It is therefore necessary to consider the different modalities that can be enacted when attempting to understand imagery ability in children. For instance, the kinesthetic component seems particularly important for the development of motor skills, especially those requiring greater motor control (Féry, 2003). Accordingly, a measure of imagery ability ought to be able to differentiate ability relative to visual and kinesthetic imagery modalities. Since children as young as 7 years are able to image movements from an internal perspective (Skoura et al., 2009) and developmental differences exist in the use of visual information which may influence the ability to image via different perspectives (e.g., internal and external) (Gabbard, 2009), a movement imagery questionnaire aimed at children should incorporate both internal and external visual perspectives.

While there are several self-report questionnaires that test imagery ability, considering different perspectives, such as the Vividness of Movement Imagery Questionnaire 2 (VMIQ-2; Roberts et al., 2008), we chose to adapt the Movement Imagery Questionnaire (MIQ; Hall & Pongrac, 1983), a popular and well-established questionnaire for testing visual and kinesthetic movement imagery ability. The basic premise of the MIQ is that when one's movement imagery ability is better, the easier one can visualize and feel imaged movements (Hall & Pongrac, 1983). In the most recent revision of the MIQ, the Movement Imagery

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Questionnaire-3 (MIQ-3; Williams et al., 2012), the kinesthetic modality and the internal and external perspectives of the visual modality of imagery ability were distinguished from each other by having the individual consider the movements being imaged from each of these modalities and perspectives. As such, it consists of four movements, repeated from each of these three aspects, i.e., from an external perspective within the visual modality (external visual image) and from an internal perspective within each of the kinesthetic and visual modalities (internal visual imagery, kinesthetic imagery), resulting in a 12-item measure. For each item, participants are asked to physically perform the movement, and then to image movement from a particular perspective. Following the imaging step, participants rate their ease of imaging on a 7-point Likert-type scale, where a greater ease of imaging in each subscale is represented by higher scores. External visual imagery, internal visual imagery, and kinesthetic imagery subscale scores are obtained. The MIQ-3 demonstrates good internal reliability for each subscale and concurrent validity (Williams et al., 2012).

In addition to the advantage of the MIQ-3 differentiating kinesthetic, internal visual, and external visual imagery, it was also selected to be adapted for use with children for other reasons. First, unlike the VMIQ-2 where responders need to recall different movements to be imaged from long term memory, participants physically perform each movement before engaging in the imagery component. This feature ensures that all participants are attempting to image the same movement, and also removes the potential issue of individual differences in task familiarity (Williams et al., 2012). For example, not all children may have recent experiences with the VMIQ-2's 'jumping off a wall' task, or may be imaging a different variation of the movement (e.g., jumping from different wall heights). As such, an advantage of the MIQ-3 is that "discrepancies in…scores between individuals can more likely due to the ease with which individuals are able to generate the images rather than being more or less

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familiar with performing the physical movement, or due to discrepancies in imagery content" (Williams, Cumming, & Edwards, 2011, p. 556).

For all the above-stated reasons, the first step of the development of the measure for children was to adapt the MIQ-3 to ensure children could understand the wording and instructions of the questionnaire. This was accomplished via cognitive interviewing during the administration of the MIQ-3 to a group of children (Study 1). The second study then involved validation of the psychometric properties of the adapted MIQ-3 measure with the intended population of children.

Study 1: Adaptation of the MIQ-3 for use with children

Given that children's social, linguistic and cognitive skills are quite different from those of adults, the purpose of the first study was to modify the MIQ-3 (Williams et al., 2011) such that children could well understand the nature of the questionnaire.

Pretesting a questionnaire is a 'critical step' when developing child self-report measures (Presser, Couper, Lessler, Martin, Martin, Rothgeb, & Singer, 2004; Woolley, Bowen, & Bowen, 2004). It is a necessary step to ensure the robustness of the questionnaire as it helps establish the developmental validity of items for children, such as ensuring appropriateness of language and cognitive demands (Woolley, Bowen, and Bowen, 2006), and tests whether the instrument works as expected before it is distributed to a target population (Bell, 2007).

One way to pre-test a questionnaire is through cognitive interviewing. Cognitive interviewing is a method of identifying questions that may produce invalid or unreliable responses (Drennan, 2003). It entails administering a questionnaire while collecting additional verbal information about participants' responses (Beatty & Willis, 2007). For example, respondents can describe any difficulties they had answering questions or what they think a question meant (Beatty & Willis, 2007). The overall aim is to gain an understanding

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of how respondents perceive and interpret questions and identify potential problems that may occur in the process of answering a questionnaire (Drennan, 2003; Presser et al., 2004).

Cognitive interviewing practices are based on two paradigms: think-aloud (participant verbalizes thoughts aloud while answering questions) and probing procedure (researcher asks questions to gain information on thought processes) (Beatty & Willis, 2007). The probing process is described as having several advantages over the think-aloud process such as being less intrusive, providing the participant with more focus, and generating useful information that may not emerge unless there is a specific request by the interviewer (Beatty & Willis, 2007). Given these advantages, the probing paradigm was adopted for the cognitive interviewing in Study 1. As such, the adaptation process of the MIQ-3 questionnaire for use with children involved, first, an initial simplification of the language used, followed by two rounds of cognitive interviewing using the adapted MIQ-3 (i.e., MIQ-C-round 1). The questionnaire was modified in response to the results of the first round of cognitive interviews (MIQ-C-round2), which was then used in the second round of cognitive interviewing.

Methodology

Simplification of language. The first step towards adapting the MIQ-3 was to make it developmentally appropriate for use with children. A readability calculation (Simon's Readability Test Tool, 2010) was initially performed on the MIQ-3, which revealed it read at a grade 11 level (approximately 16-17 years old). This level is much too advanced for our intended sample of children aged 7-12 years. We therefore reworded and simplified the questionnaire to a readability level of grade 7 by creating shorter, simpler sentences and more straightforward language, as per recommendations by Bell (2007). While this readability level is still above that the population of targeted by this questionnaire, one must consider that this is not a self-administered questionnaire and that the questionnaire administrator is

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available to confirm comprehension of the concepts. Furthermore, the original instructions of the MIQ-3 were shortened to accommodate a child's shorter attention span (Woolley et al., 2004) and wording on the Likert scales was changed by replacing phrases "somewhat hard/easy to see/feel" to "kind of hard/easy to see/feel". As such, the MIQ-C-round 1 that resulted from the adaptation of the MIQ-3 contained the same 12 items as the MIQ-3 with the same four movements, repeated from each of the three different imaging perspectives. The principle difference from the MIQ-3 and the MIQ-C-round 1 was that the instructions were shortened in length and the vocabulary simplified.

Cognitive interviewing. In preparation for the cognitive interviewing, anticipated probes were developed and placed at key points in the questionnaire. The probes allowed the researchers to ascertain whether the child understood the content of the items being addressed. For instance, after the instructions were read to them, children were asked "Can you describe in your own words what seeing the movement through your own eyes means?", or after completing a question, the child could be asked "What did you see?". Condition probes were also developed for when the researcher required more information from the child. For example, if a child gave a score that was inconsistent with previous responses, the researcher may have asked "Why did you choose this answer?" so as to better understand the child's thought process. The interviews were conducted until no issues with the questionnaire arose and no new insights yielded (Beatty & Willis, 2007). This resulted in two rounds of interviewing (steps 2 and 3). Revisions to the questionnaire were done subsequent to each round so as to address the problem(s) identified.

Participants. To determine the necessary sample size, Beatty and Willis' (2007) recommendation of ten to fifteen participants per round were followed, resulting in a total of 20 children (n = 10 for each round) participating in Study 1 (see Table 1 for participant characteristics).

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Table 1

Participant characteristics

Age group (years)	Total	Male	Female	Involved in competitive sport
		Round 1		
7-8	3	0	3	0
9-10	3	1	2	0
11-12	4	2	2	0
Total	10	3	7	0
		Round 2		
7-8	2	1	1	0
9-10	6	2	4	3
11-12	2	1	1	0
Total	10	4	6	3

Procedure. Children were recruited from local sports clubs, recreation facilities, summer day-camps, and after-school programs in the community. Parents/guardians of participants provided information regarding age, gender, and sport participation. Prior to recruitment, ethical approval was obtained from the Health Sciences and Science Research Ethics Board at a Canadian university. Once parents signed consent forms providing permission for their child's participation in the study, the child was taken to a quiet area where an investigator explained the study to them and obtained their assent for participation. Once assent was obtained, the examiner proceeded to administer the MIQ-C version using a one-on-one format. This involved the researcher reading the instructions to the participant. In these instructions, children were asked to perform a movement item and then to imagine it from a particular perspective. The child then said or pointed to the number on the 7- point Likert scale that reflected how difficult or easy it was to imagine the movement. At different points in the administration of the questionnaire, probes were used to generate verbal responses from the child. Interviews were audio recorded and written notes were taken to

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supplement the audio. This ensured an accurate verbatim for data analysis. Each testing session lasted approximately 30 minutes.

Data analysis. At the end of each round, the data from the cognitive interviews were transcribed. The transcripts were then reviewed and systematically coded. The coding was based on the types of issues or difficulties the children encountered with the questionnaire (Beatty & Willis, 2007). The problems were then summarized across children and for different aspects of the questionnaire (e.g., instructions, items, scales). Issues were deemed problematic if two or more of the ten children identified the same issue or problem.

Results

Round One Results. After the first round of cognitive interviews, eight important issues with the questionnaire emerged, which were grouped into four main categories. The first three involved comprehension of (1) visual imagery perspectives, (2) kinesthetic imagery, and (3) 'ease of imaging'. The fourth category related to attention span.

Comprehension of visual imagery perspectives. All children, regardless of age, showed difficulty with understanding the difference between the internal and external perspectives. This may have been due to diminished attention as the explanations of these occurred late in the instructions, or that the explanations themselves were too vague.

Several steps were taken to remediate these issues. First, the verbal instructions were modified such that the explanation of the imagery perspectives was provided earlier in the instructions. As well, two photographs of a child kicking a ball (Figure 1) were added wherein one displayed the visual perspective associated with adopting an internal perspective and the other from that of an external perspective (lateral view). Following the explanation of the different perspectives, the children were asked to point to the picture that corresponded with the two visual perspectives described to confirm their understanding.

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Comprehension of kinesthetic imagery. Seventy percent of the children reported being unable to engage in kinesthetic imagery, saying they "couldn't feel anything". Four of the children said they based their answers on how easy it was to feel the actual movement, rather than the imaged feeling of the movement. Three children reported conjuring a visual image when asked to generate a kinesthetic image. Instructions were modified to resolve these issues by introducing a practice task of kinesthetically imaging what it feels like to kick a ball. This task was used because the children had just finished identifying visual perspectives with the ball kicking task. During this component, we asked the children to first describe the muscles that would be used to do the task and what body parts would be involved. They were then guided to image how that action would feel without actually doing it. Following this, they rated the ease/difficulty of imaging the feeling of kicking the ball.

Comprehension of 'ease of imaging'. As a third issue, children's responses often indicated a lack of understanding of the concept of the ease of imaging and its relation to the Likert scale. To address this, photographs of three different glasses: one filled with muddy water, one filled with cloudy water, and one empty clear glass, were placed at different points of the Likert scale. The glass filled with muddy water and the clear glass were anchored at the very hard/easy ends of the scale, and the image of the cloudy water was placed in the center (see Figure 1). Children were again referred to thinking about kicking a ball, and were asked about how easy/hard it would be to see the skill if they had to do so through the glass. Through this questioning and the photographs of the different glasses, we ensured that the children understood the use of the scale and the concept of the ease/difficulty of imaging.

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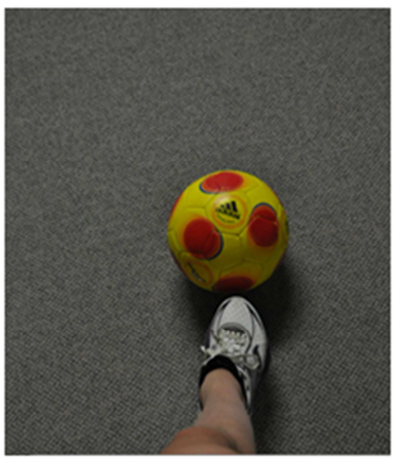

Internal Visual Imagery
(1st Person Perspective)

External Visual Imagery
(3rd Person Perspective)

Glass of Mud
(Very hard to…see or feel)

Glass of cloudy water
(Not easy nor hard…to see or feel)

Empty Glass
(Very easy to…see or feel)

1	2	3	4	5	6	7
Very Hard	Hard	Kind of Hard	Not Easy nor Hard	Kind of Easy	Easy	Very Easy

Figure 1. Photos and Likert chart included in the MIQ

Maintaining attention. Questionnaire administrators noted that it was difficult to maintain children's attention during the instructions. This issue emerged for all children in the ages ranging from 7-10 years, but only one child from the 11-12 age group. Maintaining attention during instructions is important if we want to ensure that the children understand what is being asked of them. As such, the initial instruction paragraph was further shortened

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and simplified. In addition, it was expected that having the children engage in the above-described activities during the instructions would also help them to stay engaged. Finally to help focus attention, one word descriptor cues were added to instructions of 'seeing' or 'feeling' a movement to clarify what movement the instruction was referring. For instance, instead of "Try to see the movement you just did…", a word cue was added to better orient child to the referred movement (e.g., "Try to see the *jumping* movement you just did…"). The readability was re- calculated and it was maintained at a grade 7 level (Simons, 2009-2014).

In sum, the modifications implemented prior to the second round of cognitive interviews included: i) uninterrupted verbal instructions were shortened in length, vocabulary has been simplified, and notes to administrator were added to engage child and very his/her understanding; ii) two images of a child kicking a ball were shown to determine that the child understood the difference between internal and external perspectives; and iii) three images of glasses with liquid of different transparencies were shown to facilitate comprehension of different levels of ease of imaging. This MIQ-C-round 2 version was used in a second round of cognitive interviews conducted with a second group of ten children. There were no changes to the method used for that of Round 1.

Round Two Results. No new issues emerged when the transcripts of the second round of cognitive interviews were examined. It was clear that the modifications had resolved the concerns that had been raised. Not only were all children able to maintain their attention for the duration of the instructions, all children demonstrated an understanding of the kinesthetic imagery perspective and the ease of difficulty concept. Three children (aged seven, nine, and ten) did initially fail to choose the correct corresponding photograph in relation to the imagery perspectives, but with further explanation, they did show an understanding of the two visual perspectives. Given that no new issues emerged in this

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second round, no further modifications were made to the MIQ-C-round 2 questionnaire nor was another round of cognitive interviews warranted.

The results of this three-step process for the adaptation of the MIQ-3 showed that instructions needed to be shortened, simplified, and supplemented with guided questions, photographs, and cues to be effective with children. Having adapted the MIQ-3 for children, the resulting questionnaire will herein be referred to as the Movement Imagery Questionnaire for Children (MIQ-C).

Validation of the Movement Imagery Questionnaire for Children (MIQ-C): Study 2

The aim of this second study was to determine the psychometric properties of the newly developed MIQ-C in order to verify whether the MIQ-C's factor structure is similar or not to that of the MIQ-3. To do so a multitrait-multi method (MTMM) approach to confirmatory factor analysis (CFA) was used to determine the relationship among the imagery perspectives (i.e., traits) when method variance effects and random error were present (Schmitt & Stults, 1986). Test-retest reliability was also examined.

Methodology

Participants. The participants were 204 healthy children without coordination difficulties (79 boys and 125 girls) between the ages of 7 and 12 years (M_{total} = 9.6 years, SD_{total} = 1.77; M_{boys} = 9.5 years, SD_{boys} = 1.85; M_{girls} = 9.58 years, SD_{girls} = 1.72)[1].

Procedure. As with study 1, children were recruited from sports clubs, recreation facilities, summer day-camps, and after-school programs in the community. The same consent and administration procedures (described in study 1) were also used, except that to

[1]Children with coordination difficulties have been found to exhibit poor movement imagery ability (Gabbard & Bobbio, 2011). Therefore, to ensure proper validation of the MIQ-C, all children recruited for the present study were screened for coordination problems by asking parents to complete the Development Coordination Disorder Questionnaire (DCD-Q'07) and suspected difficulties confirmed using the Movement Assessment Battery for Children (MABC-2). No children were excluded from the study as none of those recruited were identified as having coordination difficulties.

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determine test-retest reliability, the MIQ-C was administered to twenty-three children (8 boys; 15 girls) on two occasions, 1-2 weeks apart.

Data analysis.

MIQ-C validation. As with the MIQ-3, the MIQ-C uses the same item (movement) to assess three types of imagery (i.e., internal visual imagery, external visual imagery, and kinesthetic imagery). Therefore, as recommended by Williams et al. (2012; also see Roberts et al., 2008) a MTMM approach to CFA was adopted. In this case, the four movements of the MIQ-3/MIQ-C (i.e., arm, leg, jump, and waist bend) are defined as the "methods" whereas the three types of imagery are the "traits". MTMM is preferable to traditional CFA as it accounts for method effects and random error when examining the relationships amongst the traits (Schmitt & Stults, 1986; Marsh & Grayson, 1995). Large trait factor loadings indicate convergent validity, while a lack of discriminant validity is evidenced by large correlations between trait factors (Byrne, 2009). For a model to be chosen, it has to display the best fit indices and converge to a proper solution (Marsh & Grayson, 1995). The MTMM analysis was conducted via structural equation modeling with maximum likelihood estimations using SPSS AMOS 21 (IBM ®).

In accordance with Marsh (1989), we tested and compared four models to determine the best model fit. Specifically, we tested and compared the correlated trait (CT) model, the correlated trait-correlated method (CTCM) model, the correlated trait-uncorrelated method (CTUM) model, and the correlated trait-correlated uniqueness (CTCU) model. The CT model is akin to a traditional CFA and involves correlating the traits (i.e., imagery perspectives) but no method effect is predicted.

The subsequent two models include a method effect, but differ as to whether these are correlated or not. In the CTCM model both the traits and methods are correlated, whereas

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only the traits are correlated in the CTUM model. Both the CTCM and CTUM models assume the method effects are single factored (i.e., invariant across traits).

Finally, the CTCU model (figure 2) also predicts that the traits are correlated but the methods effect are obtained from the correlated uniqueness (i.e., the error terms are correlated) among the responses that share the same method. Marsh (1989) contends the size of correlations between the uniqueness terms and the fit of this model compared with that of the CT model determine the extent of method effects. The CTCU model differs from CTCM and CTUM by allowing for multi-dimensional effects of the method. By comparing the CTCU model with these other models provides indication of whether any method effects are multi- or uni-dimensional (Kenny & Kashy, 1992).

All models' overall goodness of fit to the data were evaluated using the chi-square likelihood ratio statistic (χ^2). For this statistic, a good model fit is signified by a non-significant χ^2 value; however, MacCallum (2003) has noted that this is not often found. Because this value cannot be ignored, the model fit information was supplemented using the Tucker Lewis index (TLI), the comparative fit index (CFI), standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA). Hu and Bentler (1999) recommend that acceptable values for each of the fit indices are: close to .95 or above for both the TLI and CFI; close to .08 or lower for the SRMR; and close to .06 or lower for the RMSEA. These stringent cut-off values for evaluating adequate model fit are the most commonly reported indicators when validating questionnaires (see Schreiber, Nora, Stage, Barlow, and King, 2006 for a discussion). However, Marsh, Hau, and Wen (2004) have warned that these criteria are too restrictive for multifactor rating instruments with few items per factor, such as in the case of the MIQ-C. Therefore, we also considered the less conservative cutoff values for the incremental fit indices (e.g., GFI, CFI, and TLI > .90).

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We also follow Marsh et al.'s (2004) recommendation to compare the fit of the best three factor model with alternative nested models. Consistent with Williams et al. (2012), once the best three factor model was identified via MTMM CFA, this model was compared with two alternative two factor models using a chi-square difference test.

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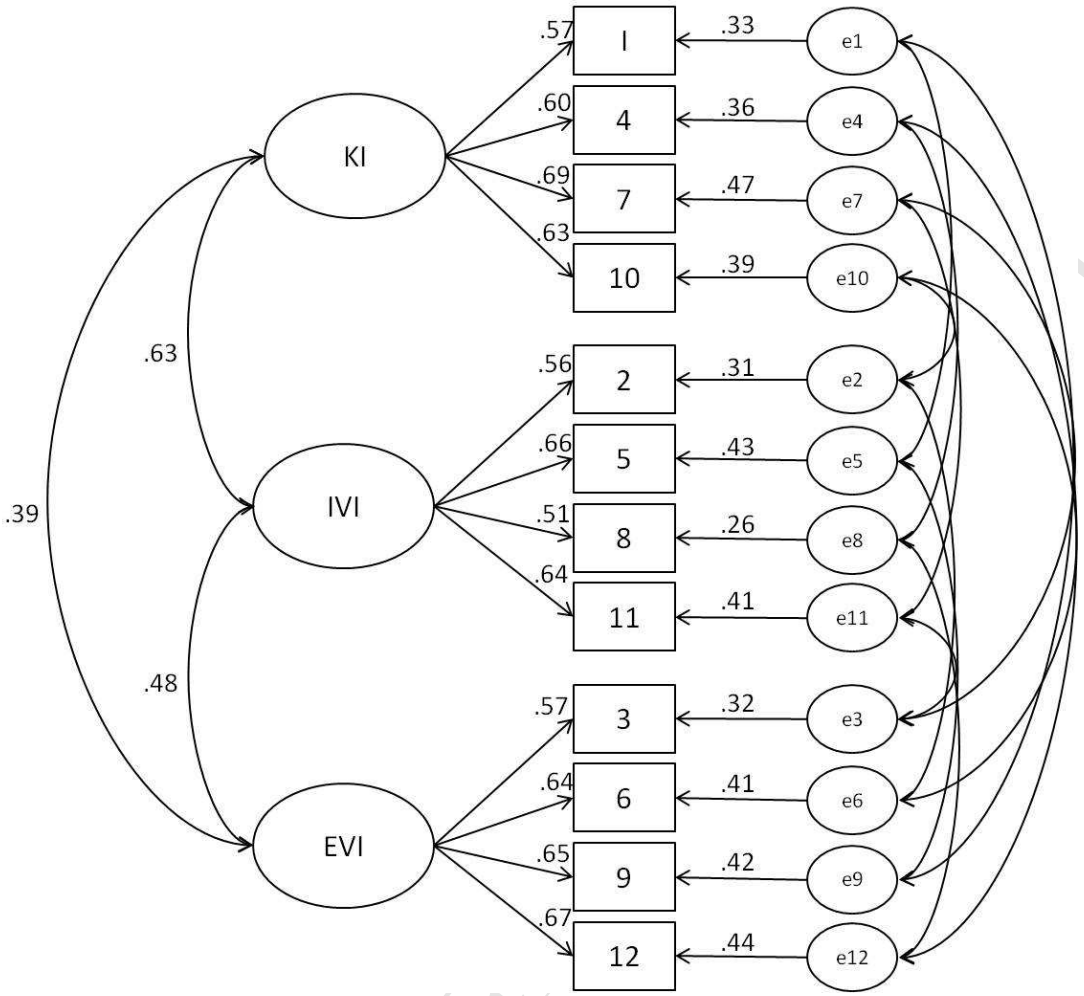
Figure 2. 3CTCU Model



Note. The CTCU model postulates that imagery types are correlated and method effects are obtained from correlated uniqueness (i.e., correlated error terms) among the responses that share the same method.

Test-retest reliability. Scores from the two sessions were compared using Intraclass Correlation Coefficient (2-way mixed model ICCs with absolute agreement). The benchmarks proposed by Shrout (1998) were used for the interpretation of reliability coefficients: .00 to .10 (virtually none); .11 to .40 (slight); .41 to .60 (fair); .61 to .80 (moderate); and .81 to 1.0 (substantial).

Self-reported movement imagery abilities. We were also interested in determining whether self-reported movement imagery abilities were distinguished by the age and gender of the participants as well as the imagery perspective. Therefore, we analyzed self-reported ease of imaging in a 3 (Age: 7-8, 9-10, 11-12) x 2 (Gender: male, female) x 3 (Modality:

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external, internal, kinesthetic) analysis of variance with repeated measures on the last factor. Differences with a probability of less than .05 were considered significant and partial eta squared (η_p^2) is reported as an estimate of the proportion of the variance that can be attributed to the tested factor. Tukey's HSD *post hoc* tests were administered when appropriate to determine the locus of any significant differences.

Results

Data screening and normality. According to Mardia's coefficient (Mardia, 1970), the data did not display multivariate normality (normalized estimate = 40.31). As a result, bootstrapping was utilized in all further analyses. Bootstrapping results in multiple subsamples being created from an original data set to allow the examination of parameter distributions relative to each of the spawned samples (Byrne, 2009, p. 331).

MTMM CFA. Both the CTCM and the CTUM models resulted in improper solutions and were therefore disregarded. Proper solutions were found for the CT and CTCU models and their respective fit indices are displayed in Table 2 with standardized factor loadings for the accepted model in Table 3 and correlated error terms in Table 4. Standardized factor loadings ranged between 0.51 and 0.67 (CT model) and between 0.51 and 0.69 (CTCU model). The intertrait correlations ranged between 0.42 and 0.65 (CT model) and between 0.39 and 0.63 (CTCU model). The uniqueness correlations for the CTCU model ranged between -0.08 and 0.33. All factor loadings, modification indices, and standardized residuals were within acceptable limits (Hair, Anderson, Tatham, & Black, 1998). Also, as noted in Table 2, a chi square difference test ($\Delta\chi^2$) evaluated at $p = .001$ with a critical ratio of 32.91, confirmed that the CTCU model was a significant improvement in model fit over the CT model.

MIQ-C validation: Alternative models. Following recommendations from Marsh et al. (2004) to test alternative nested models, we compared the three factor CTCU with the

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same two factor CTCU models proposed by Williams et al. (2012). In the first alternative model, the external and internal imagery perspectives were collapsed into one factor termed visual imagery. The four kinesthetic items remained together on the second trait factor to assess kinesthetic imagery separately. This two factor CTCU model is akin to the factor structure of the original and second version of the MIQ, which did not distinguish between visual imagery perspectives. The model fit results are displayed in Table 2 and it can be seen that this model resulted in a poor fit to the data (interfactor correlation between visual imagery and kinesthetic imagery = .58).

We also ran another two factor CTCU model in which internal visual imagery and kinesthetic imagery were forced onto one factor and external visual imagery remained on the second factor. Similar to Williams et al. (2012), we found a large interfactor correlation (.63) between internal visual imagery and kinesthetic imagery in the three factor CTCU model. We also therefore considered it plausible that types of imagery might be better represented as a single factor. This is also consistent with past conceptualizations of imagery, which confounded an internal perspective with the sensations experienced in the situation being imaged (e.g., Mahoney & Avener, 1977). As also can be seen in Table 2, this alternative two factor CTCU model also resulted in a poor fit to the data (interfactor correlation between the combined internal visual imagery and kinesthetic imagery factor and external visual imagery = .55) . The chi square difference further confirmed that the 3 factor CTCU model was a significantly better fit to the data compared to both alternative models.

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Table 2.
Goodness-of-Fit indices (with bootstrapping) for the Correlated Trait (CT) and Correlated Trait-Correlated Uniqueness (CTCU) Models

Model	χ^2	*df*	GFI	TLI	CFI	SRMR	MSEA (90% CI)	$\Delta\chi^2$	Δdf
Criteria	$p > .05$		>.90-.95	>.90-.95	>.90-.95	<.05-.09	<.06		
3CT	114.73**	51	.91	.85	.88	.06	.08 (.06-.10)		
3CTCU	75.33**	39	.95	.89	.93	.05	.07 (.04-.09)	39.40**	12[a]
2CTCU VI vs. KI	147.86**	41	.89	.68	.80	.07	.11 (.09-.13)	72.53**	2[b]
2 CTCU IVI + KI vs. EVI	113.60**	41	.92	.78	.86	.06	.09 (.07-.11)	38.27**	2[b]

Notes: **p < .001; $\Delta\chi^2$ = chi-square difference test; Δdf = difference in degrees of freedom; [a]= compared to CT model and [b]= compared to CTCU model. The CTCU VI vs. KI is the correlated trait-correlated uniqueness model with internal visual imagery (IVI) and external visual imagery (EVI) combined into a single factor (visual imagery; VI) and kinesthetic imagery (KI) as the other factor. The CTCU IVI + KI vs. EVI model is the correlated trait-correlated uniqueness model with IVI and KI combined into a single factor and EVI as the other factor.

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Table 3
Standardized Factor Loadings for CT and CTCU models

Item	Trait ıd	CT model	CTCU model	CTCU VI vs. KI	CTCU IVI + KI vs. EVI
1	KI	.58	.58	.56	.55
2	IVI	.56	.56	.59	.50
3	EVI	.57	.57	.53	.57
4	KI	.60	.60	.62	.51
5	IVI	.66	.66	.64	.59
6	EVI	.64	.64	.65	.64
7	KI	.69	.69	.65	.64
8	IVI	.51	.51	.51	.40
9	EV	.65	.65	.67	.64
10	KI	.63	.63	.62	.57
11	IVI	.64	.64	.61	.59
12	EVI	.67	.67	.66	.66

Table 4
Correlated Error Terms for CTCU models

Item	CTCU model	CTCU VI vs. KI	CTCU IVI + KI vs. EVI
e1↔ e5	.008	.045	-.089
e1↔ e9	-.079	-.130	-.102
e5↔ e9	.164	-.029	.184
e4↔ e8	.191	.192	.080
e4↔ e12	-.030	-.013	-.041
e8↔ e12	.062	-.067	.088
e7↔ e3	.066	-.005	.050
e7↔ e11	-.068	.036	-.193
e3↔ e11	-.040	-.155	-.042
e2↔ e6	.326	.150	.335
e2↔ e10	.206	.215	.106
e6↔ e10	.268	.211	.242

Test-retest reliability. Based on Shrout's (1998) classification, test-retest reliabilities varied from fair to substantial. ICC classifications were substantial for kinesthetic imagery (0.82), moderate for internal visual imagery (0.72), and fair for external visual imagery (0.43). Similar trends were found for both males and females, with higher correlations obtained for kinesthetic imagery and lower correlations obtained for external visual imagery (see Table 5).

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Table 5.
Test-retest IntraClass correlations

	Kinesthetic imagery	Internal visual imagery	External visual imagery
Total	0.82[s]	0.72[m]	0.43[f]
Male	0.70[m]	0.75[m]	0.50[f]
Female	0.82[s]	0.70[m]	0.41[f]

Note. [a]substantial agreement; [m]moderate agreement; [f]fair agreement

Self-reported movement imagery abilities. The means and confidence intervals for the self-reported ease of imaging as a function of sex, age group, and imagery perspective are displayed in Table 6. Self-reported ease of imaging showed differences across the imagery modalities, with external being the easiest, followed by internal, and kinesthetic being the most difficult. This was supported by a significant main effect of Modality, $F(2, 396) = 64.04$, $p < .001$, $\eta_p^2 = .25$. *Post hoc* analysis revealed that each imagery modality was significantly different from one another ($p < .001$).

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Table 6. *Means, confidence intervals, and standard deviations*

Gender	Age group (years)	Modality	Mean (95% CI)	Standard deviation (SD)
All	7-8	EVI	5.55 (5.32-5.79)	0.993
		IVI	4.99 (4.76-5.23)	1.007
		KIN	4.74 (4.51-4.96)	0.970
	9-10	EVI	5.95 (5.79-6.12)	0.640
		IVI	5.25 (5.00-5.51)	0.976
		KIN	4.70 (4.37-5.02)	1.252
	11-12	EVI	5.59 (5.34-5.84)	1.068
		IVI	5.29 (5.04-5.54)	1.070
		KIN	4.89 (4.65-5.13)	1.006
	All ages	EVI	5.69 (5.55-5.82)	0.994
		IVI	5.17 (5.03-5.32)	1.025
		KIN	4.78 (4.63-4.93)	1.070
boys	7-8	EVI	5.41 (5.06-5.76)	0.972
		IVI	5.03 (4.64-5.41	0.976
		KIN	4.76 (4.36-5.16)	0.939
	9-10	EVI	5.96 (5.56-6.35)	0.554
		IVI	5.18 (4.75-5.61)	0.976
		KIN	4.69 (4.24-5.15)	0.938
	11-12	EVI	5.72 (5.37-6.06)	0.969
		IVI	5.42 (5.05-5.80)	1.120
		KIN	4.89 (4.49-5.28)	1.017
	All ages	EVI	5.69 (5.48-5.90)	0.892
		IVI	5.21 (4.98-5.44)	1.057
		KIN	4.78 (4.54-5.02)	0.959
girls	7-8	EVI	5.64 (5.36-5.92)	1.006
		IVI	4.97 (4.67-5.28)	0.992
		KIN	4.72 (4.40-5.04)	0.999
	9-10	EVI	5.95 (5.65-6.25)	0.692
		IVI	5.30 (4.97-5.62)	0.986
		KIN	4.70 (4.35-5.04)	1.414
	11-12	EVI	5.51 (5.23-5.79)	1.134
		IVI	5.20 (4.89-5.59)	1.039
		KIN	4.90 (4.57-5.21)	1.011
	All ages	EVI	5.70 (5.54-5.87)	0.981
		IVI	5.16 (4.97-5.34)	1.008
		KIN	4.77 (4.58-4.96)	1.139

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Discussion

Having adapted the MIQ-3 to produce a first iteration of the MIQ-C, we were interested in examining its psychometric properties using a MTMM approach to CFA to determine the model that best describes the relationship among imagery perspectives and by exploring its test-retest reliability.

For the MTTM approach to CFA, results revealed that the three factor CTCU model provided a significantly better fit than other models. Specifically, compared to the CT model, the MIQ-C shows improvement in model fit when method effects are included in the model. We expected the CTCU model to be a better fit than the CT model because the same four items (movements) are used to measure the different imagery types. Also, when comparing to alternative two factor CTCU models, the three factor CTCU model was found to be a significantly better fit. The three factor model used by Williams et al. (2012) also demonstrated the most appropriate model fit for the MIQ-C. The similarity in findings is not surprising given that the MIQ-C is an adaptation of the MIQ-3 instructions with no modifications to the actual item intent. These findings also suggest that internal visual, external visual and kinesthetic imagery are separate constructs in the school-age children population as they are in the adult population (Williams et al., 2012). When one compares the fit of the MIQ-C with that of the MIQ-3, we find that MIQ-C has somewhat poorer fit than the MIQ-3 but still acceptable. These differences might be due to greater sample sizes used by Williams et al. as well as differences in the sample (adults vs. children) and the modifications to the wording/instructions. Despite these differences, we note more similarities than differences. First, both the MIQ-3 and the MIQ-C found the CTCU model to be the best fit to the data, similarly sized interfactor correlations, factor loadings, and correlated uniqueness terms were found.

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The MIQ-C'S ability to distinguishing the kinesthetic perspective and each visual imager perspective (internal vs external) has been shown to fit how athletes use imagery and is also supported statistically (Williams et al., 2012). Possessing imagery ability information on each of the three perspectives will provide a more comprehensive understanding of children's ease of imaging. Furthermore, as described by Williams et al. (2012), separately assessing imagery perspectives, allows one to design a more beneficial imagery intervention (e.g., determine whether a particular imagery ability requires more improvement so it can be used more efficiently).

A strength of this study is that a MTMM was used to examine the data, revealing that a methods effect occurs when using the same item to measure different factors. This is significant as this was not identified in earlier attempts to validate earlier version of the MIQ (such as the MIQ-R), but was an issue that has been pointed out by Roberts et al. (2008) for the VMIQ-2 and Williams et al. (2012) for the MIQ-3.

Test-retest values for the MIQ-C ranged from fair for external visual imagery to substantial for kinesthetic imagery. This was surprising given external visual imagery was reported as the easiest perspective to image from and kinesthetic was reported as the most difficult. Williams et al. (2011) noted that ease of imaging is facilitated by observation when it is congruent with (i.e. matches) the imaging perspective. We propose similar reasoning may also be true for our results.

The increased reliability with the kinesthetic perspective may be due to increased congruence between recent movement performance and imaging request. Notably, children performed the movement prior to imaging it and had just been actively engaged in discerning their kinesthetic sense in the instruction phase of the questionnaire administration. The internal visual perspective test-rest reliability was also found to be better than external visual imagery. As with the kinesthetic perspective, there is an increased congruence between the

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performance engaged in and imagery perspective. During the movement requested, prior to the internal visual imaging request, children's view during movement was likely that from an internal visual perspective. While the external visual perspective was found to be the easiest to imagine, this perspective showed the lowest test-rest reliability. We hypothesize that this may be influenced by a lack of congruence experience with this perspective. It is unlikely that children's movement performance would allow them view themselves from an external visual perspective thereby diminishing the congruence between children's view during movement and the visual imagery perspective requested.

Boys and girls did not differ in their MIQ-C scores. This lack of gender difference was also noted in studies with adults (Williams et al., 2012). There was also no significant difference in the scores among the three age groups. This finding is rather surprising as it is generally accepted that imagery ability improves with age and experience (Caeyenberghs et al., 2009; Choudhury, Charman, et al., 2006; Skoura, et al., 2005; Smit-Engelsman, & Wilson, 2013) so it was expected that older children would demonstrate a greater ease to image than younger children. It is possible that once the ability to image is established at around 7 years of age, there are few occasions to intentionally use imagery and so the ease of imagery does not change significantly between 7 and 12 years.

Significant differences were obtained among the three imagery modalities. The kinesthetic modality was rated as the most difficult while external visual imagery was rated as the easiest. These findings confirm that ease of imagery differs depending on the imagery modality and perspective used (Callow & Roberts, 2010) and corroborates that younger children can use KI to image simple movements (Quinton, Cumming, Gray, Geeson, Cooper, Crowley, & Williams, 2014). A similar finding is reported in other imagery studies where kinesthetic imagery was also reported as more difficult to do than visual imagery (e.g., Hall

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& Martin, 1997). However, these studies involved adults and did not distinguish between visual perspectives.

Parker and Lovell (2012) investigated whether age differences in movement ability exists within samples of youth sport performers. They used the VMIQ-2 with youth sport performers (12-20 years) and found, contrary to the present study, greater mean scores for IVI and lowest scores for EVI. More recently, Quinton et al. (2014) investigated an imagery intervention with school-aged children (7-12 years) from a futsal club. Using the MIQ-C, as in the present study, they found that children more easily imaged from a visual perspective than a kinesthetic perspective. However, unlike the present study's findings, they did not find any significant difference in the two types of visual imagery. Choudhury, Blakemore, and Charman (2006) reported that the ability to take on different spatial perspectives (internal vs external) parallels brain maturation in children. Interestingly, they found that pre-adolescents displayed a greater difference in reaction times between internal perspective and external perspective than did adolescents, with the least difference found in adults. They hypothesized that the differences in spatial perspective ability in younger participants are indicative of inefficient processing and reflect an immature cognitive mechanism for perspective taking. As such, a difference between IVI and EVI scores in school age children would be expected. However, the contrasting results for significant difference for ease of imagery between IVI and EVI, obtained by Parker and Lovell (2012) or the lack of difference found by Quinton et al. (2014), are less clear. The role of age and movement experience (youth performers) in relation to the development of perspective taking needs to be further explored.

In conclusion, through this multi-step process, we have adapted an existing movement imagery questionnaire so it can be used with children. The resulting MIQ-C questionnaire was found to be a valid and rather reliable movement imagery questionnaire that is

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appropriate to use with children. As such, it can be used as a screening tool, in a research, sport or rehabilitation setting, for identifying children who may benefit from an imagery intervention. Likewise, it can be used as an evaluative tool for assessing imagery ability in children prior to and following intervention, as in Quinton et al. (2014), to determine the effectiveness of interventions on imagery ability. Such an evaluation tool can provide important information on possible movement imagery ability difference among children of different ages, movement experience, and disorders (e.g., developmental coordination disorder). Imagery is a complex, multidimensional construct that, to be properly understood, requires a combination of evaluation approaches that can be combined to produce an aggregate index of movement imagery (Collet et al., 2011). The MIQ-C can be used to supplement the other approaches recommended by Collet et al. (2011), so as to produce the most accurate measure of a Motor Imagery Index for children. Presently, movement imagery in children is poorly understood. It is hoped that this questionnaire can help provide greater insight on the movement imagery abilities of children aged 7-12 years. Further research should continue to explore the psychometric properties of the MIQ-C such as predictive validity and concurrent validity with other imagery measures.

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Highlights

- **Using cognitive interviewing, we adapted the MIQ-3 for use with children (MIQ-C)**
- **The MIQ-C was validated with 206 children using a confirmatory factor analysis**
- **Test-retest reliabilities were explored with a subset of 23 children**
- **The MIQ-C was found to be a valid and rather reliable movement imagery question for children**
- **This questionnaire can help provide greater insight on the movement imagery abilities of children aged 7-12 years.**

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