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# Cognitive developmental influences on the ability of preschool-age children to self-report their pain intensity

Jenny Yun-Chen Chan [1]

Carl L von Baeyer [2]

[1] Institute of Child Development, University of Minnesota-Twin Cities, Minneapolis, USA

[2] Department of Clinical Health Psychology, and Department of Pediatrics and Child Health, Faculty of Medicine, University of Manitoba, Winnipeg, Canada

Address for correspondence:

Prof Carl L von Baeyer, 203 – 147 Provencher Blvd, Winnipeg, MB R2H 0C9, Canada

Phone: +1 204 235 1314; email: carl.vonbaeyer@usask.ca ; web: www.tinyurl.com/cvb-pubs

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## 1. Introduction

Pain is defined primarily as a subjective experience [25]; thus, self-report, when available, is considered to be the primary source of information on pain intensity [46]. Children are not always reliable at self-report [40], so it is not surprising that children under the age of 5 years often report their pain intensity in an idiosyncratic way that appears inappropriate for the context [44, 45].

To elucidate young children's understanding and use of pain intensity scales, we provide an overview of literature on the development over the preschool years of a variety of cognitive skills required for self-report of pain. Table 1 lists many of these age-related abilities, with reference to relevant studies. As discussed below, these abilities are important for understanding, estimating, and reporting pain intensity.

*Insert Table 1 about here*

## 2. Memory and Knowledge of Pain

Having some knowledge of pain is needed to support accurate reporting of its existence, intensity, location, and quality. Children's understanding of pain depends in part on their previous experience with it. Although infants show anticipatory avoidance of pain, it is not until around 5 years of age that children are able to accurately describe concrete causes and perceptions of pain [17,18,28]. Infants have implicit memory of pain (e.g., sensitization, conditioning); however, the developmental constraints in language skills and the ability to organize memories in the perspective of oneself limit young children's ability to recall explicit memory of early experience [17,22,28,29,30].

When memory and knowledge of pain are available, they serve as resources for young children to draw upon when reporting pain. For instance, children who have experienced hospitalization report pain intensity from vaccination needles that is more appropriate to the situation and that correlates more highly with their parents' estimates than those without hospitalization experience [39]. Furthermore, 3- and 4-year-olds report pain intensity similar to older children after, but not before, surgery, suggesting that the experience of post-operative pain influences their understanding of pain and hence their ability to self-report pain intensity [45]. These findings suggest that knowledge, memory, language, and experiencing pain are crucial for children to understand and report pain intensity appropriately.

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## 3. Seriation and executive function skills

Performance on seriation, such as identifying the mid-sized cup from 3 different-sized cups, has been proposed to be a screener for the ability to use a self-report scale [3,42,45]. The evidence supporting this notion is weak. One study [42] found that children who failed to seriate geometric shapes by size were less accurate at rank ordering the faces in the Oucher faces scale [4], but no data on the validity of actual pain ratings using that scale in relation to the screener were collected. However, a similar study [34] found no relation between performance on a seriation task and accuracy of rank-ordering faces in the Facial Affective Scale in 3- to 5-year-olds  Although seriation seems to be a promising screener for assessing children's ability to report pain intensity, it taxes other executive function skills (e.g., cognitive flexibility, working memory, and inhibition) as discussed below. These cognitive processes develop throughout early childhood [8] and may constrain children's performance on seriation, thus weakening the association between seriation and use of a pain scale.

Cognitive flexibility is a skill of considering multiple options simultaneously or shifting attention between tasks. Children tend not to switch flexibly between rules or standards until 4 and 5 years of age [8,16,51]. Although considering multiple points on a pain scale may require some cognitive flexibility, seriating objects may demand more. Comparing and seriating multiple objects require shifting between and incorporating different comparison standards. For instance, the medium cup is big compared to the small cup but small compared to the big cup. Children need to shift between and incorporate these comparisons to correctly seriate three or more objects based on size.

Working memory, the ability to retain and manipulate information during the task, may also play a role in children's performance on seriation. The number of items an individual can hold in mind increases with development as the child acquires knowledge and learns to use memory strategies [10,20,37]. When 4-year-olds remember the relations between pairs of objects, they are more likely to succeed at seriating 5 objects according to size [6]. This suggests that the ability to hold and use information relevant to the task is important for performing seriation.

Furthermore, children need to inhibit irrelevant information and compare objects based on the relevant dimension. They also need to incorporate information from their comparisons and seriate the objects based on their ordinal relations. Four-year-olds use several strategies to seriate

multiple objects, both within and between individuals. Early emerging strategies include sorting objects based on irrelevant features (e.g., colors), stringing together pairs of small and large objects, and identifying endpoints but failing to seriate intermediate objects. More advanced strategies include the method of extremum which involves finding the largest object and the next largest and so on, then estimating and comparing neighboring items before adjusting the placements [23,38]. Implementing the steps of such advanced strategies requires inhibition of irrelevant information and coordination of executive function skills, however, these skills may not be essential for using pain scales.

**4. Knowledge of Magnitude for Estimating Pain Intensity**

One component of seriation is the understanding of magnitude and this may be the most relevant skill for using pain intensity scales. Specifically, being able to discriminate and understand the magnitude relations of objects based on a given dimension (e.g., size, brightness) is an important skill for appropriately estimating pain intensity to the extent that these dimensions are used as analogies for pain in scales.

To understand the relations between objects based on a given dimension, children need to acquire the labels to categorize magnitudes and learn the relations within a dimension (e.g., big, small, long, short, more, less) [14,32,35]. Children can verbally produce magnitude labels for size and numbers around 2 years of age [5,33], and they can reliably use the terms “more” and “less” around 4 years of age [19,47]. These relational terms are often used in the pediatric setting when asking about pain intensity, and may contribute to children’s ability in appropriately reporting pain intensity.

Children are able to label and compare two objects based on size at around their second birthday; however, they are not as flexible and efficient at doing so with three or more objects perhaps due to the developmental limitations in executive function skills mentioned above [33]. In fact, 2- and 3-year-olds are able to identify the terminals (biggest/smallest) of a series, but finding the inner positions (next smallest or medium) remains difficult for 4-year-olds [33]. Moreover, many 4-year-olds have a bias towards selecting the end points when asked to estimate the position of a number on a number line, whereas 6-year-olds are able to use the entire line for quantity estimation [2]. These results align with the finding that many 3-year-olds often fail to use the intermediate levels of a pain scale when using a 6-point scale [44], but the bias toward the scale endpoints is reduced when a simplified 3-point scale is used [43]. Together, these

findings suggest that the difficulty in discriminating and estimating intermediate levels within a scale or a dimension may be a general developmental challenge for young children.

## 5. Symbolic Processing and Related Knowledge for Using Pain Scales

Using a pain scale requires knowing the meaning of symbols such as poker chips or pictures of faces. To use these symbols, children must be able to mentally represent and maintain information about both the symbols themselves and their relations to the referent (pain intensity). This ability develops gradually over ages 2 to 6 years and is especially challenging for 2- and 3-year-olds because all symbols are simultaneously objects and representations for something else [12,13]. Thus, treating pictures or objects on pain scales as symbols representing pain intensity may not be intuitive for children 2 to 3 years of age.

In addition to representing objects as symbols, young children's ability to provide an accurate report of pain intensity may also depend on the types of scales. Although children as young as 3 years generally seem to understand the relationship between two-dimensional representations and three-dimensional objects [1], children's performance on using scales may vary. For instance, concrete physical objects may be perceptually distracting and impede children's use of scales [13,26]. Numerical scales such as the Poker Chip Tool [21] require some understanding of number, whereas faces scales require some recognition of the expression of emotion in facial expression as well as linking emotions with pain experience.

### *5.1. Numerical Scales*

Numerical scales include the Poker Chip Tool (more recently referred to as Pieces of Hurt) [21], verbal numerical rating scales (e.g., [15]), and various concrete ordinal scales [9]. Using this type of scale requires some knowledge of magnitude relations between numbers. Many children are able to recite the number sequence (i.e., 1, 2, 3, 4 …) as early as 2 years of age, without understanding their magnitude. After children learn to place number words in the number sequence, they map these words onto corresponding values that capture their magnitude relations [24]. This understanding of mapping between the first few number words and their corresponding values typically begins at around 3 years of age and develops gradually over the next 2 years [50]. The acquisition of numerical concepts supports children's ability in using numerical tools to report pain intensity.

### *5.2. Faces Scales*

Faces scales include photographic and drawn face pain scales [41]. Using this type of scale requires some knowledge of emotions and facial expressions associated with pain [11,49]. Although by age 2, many children have some basic understanding of perception, intention, and emotions, their ability to recognize emotions continues to develop in early childhood [48]. Whereas many preschoolers are successful at recognizing happiness and sadness, other more complex emotions, such as surprise and disgust, are more challenging [7]. Furthermore, while some 3-year-olds are able to recognize happy, angry, scared, and "just alright" faces, it is not until around 7 years of age that most children are successful in recognizing these facial expressions [31]. The subtle differences between the adjacent faces on pain scales may also contribute to young children's difficulty in using these scales to report pain intensity accurately.

## 6. Conclusion

In summary, using a scale to estimate and report pain intensity is a complex mental process and is often challenging for children under the age of 5 or 6. Knowledge and memory of pain are important to accurately describe and quantify pain. Knowledge of magnitude and of symbolic processing are likewise crucial. Depending on the instrument used, other cognitive variables, such as knowledge of emotions or numbers, may be involved in the process of reporting pain intensity. The participants of the cognitive developmental studies cited here are mostly typically developing children from middle and high socioeconomic status in the USA; caution should be applied when extending the findings to other populations.

Preschool children may be confused by scales designed for older children; their responses may be idiosyncratic and hard to interpret. Taking into account young children's cognitive abilities in order to simplify a faces scale has been shown to improve young children's appropriate response on self-report scales of pain intensity [43]. Methods to obtain children's self-reports of pain intensity should work within their cognitive developmental abilities so that accurate reports can be obtained for use in their health care. Such simplifications might entail reduction of the number of response alternatives, refinements in scale anchors, and careful selection of visual aids that are easily understood by most young children. Table 2 presents suggested guidelines for practice based on the cognitive developmental findings reviewed here.

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**Conflict of interest statement**

The authors have no conflict of interest related to the content of this article.

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Table

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Table 1. Task analysis of the minimum skills required for use of self-report tools. Adapted from Besenski et al [3], with permission.

| Domain | Skill | Example | References |
|---|---|---|---|
| **Memory and knowledge of pain** | | | |
| | Perceive, identify, localize pain | Pain present or absent | [17,18] |
| | Imagine or remember experiences of past events | Recall memories of painful experiences | [17,30] |
| **Receptive language and comprehension** | | | |
| | Understand the words used by the adult who is giving the instructions | Look, point to, give, tell | [39,40] |
| **Symbolic processing** | | | |
| | Recognize a symbol as representing something else | Poker chips as pieces of pain | [12,13] |
| **Magnitude estimation and relations** | | | |
| | Acquire relational terms | Understand big, little, more, less | [19,33,47] |
| | Numeration | Count out 1 to 4 poker chips | [50] |
| | Compare objects in a given dimension | Estimate and compare levels of pain in relational terms | [2,5,33,36] |
| **Emotion recognition** | | | |
| | Recognize the connections between emotions and facial expressions | Match a feeling or emotion to a picture of a face in a face pain scale | [7,9] |
| **Executive function skills** | | | |
| | Attend to the instructions and the tasks | Look at the pain scale while listening to instructions | [8,16,51] |
| | Working memory | Remember the instructions while using the pain scale | [6,20] |

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Table 2. Suggested guidelines to obtain self-report of pain intensity from preschool-aged children, based on cognitive developmental findings.

| |
|---|
| **Instructions** |
| Use the term "more" instead of "less" |
| Use visual cues in addition to verbal cues |
| Use age-appropriate terms to describe "pain" or "hurt" |
| Be aware of the working memory demand on the child |
| **Knowledge of Magnitude** |
| Make endpoints and intermediate levels clear to the child |
| The maximum number of response options should probably be 3 |
| **Knowledge of scales** |
| Use age-appropriate, familiar symbols to depict pain |
| Establish the connections between symbols and referents |
| **Memory and Knowledge of Pain** |
| Be aware of children's past experience and knowledge of pain: incorporate this information in pain assessment |