Featured Article

Conceptualising a modified system for classification of in-hand manipulation

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Occupational therapists consider in-hand manipulation (IHM) to be an important component of fine motor skills and to be related to handwriting and self-care proficiency. These relationships have not been well explored nor has the impact of intervention including IHM skill enhancement on proficiency in motor tasks. We propose that the existing conceptualisation of IHM may contribute to a dearth of evidence in this area. This paper closely examines the existing classification systems of IHM. We propose an adaptation of Exner’s classification system which contains more discrete categories of IHM movements and includes: finger-to-palm translation to achieve stabilisation, palm-to-finger translation, simple shift, complex shift, simple rotation and complex rotation. Further research to test this modified classified system and to explore evidence for IHM intervention is warranted.

KEY WORDS child, fine motor skills, hand, in-hand manipulation, task performance and analysis.

Introduction

The term in-hand manipulation (IHM) was coined by Exner (1989) and is used to describe the manipulation of an object within the hand after grasp. IHM skills develop in children between the ages of 18 months and 7 years (Exner, 1992), but between 3 and 6 years of age, there is rapid development in IHM skills, with an increase in the consistency and maturity of methods used to manipulate objects (Pehoski, Henderson & Tickle-Degnen, 1997a,b). There appears to be no significant difference between boys and girls in the performance of IHM skills (Pehoski et al., 1997a,b).

Occupational therapists consider IHM to be an important component of fine motor skill (Ziviani & Wallen, 2006). A component analysis to identify the source of occupational dysfunction is fundamental to the occupational therapy diagnostic and treatment processes. Few studies however, have examined the relationships between IHM and various fine motor activities in order to better understand the interrelationship between these factors. Case-Smith (1995, 2000), for instance, tested aspects of IHM and fine motor proficiency in children aged 4 to 6 years (total n = 74) and found moderate to high correlations between two IHM tasks and the Peabody Developmental Motor Scales — Fine Motor Scale (Folio & Fewell, 1983) (r = –0.65 to –0.80, P < 0.005). These results provide some support for a relationship between IHM and fine motor skills. The nature of this relationship needs more extensive research.

Although IHM is also thought to be an integral component of the motor aspect of handwriting (Cornhill & Case-Smith, 1996; Denton, Cope, & Moser, 2006; Feder, Majnemer, Bourbonnais, Blayney & Morin, 2007; Feder, Majnemer, Bourbonnais, Platt & Blayney, 2005; Tomchek & Schneck, 2006; Ziviani & Wallen, 2006), there has been very little research exploring the relationship between IHM and handwriting. There are inconclusive. Cornhill and Case-Smith found high correlations between the Minnesota Handwriting Test (MHT, Reisman, 1995) and IHM tasks using a pegboard (r = –0.77 to –0.80, P < 0.01). In contrast, Feder and colleagues in two studies (2005, 2007) did not find meaningful correlations between the Evaluation Tool of Children’s Handwriting-Manuscript (ETCH-M; Amundson, 1995) and IHM measured using a pegboard (2005: r = –0.05 to –0.28, P > 0.05; 2007: r = 0.44 to –0.31, P < 0.05). Children who experience difficulty with IHM skills may encounter difficulty mastering basic self-care tasks (Breslin & Exner, 1999; Exner, 1990; Jewell & Humphry, 1993). Humphry, Jewell and Rosenberger

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IHM can be broadly classified into two categories at best but often contradictory. Methods of testing findings and may give rise to evidence that is inconclusive used to test IHM skills makes it difficult to compare methods of testing IHM skills. The four existing methods described in the literature include the In-Hand Manipulation (Humphry, 1999), the Test of In-Hand Manipulation (TIHM) (Case-Smith, 1995), the Observation Protocol of In-Hand Manipulation and Functional Skill Development (Humphry et al., 1995) and the IMT-Q (Breslin & Exner, 1999) are included in this first category.

The category of tests that employ a pegboard, measures only two categories of IHM: rotation and translation with stabilisation. Pehoski and colleagues’ (1997a,b) unnamed method of testing IHM and the TIHM (Case-Smith, 1996) are included in this category. Using a single piece of equipment increases the ease of administration of the test. However, IHM is only observed in one context and during the performance of an unfamiliar task. The tests do not include all forms of IHM which may reduce the ability to directly relate the test results to the child’s everyday level of function as compared to multi-object tests of IHM skills. This assertion that has yet to be tested.

Differences in test administration also have made comparison of findings difficult, even when the studies were done by the same researcher. For example, Smith-Zuzovsky and Exner (2004) used Draft number 11 of the IMT-Q, which included 55 items, to examine the effect of different seating positions on IHM skills in 40 children. In 1999, Breslin and Exner used another version of the IMT-Q with 60 items to examine the ability of the test to discriminate between boys with and without spastic diplegia. Variations in the number of items and the scoring procedures have been observed in earlier studies also (Exner, 1990a,b, 1993).

Differences in the use of data from Case-Smith’s studies have also been observed. Case-Smith has used six different combinations of results produced by the TIHM in her data analyses from different studies. For example, in Case-Smith’s 1996 study, two tasks, rotation and translation are examined. Two results are produced for each task: time taken to complete the task and number of drops. Since 1998, however, Case-Smith has used a single composite score of the time taken and number of drops for each of the rotation and translation tasks (Case-Smith, 2000, 2002; Case-Smith et al., 1998).

The precise reasons for the inconsistencies in the nature of tests of IHM and in the coding of scores are unknown. IHM is a complex phenomenon. Not only are there several discrete albeit related aspects of IHM but each aspect demands an evaluation of both quality and speed of execution. Potentially, difficulties accurately conceptualising IHM may contribute to these issues with measuring IHM and relating these measures to other aspects of fine motor and occupational performance.

Issues relating to the measurement of in-hand manipulation

Researchers exploring IHM have developed their own methods of testing IHM skills. The four existing methods described in the literature include the In-Hand Manipulation Test — Quality Section (IMT-Q) (Breslin & Exner, 1999), the Test of In-Hand Manipulation (TIHM) (Case-Smith, 1996), Pehoski and colleagues’ unnamed test (Pehoski et al., 1997a, 1997b), and the Observation Protocol on In-hand Manipulation and Functional Skill Development (Humphry et al., 1995). Variation in the methods used to test IHM skills makes it difficult to compare findings and may give rise to evidence that is inconclusive at best but often contradictory. Methods of testing IHM can be broadly classified into two categories characterised by the type of tasks used in testing. These are simulated performance of daily life tasks and pegboard tasks.

The authors of tests that simulate daily life tasks assert that observing IHM in the way that a child would normally complete everyday tasks, and in a number of different situations, leads to more thorough measurement and results in a more realistic perception of a child’s abilities. The IMT-Q (Breslin & Exner, 1999) and the Observation Protocol of In-Hand Manipulation and Functional Skill Development (Humphry et al., 1995) are included in this first category.

The lack of evidence to support prevailing practice in this area possibly stems from difficulties with the measurement of IHM based on a potentially faulty conceptualisation of IHM. This paper briefly explores inconsistencies in IHM measurement and then examines the literature from which occupational therapists’ classification of IHM was drawn. Based on this examination, we propose a modification of the classification system that may be used as a basis for future test development and subsequent research.
Issues relating to the conceptualisation of in-hand manipulation

A comprehensive search of the literature revealed two systems for conceptualising and classifying IHM: Elliott and Connolly (1984) Classification of Intrinsic Hand Movements, and Exner’s (1992) Classification System of IHM. These systems have been critical in advancing the understanding of hand movements and in providing a framework for the existing research in the area of IHM. Both of these classification systems have advantages and disadvantages in relation to their use by clinicians to describe IHM.

Elliott and Connolly’s classification of intrinsic hand movements

Elliott and Connolly developed a detailed classification system to describe the movements of the fingers used to manipulate an object within the hand after grasp. They described four broad classes of manipulative hand movements: simple synergies, reciprocal synergies, sequential patterns, and palmar combinations (see also Table 1).

1 Simple synergies describe movements involving all the participating digits, including the thumb, moving as one unit (i.e. all flex or extend). Examples include threading cotton through the eye of a needle, or squeezing a small ball.

2 Reciprocal synergies are seen when the thumb moves independently of the fingers, and when all the fingers involved act as a single unit. An example of a reciprocal synergy movement is unscrewing a freely turning nut or rolling a small piece of clay between the pads of the thumb and fingers.

3 Sequential patterns are characterised by the participating digits moving independently of each other to form a distinct pattern. Discontinuous movement of the object occurs while some or all of the digits break contact with the surface of the object, enabling the object to be repositioned. For example, making multiple turns when unscrewing a jar lid, or turning a pen end-over-end.

4 Palmar combinations involve part of an object being immobilised in the ulnar portion of the hand while the radial digits manipulate another part of the object at the same time. Tying knots with string or pushing the lid off a pen using one hand are examples of palmar combinations.

Elliott and Connolly (1984) also described a number of individual movement patterns in each class of intrinsic hand movements. These movement patterns can be distinguished by the number of digits involved or by different movements of the thumb (e.g. flexion and extension versus abduction and adduction). Elliott and Connolly focussed on a detailed description and classification of intrinsic hand movements based on the movement patterns of the hand required to displace an object. The classification system is complex, and the small differences in the classification of individual movement patterns within each of their four classes may be difficult to observe. Exner (1992), in appraising the classification system, expressed concern that the palmar combinations class did not address handling more than one object in the hand at a time. Exner also noted that the language used to label and describe the movement patterns in the classification system could not be easily adapted to assist communication between the therapist and parents or teachers, which may limit its clinical utility. Thus, she did not include it in her description of IHM. This classification, however, may be beneficial for use in research when a comprehensive system is required (Exner, 1992).

Exner’s classification system of in-hand manipulation

Exner’s work on IHM was based in part on the earlier work done by Elliott and Connolly (1984). Her system for classifying IHM (Exner, 1989, 1990, 1992) has been used by therapists and authors for nearly 20 years. Exner (1992) described five types of IHM: finger-to-palm translation, palm-to-finger translation, shift, simple rotation and complex rotation. She also described an aspect of IHM named ‘stabilisation’, which is when one or more objects are held in the ulnar portion of the palm during an IHM. Stabilisation can occur with any of the following five types of IHM.

1 Finger-to-palm translation describes an object being moved from the fingertips into the palm of the hand for at least brief storage there (e.g. picking up coins from a purse and moving them into the hand).

2 Palm-to-finger translation is seen when an object is moved from the palm of the hand into the fingertips (e.g. when putting multiple coins into a vending machine one at a time). To be considered a translation movement, the object needs to start or stop in the fingers distal to the distal interphalangeal joint.

3 Shift describes the linear movement of an object along or across the fingertips. Two examples of shift movements are fanning several playing cards or moving the fingers down the shaft of a pencil in preparation for writing.

4 Simple rotation occurs when an object is turned or rolled between the pads of the thumb and fingers (e.g. rolling a small piece of play dough into an elongated shape).

5 Complex rotation describes the isolated and independent finger movement required to rotate an object between 180° and 360°. An example of complex rotation is turning a pen end-over-end.
### TABLE 1: Comparison of Elliot and Connolly (1984), Exner (1992) and Pont et al.’s Classifications of in-hand manipulation (IHM)

<table>
<thead>
<tr>
<th>Reciprocal synergies</th>
<th>Exner (1992)</th>
<th>Pont, Wallen &amp; Bundy</th>
<th>Examples</th>
<th>Differences between classifications</th>
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<tbody>
<tr>
<td>Movement of an object where the thumb moves independently of the fingers, and when all the fingers involved act as a single unit.</td>
<td>Finger-to-palm translation, where an object is moved from the fingertips into the palm of the hand for at least brief storage there.</td>
<td>Finger-to-palm translation to achieve stabilisation</td>
<td>• Picking up multiple objects (e.g. coins, pegs, small pieces of food — sultanas, grapes, small building blocks) with one hand, storing them in the palm of the hand.</td>
<td>Exner’s (1989) earlier definition of finger-to-palm translation was congruent with Elliot and Connolly’s simple synergies class, which Pont et al. define as simple shift. However, as Exner’s definitions evolved, her description of translation (Exner, 1992) diverged from Elliot and Connolly. Elliot and Connolly do not mention movement patterns that are similar to Exner’s (1992) later definitions of finger to palm or palm-to-finger translation. It seems that translation is not a ‘pure’ IHM, rather, it is a combination of shifts and rotations, which may account for the use of passive forces, such as gravity to assist the most mature method of accomplishing some translation tasks. Pont et al.’s classification system acknowledges the importance of achieving stabilisation. Translation is included as it is considered an important aspect of IHM rather than the individual movement patterns that are used to achieve translation, reinforcing that stabilisation is the principal objective of finger-to-palm translation.</td>
</tr>
<tr>
<td>Palm-to-finger translation</td>
<td>Palm-to-finger translation</td>
<td>An object is moved from its stabilised position in the palm to the tips of the fingers. With maturity, gravity may be used to assist the movement of the object.</td>
<td>• Placing multiple coins from the palm of the hand into the fingertips for placement in a vending machine, money box, etc.</td>
<td>• Retrieving objects (e.g., pegs, small building blocks, small pieces of food) for use of voluntary release (e.g., placement of blocks to make a tower, eating sultanas/grapes, using multiple pegs while hanging washing • Retrieving one key from a key ring held in the palm of the hand.</td>
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Simple synergies
Movement of an object where all the participating digits, including the thumb, move as one unit.

Sequential patterns
Movement of an object where participating digits move independently of each other to form a distinct pattern.

Discontinuous movement of the object occurs while some or all of the digits break contact with the surface of the object, enabling the object to be repositioned.

Shift
Linear movement of an object along or across the fingertips.

Simple shift
Linear movement of an object where all the participating digits, including the thumb, move as one unit.

May be completed in combination with stabilisation which has been achieved using translation.

- Squeezing a ball.
- Squeezing a syringe.
- Threading cotton through the eye of a needle.
- Pushing a key into/out of a keyhole.
- Pushing a coin from the fingertips into the slot of a vending machine.
- Pushing beads onto a piece of string.
- ‘Walking’ fingers down the shaft of a pen to position it for use.

Complex shift
An object is moved in a linear direction by the digits repositioning on the object. The three ulnar digits tend to move as a unit.

- Squeezing a ball.
- Squeezing a syringe.
- Threading cotton through the eye of a needle.
- Pushing a key into/out of a keyhole.
- Pushing a coin from the fingertips into the slot of a vending machine.
- Pushing beads onto a piece of string.
- ‘Walking’ fingers down the shaft of a pen to position it for use.

TABLE 1: Continued.

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<td>Simple synergies</td>
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<td>object to be repositioned.</td>
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Pont et al.’s definition takes into consideration the possible utilisation of gravity to assist the movement of the object between the fingertips and the palm.

Pont et al. defines shift using the movement patterns of the involved digits and the displacement of the object. This removes the potential for overlap with rotation noted with Exner’s descriptions of shift and rotation.

The complex shift pattern described by Pont et al. acknowledges that shift in a linear direction is also achieved with discontinuous movements of the radial fingers (in particular). Two subgroups of Elliott and Connolly’s sequential pattern class have been delineated into Pont et al.’s complex rotation and complex shift. This delineation increases the congruence between Elliott and Connolly and Exner’s classification systems, taking into consideration the complexity of the movement patterns and the nature of displacement of the object.
TABLE 1: Continued.

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<tr>
<td>Complex rotation</td>
<td>Complex rotation</td>
<td>Independent and isolated finger movements are used to rotate an object about one or more of its axes.</td>
<td>• Picking up a pencil with tip facing ulnarly or radially and orientating it for use.</td>
<td>Pont et al.’s definition of complex rotation modifies Exner’s description to include rotation produced by complex movement patterns without being dependent on the magnitude of the rotation. This reduces the overlap in Exner’s system between simple rotation and complex rotation categories.</td>
</tr>
<tr>
<td>Reciprocal synergies</td>
<td>Simple rotation</td>
<td>Simple rotation</td>
<td>• Screwing/unscrewing the lid of a jar/bottle.</td>
<td>Pont et al.’s description of simple rotation is distinguished from other IHMs by the movement patterns of the hand rather than the magnitude or nature of object displacement. Manipulation results in rotatory action which usually results in rotation around a single axis in appropriately shaped objects.</td>
</tr>
<tr>
<td>Movement of an object where the thumb moves independently of the fingers, and when all the fingers involved act as a single unit.</td>
<td>- Screwing/unscrewing nuts and bolts.</td>
<td>- Rolling a small ball of play dough in the fingertips.</td>
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<tr>
<td>Palmar combinations</td>
<td>Stabilisation</td>
<td>One or more objects are stored in the ulnar portion of the palm. Stabilisation can occur whilst another IHM is being performed.</td>
<td>• Fanning several playing cards.</td>
<td>Stabilisation is not a unique class of Pont et al.’s classification of IHM. It is acknowledged that one or more, or part of an object may be stabilised in the ulnar portion of the hand while another object or part of an object is being manipulated by other digits, using any one of the other forms of IHM.</td>
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Exner (1989, 1990, 1992) seems to have considered three factors in developing her classification system: the amount of displacement of an object, the type of displacement of the object and the movement patterns of the hand. Although these factors appear clearly delineated, their combination in Exner’s classification system may result in confusion when applied clinically. An example is picking up a pen placed with the tip oriented toward the ulnar side of the hand. The pen is picked up and then rotated in the fingertips slightly less than 180° to be positioned for writing. According to Exner’s (1992) classification system, simple rotation results in rotation of an object 180° or less by using reciprocal thumb and finger movements; and when more than one finger is involved, they typically act as a single unit. The pen in the example is rotated less than 180° thus the IHM has the potential to be defined as simple rotation. To position the pen for writing, however, it is prehended between the thumb and index finger while the middle finger guides it into position. This isolated movement of the middle finger is not consistent with Exner’s definition of simple rotation. In contrast, Exner’s definition of complex rotation involves independent and isolated movements of the digits, where the object is typically stabilised by some digits while being moved by others. The movement of a pen in the example therefore might be more correctly classified as complex rotation. Exner, however, also specifies that during complex rotation the object is rotated between 180° and 360°.

Difficulty distinguishing simple from complex rotation is also observed in the literature. Both Case-Smith (1993) and Denton and colleagues (2006) observed IHM skills in children using a rotation task where five pegs are picked up from a pegboard, rotated 180° in the fingertips, and then replaced in the pegboard. Case-Smith described this task as a complex rotation, whereas Denton and colleagues used the term simple rotation to describe the same task. Confusion about the distinction between complex and simple rotation may contribute to inconsistent conclusions about the relationship between IHM and other aspects of fine motor performance.

Similar confusion surrounds Exner’s classification of shift and simple rotation. Exner (1989, 1990, 1992) described shift as the linear movement of an object in either vertical or horizontal directions across or among the fingers and, further, that shift involves alternating movements of the thumb and fingers. Exner’s (1989, 1990, 1992) descriptions of shift and simple rotation differ only in that during shift the object is moved in a linear direction, whereas in simple rotation the object is rotated. Exner (1989, 1990) illustrated simple rotation with a description of a small ball of clay rolled between the fingertips of the thumb and radial fingers; and horizontal shift by separating pages to turn one at a time (Exner, 1989, 1990). In both types of IHM, the movements of the thumb alternate with those of the fingers. Thus, the primary difference between rotating and shifting an object in a linear direction may be more a function of the shape of the object than of differences in finger movements. The shape of the page does not allow the thumb and fingers to rotate it in the hand; rather, the paper slides through the thumb and index finger.

Further confusion arises when the example of ‘walking’ the fingers along the shaft of a pencil is considered. The pen is being ‘shifted’ because it moves in a linear direction. However, the fingers and thumb move in complicated reciprocal patterns that do not seem consistent with Exner’s (1989, 1990, 1992) descriptions of shift involving alternating movements of the thumb and fingers. Shift therefore is not a straightforward classification and this complexity may be the reason that shift is not included in tests of IHM other than Exner’s (Breslin & Exner, 1999).

Translation is another component of Exner’s classification that requires further consideration. Pehoski and colleagues (1997b) found that the most mature method of translation involves gravity assisting with the movement of the object into and out of the palm. In mature finger-to-palm translation, for example, an object is moved into the palm by supinating the forearm and flexing the wrist and allowing the object to drop into a position whereby it can be stabilised by the ulnar fingers. Pehoski and colleagues also found that gravity is used to assist in the most mature method of palm-to-finger translation as the forearm is lowered to allow the object to drop into the fingertips. Thus, both these translations may occur without substantial use of IHM skills. Clearly there are difficulties with classifying IHM skills using Exner’s system.

A proposed method of classifying in-hand manipulations

Increasing the consistency between Elliott and Connolly’s (1984) and Exner’s classifications of manipulative hand movements may help to focus knowledge in IHM leading to development of a uniform assessment to measure IHM and as a basis for future research to boost our understanding of the relationship of IHM to occupational performance. Towards that aim, we propose an adaptation of Exner’s (1992) classification system that incorporates the following two considerations drawn from Elliott and Connolly.

First, we seek to achieve discrete classes of IHM that consider both displacement of the object and the complexity of the movement patterns required to complete the manipulation. The proposed classification system divides Exner’s ‘shift’ category into two IHM types: simple shift and complex shift. Simple shift describes the movements of an object produced by simultaneous flexion or extension of the thumb and fingers as a single unit. Simple shifts would be classified as simple synergy movements in Elliott and Connolly’s (1984) system; typically simple shifts result in linear movement of the object. In contrast, complex shift describes the linear movement of an object produced by individual finger
movements (e.g., ‘walking’ the fingers down the shaft of a pen). Complex shifts would be classified as one of Elliott and Connolly’s sequential patterns.

The second consideration involves explicit acknowledgement of the importance of achieving stabilisation of objects in the palm of the hand during translation whether or not stabilisation is the result of IHM. Mature finger-to-palm translation often is characterised by use of gravity to drop the object into the palm where it can be stabilised. It is the ability to position objects so that they can be stabilised in the ulnar portion of the hand that is the important aspect of translation rather than the use of finger movements to achieve translation. Similarly, mature palm-to-finger translations also involve use of gravity, this time to assist the object into the fingers.

This proposed alteration to Exner’s classification system of IHM movements is compared with the existing classification systems in Table 1 and further described as follows:

**Finger-to-palm translation to achieve stabilisation**

During finger-to-palm translation, an object is moved from the fingertips and pad of the thumb into the palm of the hand for at least brief storage there. Finger-to-palm translation to achieve stabilisation may occur with the assistance of gravity to assist the movement of the object. For example, picking up coins prior to placing in a purse. Figure 1 includes an example of supination to achieve stabilisation.

**Palm-to-finger translation**

Palm-to-finger translation occurs when an object is moved from its stabilised position in the palm to the tips of the fingers. Gravity may be used to assist in the movement of the object from the palm to the fingertips. Palm-to-finger translation is commonly used to retrieve an object from storage within the palm of the hand, for example when placing multiple coins into a vending machine (see Fig. 2).

**Simple shift**

In simple shift, all the participating digits, including the thumb, move as one unit (i.e. all the participating digits flex or extend). The movement required to thread a needle is an example of a simple shift movement (see Fig. 3).

**Complex shift**

Complex shift occurs when an object is moved in a linear direction as a result of the digits being repositioned on
the object. During complex shift, the two ulnar digits tend to move as a unit. An example of complex shift occurs when a ‘walking’ movement of the fingers down the shaft of a pen is used to reposition the pen in the hand to write (see Fig. 4).

**Simple rotation**

During simple rotation, the thumb moves independently of the fingers, and all the involved fingers act as a single unit. Movements classified as simple rotation include
screwing/unscrewing jar lids, rolling clay to make an elongated shape, turning a page in a book and unscrewing freely turning nuts (see Fig. 5).

**Complex rotation**
Complex rotation occurs when an object is rotated about one or more of its axes and when independent and isolated finger movements are required to rotate the object.

An example of complex rotation is turning a pen end-over-end to position it for writing (see Fig. 6).

Stabilisation is another aspect of IHM that occurs when one or more objects, or part of an object are prehended in the ulnar portion of the hand. Stabilisation may occur during other IHM movements, but translation is used to move the object to and from the stabilised position.
In proposing an adaptation of Exner’s classification system of IHM, we took great care to systematically reveal and describe the inconsistencies identified in the existing classifications. Further research, however, will inform as to whether this adapted classification system will facilitate the development of evidence about the importance of IHM and its relationship to the performance of fine motor skills.

Summary and conclusions

IHM is widely considered to be an essential skill that enables dextrous use of the hands to manipulate tools and objects in a meaningful way. There continues to be a strong interest in IHM despite insufficient evidence demonstrating a relationship between IHM and other aspects of children’s fine motor performance. This attention seems to be based on therapists’ intuitive beliefs that fine motor skill is dependent on the manipulation of objects or tools to prepare them for voluntary placement or use.

Work by Exner (1989, 1990, 1992) has provided an essential foundation for the existing research in IHM. Her classification system has guided clinical practice in relation to IHM since it was first proposed in 1989. Some difficulties discretely classifying IHM movements using Exner’s system may cause confusion when describing IHM skills and consequently to the inconsistencies observed in the literature and the difficulty developing a test of IHM. Confusion over the classifications of IHM may also result in therapists not including all types of IHM in their observation of IHM skills. Such omissions may lead to incomplete assessment.

Our adaptation of Exner’s (1992) classification system involves more discrete categories of IHM movements. This adaptation is consistent with both Elliot and Connolly’s (1984) classifications of manipulative hand movements and Exner’s (1989, 1990, 1992) descriptions of the movements required to manipulate objects within the hand after grasp. The proposed classification system includes six categories of IHM: finger-to-palm translation to achieve stabilisation, palm-to-finger translation, simple shift, complex shift, simple rotation and complex rotation. This classification system should form the basis for the development of an IHM assessment with consideration for the more discrete IHM categories proposed by this system.

A reliable and valid assessment of IHM is required to enable a deeper understanding of the relationships between IHM and other aspects of performance as well
FIGURE 6: Sequence showing complex rotation.
as providing convincing evidence about the effects of therapy using specific IHM intervention (Dunn, 2005). Measurement of IHM skills is also useful for the diagnosis of IHM dysfunction, intervention planning and measurement of outcomes. Such a test is not readily available for use despite experimental work reported in the literature on several instruments (Breslin & Exner, 1999; Case-Smith, 1996; Humphry et al., 1995; Pehoski et al., 1997a,b). The challenges we have outlined in adequately classifying IHM may have contributed to the lack of availability of a definitive test of IHM, one that can be tested for psychometric properties and then be used to examine IHM in future research.

There is a wealth of future research to pursue should a test of IHM demonstrate reliability and validity and be consistent with a classification system of IHM. As a priority, the relationships between IHM and fine motor skills, handwriting and self-care can be explored with greater authority. If a relationship is identified, then further research can identify whether intervening to improve impaired IHM will result in enhanced performance in functional fine motor tasks such as handwriting, cutting with scissors and buttoning.

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