

# Assessments of sensory processing in infants: a systematic review

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**AIM** The aim of the study was to evaluate the psychometric properties and clinical use of assessments of sensory processing function, within the first 2 years of life, and to identify which assessment is the most appropriate and precise in measuring the construct of sensory processing.

**METHOD** The literature was comprehensively searched, and assessments used to measure sensory processing in infancy were systematically selected and reviewed for clinical use, reliability, validity, and responsiveness.

**RESULTS** Thirty-four assessments were identified; three met the predefined inclusion criteria. All discriminative assessments, the Sensory Rating Scale, and Infant/Toddler Sensory Profile are parent-reported questionnaires and can be administered from birth up to 3 years of age. The Test of Sensory Function in Infants is a performance-based assessment and is suitable for infants aged 4 to 18 months. Studies evaluating the psychometric properties of these three assessments differed in the properties addressed and reported poor to adequate reliability.

**INTERPRETATION** Selecting the most appropriate and precise assessment to measure sensory processing function in infancy will depend on the specific components of sensory processing that need to be evaluated, infant age, and what other sources of information are available about the infant's development.

Young children with poor sensory processing typically exhibit delays in fine and gross motor skills, poor balance, and incoordination.<sup>1</sup> In addition, behaviours associated with poor sensory processing in these children include distractibility, tactile defensiveness, and problems with language and visual-spatial skills.<sup>1</sup> The term 'sensory processing' has multiple meanings, depending on the context in which it is applied. It is used to describe the acuity of a specific sense (e.g. hearing or vision), the processing mechanisms within a sensory system (e.g. auditory processing disorder or visual perception problems), or the neurophysiological responses to different sensations, the last being often used in the food science industry. When referring to 'sensory processing', this review is concerned with the diagnostic categories used to describe the varying reception, modulation, integration, and organization of sensory stimuli, as identified by certain behavioural responses to sensory input that impair daily routines and roles.<sup>2</sup> The proposed new nosology of sensory processing disorder provides a framework to classify some of these behavioural responses into diagnostic categories using consistent terminology.<sup>3</sup> This nosology provides three umbrella terms, which are used to classify more specific sensory processing disorders into a sensory modulation disorder, a

sensory-based motor disorder, or a sensory discrimination disorder.<sup>3</sup>

The impact that early sensory processing capacities has on later learning and emotional development lacks clarity, mainly because of difficulty in defining consistent constructs within the field and an absence of assessments to detect infants with sensory dysfunctions reliably and adequately.<sup>4</sup> As the theory of sensory integration and the evaluation of sensory processing are relatively new and still in a state of evolution, there are very few instruments available specifically to assess infants for sensory dysfunction(s).<sup>4</sup> Although there are several assessments that can be interpreted from a sensory integration frame of reference, they may not have been designed specifically to measure sensory processing.<sup>5</sup> Accurate measurement of a construct requires an appropriate assessment tool that is ideally standardized and normed in the context of interest, and is supported by strong clinimetric properties.

There is no consensus on an appropriate tool for measuring sensory processing in early childhood. Provost and Oetter<sup>6</sup> state that adequate identification of sensorimotor problems in the 0 to 3 years age bracket requires comprehensive evaluations of both (1) motor systems and abilities and (2) sensory functions, or the children's ability to register, process,

integrate, and respond to sensory input. Although there are many neuromotor assessments appropriate for use in early childhood, most of these do not take into account sensory function and hence do not provide a measure of sensory processing. It is not clear which of the currently available assessments measure sensory processing in early childhood. To advance scientific enquiry and clinical practice in the field of sensory processing it is important to identify the most appropriate and precise assessment tools for measuring this construct. This will build the foundation from which sensitive research can develop and from which more relevant and individualized intervention practices can be established.<sup>7</sup>

It is well documented that early childhood experience is a crucial determinant of health, well-being, and the attainment of competencies at later ages. Identifying sensory processing dysfunction(s) as early as possible and providing appropriate intervention(s) that influence the nature of early childhood experiences may improve developmental outcomes. In this paper we present the results of a systematic review of assessments used to measure sensory processing within the first 2 years of life. The review evaluates the psychometric properties and clinical use of these potential assessments with the aim of identifying which most accurately capture this construct.

## METHOD

### Search strategy

A comprehensive search for assessments that have been used to measure sensory processing in the current literature was administered within multiple computerized databases, including Medline (1950 to April 2011), CINAHL (1981 to April 2011), PsycINFO (1872 to April 2011), Embase (1980 to April 2011), and Web of Science (1900 to April 2011). The search strategy included MeSH terms and text words for ('child behaviour' OR 'sensation' OR 'perception' OR 'sensory processing' OR 'psychomotor performance') AND ('psychometrics' OR 'outcome assessment' OR 'questionnaire' OR 'outcome and process assessment' OR 'neuropsychological test' OR 'reproducibility or results' OR 'data interpretation, statistical' OR 'observer variation') AND ('infant' OR 'premature infant' OR 'low birth weight').

The titles and abstracts from papers retrieved from the search were screened by one author (ALE) for the use of assessment tools that appeared to meet the inclusion or exclusion criteria. Papers that were not selected for inclusion were then reviewed by a second independent reviewer (RNB) to ensure consensus that they should be excluded. Where consensus was not met on the status of a paper/assessment tool, the full text article of the abstract was obtained and further discussion took place between both reviewers until agreement was reached on the eligibility of the individual measurement tools.

Once assessment tools that met all of the inclusion criteria were identified, an additional search for clinimetric data for each of the identified assessments was completed. We searched reference lists within the papers using the assessment, and the computerized databases listed previously using the titles of the assessments as the search terms.

### What this paper adds

- This is the first systematic review of potential assessment tools to measure sensory processing in infancy.
- It helps clinicians select the most appropriate tools for measuring sensory processing in infancy.

### Inclusion criteria

Assessments were included if they met all of the following inclusion criteria: (1) used to assess sensory processing for infants, regardless of gestational age at birth; (2) discriminative, predictive, and/or evaluative of sensory processing outcomes at 24 months corrected age or less; (3) was a criterion- or norm-referenced test (child criterion- or norm-referenced parent report of child); (4) published in English; (5) most (i.e. >50%) of assessment items pertained to sensory processing outcomes (visual processing, auditory processing, vestibular processing, proprioception and kinaesthesia, tactile processing, olfactory [smell] and gustatory [taste] processing); (6) considered multisensory modalities (more than one sensory system); and (7) commercially available (test and manual).

### Exclusion criteria

Assessments were excluded if they met any of the following exclusion criteria: (1) it was used as a screening tool (diagnostic tests that have high sensitivity but often only a moderate specificity; usually this is a brief test that is followed by a more accurate test performed on those positive on the screening test); (2) it was predominantly a child behaviour/temperament measure; (3) it was a child-parent or child-therapist interaction measure; (4) it was a communication or language test; (5) it was a social interaction measure; (6) it was a cognitive test, including tests of motor or mental development; or (7) it primarily assessed motor ability (>70% pertaining to motor outcomes).

### Data extraction

Once assessment tools had been identified as meeting all of the inclusion and none of the exclusion criteria, a modified version of the *CanChild* Outcome Measures Rating Form<sup>7</sup> was used to assess the clinical use, reliability, validity, and responsiveness of each included assessment. Additional assessment characteristics were extracted and documented including the primary purpose of the assessment (discriminative, predictive, or evaluative), type of assessment (norm-referenced or criterion-referenced), targeted age range, and study sample characteristics.

The psychometric properties of each of the assessments evaluated included reliability and validity.

## RESULTS

### Included and excluded assessments

There were only three assessment tools that met the predefined inclusion criteria: (1) the Test of Sensory Function in Infants;<sup>1</sup> (2) the Sensory Rating Scale;<sup>6</sup> and (3) the Infant/Toddler Sensory Profile.<sup>8</sup>

Table I lists the 34 assessments that were excluded based on the inclusion and exclusion criteria. Although the initial search yielded more general developmental assessments that are

**Table 1:** Assessments excluded and their corresponding exclusion criteria

| Assessment                                                                                              | Screening tool | <30% sensory items | Assessment single sensory modality | Not age appropriate (<24mo) | Behaviour temperament measure | No published data after 1981 | Communication/ language measure | Social interaction measure | Not commercially available |
|---------------------------------------------------------------------------------------------------------|----------------|--------------------|------------------------------------|-----------------------------|-------------------------------|------------------------------|---------------------------------|----------------------------|----------------------------|
| Behaviour inventory for rating development <sup>24</sup>                                                |                |                    | ✓                                  |                             | ✓                             |                              |                                 |                            | ✓                          |
| Budreau infant irritability scale <sup>25</sup>                                                         |                |                    | ✓                                  |                             | ✓                             |                              |                                 |                            |                            |
| Child Behaviour Checklist <sup>26</sup>                                                                 |                |                    |                                    |                             | ✓                             |                              |                                 |                            |                            |
| Children's behaviour questionnaire <sup>27</sup>                                                        |                |                    |                                    |                             | ✓                             |                              |                                 |                            |                            |
| Computerized sensory organization testing <sup>28</sup>                                                 |                |                    |                                    | ✓                           | ✓                             |                              |                                 |                            |                            |
| Conners' parent rating scales – revised <sup>29</sup>                                                   |                |                    |                                    | ✓                           | ✓                             |                              |                                 |                            |                            |
| Dean-Woodcock Sensory-Motor Battery <sup>30</sup>                                                       |                |                    |                                    | ✓                           | ✓                             |                              |                                 |                            |                            |
| DeGangi-Berk Test of Sensory Integration <sup>31</sup>                                                  |                |                    |                                    | ✓                           | ✓                             |                              |                                 |                            |                            |
| Developmental Behaviour Checklist – parent <sup>32</sup>                                                |                |                    |                                    |                             |                               |                              | ✓                               |                            |                            |
| DISCO diagnostic interview for social and communication disorders <sup>33</sup>                         |                |                    |                                    |                             | ✓                             |                              |                                 |                            |                            |
| Emotionality, activity and sociability temperament questionnaire <sup>34</sup>                          |                |                    |                                    |                             |                               |                              |                                 |                            | ✓                          |
| Evaluation of sensory processing questionnaire <sup>35</sup>                                            |                |                    |                                    |                             |                               |                              |                                 |                            | ✓                          |
| Infant reactions inventory <sup>36</sup>                                                                |                |                    |                                    |                             | ✓                             |                              |                                 |                            |                            |
| Leiter International Performance Scale-Revised <sup>37</sup>                                            |                |                    |                                    |                             | ✓                             |                              |                                 |                            |                            |
| Mexican institute of psychiatry scales <sup>38</sup>                                                    | ✓              | ✓                  |                                    | ✓                           | ✓                             |                              |                                 | ✓                          |                            |
| Modified checklist for autism in toddlers <sup>39</sup>                                                 |                |                    |                                    |                             | ✓                             |                              |                                 |                            |                            |
| Neurobehavioural indicators of atypical development <sup>40</sup>                                       |                |                    |                                    |                             | ✓                             |                              |                                 |                            |                            |
| Occupational therapy associates' sensory history checklist <sup>41</sup>                                |                |                    |                                    |                             |                               |                              |                                 |                            | ✓                          |
| Preschool behaviour inventory <sup>42</sup>                                                             | ✓              |                    |                                    | ✓                           | ✓                             |                              |                                 |                            |                            |
| Psychoeducational Profile – Revised <sup>43</sup>                                                       |                |                    |                                    |                             |                               |                              |                                 |                            | ✓                          |
| Revised functional behaviour assessment for children with sensory integrative dysfunction <sup>44</sup> |                |                    |                                    |                             |                               |                              |                                 |                            | ✓                          |
| Sensory Experiences Questionnaire <sup>22</sup>                                                         |                |                    |                                    | ✓                           |                               |                              |                                 |                            | ✓                          |
| Sensory Integration and Praxis Test <sup>45</sup>                                                       |                |                    |                                    |                             |                               |                              |                                 |                            | ✓                          |
| Sensory Motor Appraisal <sup>46</sup>                                                                   |                |                    |                                    |                             |                               |                              |                                 |                            | ✓                          |
| Sensory processing assessment for young children (unpublished material)                                 |                |                    |                                    |                             |                               |                              |                                 |                            | ✓                          |
| Social Responsiveness Scale <sup>47</sup>                                                               |                |                    |                                    | ✓                           |                               |                              |                                 | ✓                          |                            |
| Southern California postrotary nystagmus test <sup>48</sup>                                             |                |                    | ✓                                  |                             |                               |                              |                                 |                            |                            |
| The developmental sensory processing questionnaire (unpublished material)                               |                |                    |                                    |                             |                               |                              |                                 |                            | ✓                          |
| The Neurobehavioural Assessment of the Preterm Infant <sup>49</sup>                                     |                |                    |                                    | ✓                           | ✓                             |                              |                                 |                            |                            |
| Toddler behaviour assessment questionnaire <sup>50</sup>                                                |                |                    |                                    |                             | ✓                             |                              |                                 |                            |                            |
| Weiss Werry Peters hyperactivity scale <sup>51</sup>                                                    |                |                    |                                    |                             | ✓                             |                              |                                 |                            |                            |

widely used by clinicians and researchers, for example the Bayley Scale of Infant and Toddler Development (3rd edition)<sup>9</sup> and the Ages and Stages Questionnaire,<sup>10</sup> these were excluded in the screening process as they did not include any sensory items.

### **Description of included assessments**

#### ***The Test of Sensory Function in Infants***

The Test of Sensory Function in Infants primarily measures sensory defensive behaviours (e.g. avoidance behaviours and sensitivity to stimuli) between the ages of 4 months and 18 months.<sup>11</sup> It was designed both for research and clinical use to assess infants with regulatory disorders (i.e. difficult temperament, irritability), developmental delays, and those at risk for later learning and sensory processing disorders.<sup>12</sup> Composed of 24 items, it requires interaction with the baby/infant, and stimulation with various materials. The lower age limit for administration is 4 months, with the most valid and reliable results yielded between 7 months and 18 months.<sup>13</sup> The test focuses on evaluation of tactile deep pressure, visual tactile integration, vestibular functions, and ocular motor control.

#### ***The Sensory Rating Scale***

The Sensory Rating Scale is a parent report measure that is used to identify and quantify sensory responsiveness in children 0 to 3 years of age.<sup>6</sup> The assessment was created based on the findings of an initial literature review on the behaviours associated with sensory sensitivity. It was developed in collaboration with experts in sensory processing disorders by evaluation of the items in pre-existing tools. The 10 experts selected to review the Sensory Rating Scale had the responsibility of identifying items that were difficult to understand or inappropriate for children aged 0 to 3 years. The ease of administration of the Sensory Rating Scale was also evaluated in a pilot study: the New Mexico Preschool and Infant Evaluation Program. The authors of the Sensory Rating Scale do not provide the exact sample size used in the pilot study; however, they report that feedback from the study influenced the items included in the final version of the Sensory Rating Scale. These items were grouped into various sections on the final version of the Sensory Rating Scale including the following: touch, movement and gravity, hearing, vision, taste and smell, and temperament and sensitivity. The final version of the Sensory Rating Scale has two versions used to assess sensory processing in two different age brackets. Form A consists of 88 questions and is appropriate for use from birth to 8 months. Form B consists of 136 questions and is targeted at an older age range, 9 months to 3 years.<sup>6</sup>

Each item on the Sensory Rating Scale is scored on a five-point scale, with scores of 4 and 5 considered as high risk for each of the sensory defensive behaviours.<sup>6</sup> These behaviours may represent 'overt' sensory defensive or compensatory under-responsive behaviours that might be coping mechanisms for sensory defensiveness (e.g. seems to withdraw, has delayed, little, or decreased response to pain). The questionnaire consists of six sections, each of which has a section score that is the frequency of items rated four or five within the

section. A total Sensory Rating Scale score is also obtained and is a sum of all the section scores.<sup>6</sup>

#### ***The Infant/Toddler Sensory Profile***

The Infant/Toddler Sensory Profile is described by the author as a tool for linking performance strengths and barriers with the child's sensory processing patterns.<sup>8</sup> Used with infants and toddlers from birth to 36 months of age, it enables professionals to gather information about the child's sensory processing abilities, and evaluate how those patterns either support or interfere with functional performance. It is a judgement-based caregiver questionnaire that provides a standard method for measuring a child's sensory processing abilities.

Based on a sensory integration and neuroscience frame of reference,<sup>14</sup> this assessment tool supports family-centred care by actively engaging the primary caregiver in the data-gathering process.<sup>8</sup> The primary caregiver observes the child interacting with numerous contexts that characterize their everyday living and reports on a range of behaviours. The Infant/Toddler Sensory Profile uses the primary caregiver's knowledge of their child's functional performance in the realistic setting beyond the assessment room walls. The theoretical and conceptual features of the Infant/Toddler Sensory Profile are based on the author's model of sensory processing.<sup>15</sup> The primary features of this model include the consideration of a person's neurological threshold (i.e. reactivity/responsivity), consideration of responding or self-regulation strategies (behavioural response), and consideration of the interaction among thresholds and responding strategies. Neurological threshold is referred to as the number of stimuli required for a neuron or neuron system to respond.<sup>8</sup> Behavioural response/self-regulation refers to the way people act in consideration of their thresholds.<sup>8</sup> Dunn<sup>8</sup> states that neurological thresholds and self-regulation strategies are on a continuum, and that each individual has a personal range of thresholds for noticing and strategies for responding to sensory events in everyday life. This range of responding is dependent on nervous system functioning, which evolves in the context of a child's early experiences. At the extreme ends of the neurological threshold continuum are habituation and sensitization, which through maturation of the central nervous system support the infant in executing adaptive responses. Dunn<sup>8</sup> proposes that difficulties in processing sensory information can take the form of over-responsivity or lack of responsivity. The model devised by Dunn illustrates the four basic patterns of sensory responsiveness that can emerge when sensory thresholds and self-regulation strategies interact. These include low registration (high neurological threshold and passive self-regulation strategy), sensation seeking (high neurological threshold and an active self-regulation strategy), sensory sensitivity (low neurological threshold and passive self-regulation strategy), and sensation avoiding (low neurological threshold and active self-regulation strategy). Although a person's responses to sensory events can fall anywhere on the model, the four outermost or extreme interaction points are described for the purpose of dialogue and are representative of thresholds and self-regulation behaviours that are outside an acceptable range for functional performance.<sup>16</sup>

Items on the Infant/Toddler Sensory Profile questionnaire describe age-appropriate behaviours or responses to various sensory experiences within the different sensory systems. Items are grouped into six sensory sections: general processing, auditory processing, visual processing, tactile processing, vestibular processing, and oral sensory processing. Depending on the infant's response to the items in each section, they will display varying patterns across the four quadrants of sensory responsiveness featured in the model.

### Characteristics of included assessments

All three included assessments were developed as discriminative tools; that is, they are designed to discriminate between

'normal' and 'abnormal' behaviours associated with sensory processing capacities. The standardization samples for all three criterion-referenced tools consisted of infants born in the USA. Both The Infant/Toddler Sensory Profile and the Sensory Rating Scale are appropriate for use from birth to 3 years, whereas the Test of Sensory Function in Infants is appropriate for use from 4 to 18 months of age. Table II provides a summary of the characteristics of these assessments.

### Validity

As the three assessments included in this systematic review are discriminative tools, no studies on predictive validity and components such as sensitivity and specificity are available or

**Table II:** Characteristics of included assessments

| Assessment                                            | Primary purpose                  | Other purposes | Age range                                           | Type of test | Normative sample                                                                                                                                                                                                                                                                                                                                                 | Domains tested                                                                                                                                                                                                                                                                                                                                                            | Components tested                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------------------------------------------------|----------------------------------|----------------|-----------------------------------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The Test of Sensory Function in Infants <sup>13</sup> | Discriminative (diagnostic tool) | Evaluative     | 4–18mo                                              | Criterion    | One hundred and ninety-six infants from Washington, DC, classified as typically developing<br>Twenty-seven infants from Washington, DC, with symptoms associated with an early regulatory disorder<br>Twenty-seven infants from follow-up clinics in Richmond, VA, New Hyde Park, NY, Arlington, TX, and Minneapolis, MN with a diagnosis of developmental delay | Reactivity to tactile deep pressure<br>Adaptive motor functions<br>Visual–tactile integration (because play experiences involve the integration of several sensory systems)<br>Ocular-motor control (early visual exploration).<br>Reactivity to vestibular stimulation (importance in early sensory experience and relevance to later learning and emotional behaviours) | Tactile protective system<br>Sense of touch associated with ability to plan and act on the tactile stimulus<br>Visually recognize and tolerate contact from a visual–tactile stimulus<br>Ability to lateralize the eyes to a moving object in the periphery towards the central visual field and the ability to smoothly track a visual target in all planes<br>Toleration of body movements in space in different planes (vertical, circular, and inverted) |
| Sensory Rating Scale <sup>6</sup>                     | Discriminative                   | Not applicable | 0–3y<br>Two versions: form A, 0–8mo; form B, 9mo–3y | Criterion    | Two hundred and eighty-eight typically developing<br>Twenty-seven developmentally delayed<br>Twenty-seven infants with difficult temperament                                                                                                                                                                                                                     | Sensory modalities                                                                                                                                                                                                                                                                                                                                                        | Touch<br>Movement and gravity<br>Hearing<br>Vision<br>Taste and smell<br>Temperament and general sensitivity questions                                                                                                                                                                                                                                                                                                                                       |
| Infant/Toddler Sensory Profile <sup>8</sup>           | Discriminative                   | Not applicable | 0–3y<br>Two versions: 0–6mo; 7–36mo                 | Criterion    | <i>n</i> =589<br>0–6mo=100<br>7–12mo=100<br>13–18mo=100<br>19–24mo=100<br>25–30mo=100<br>31–36mo=89                                                                                                                                                                                                                                                              | Sensory processing sections<br>Quadrants                                                                                                                                                                                                                                                                                                                                  | Auditory processing<br>Visual processing<br>Tactile processing<br>Vestibular processing<br>Oral–sensory processing<br>Low registration<br>Sensation seeking<br>Sensory sensitivity<br>Sensation avoiding                                                                                                                                                                                                                                                     |



| Table III: Evidence of content, construct, and concurrent validity |                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Assessment                                                         | Content                                                                                                                   | Construct                                                                                                                                                                                                                                                                                                                                                                                                                                                             | (Criterion validity) Concurrent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| The Test of Sensory Function in Infants                            | Expert panel                                                                                                              | Item validity determined by computing a mean score for the normal, delayed, and regulatory disordered groups; a discrimination index reflecting the difference between group item performances<br>Item<br>Subtest<br>Total test<br>Criterion group performance comparisons (for screening and diagnosis purposes)<br>Intercorrelation matrix. All correlations were low (0.02–0.47), indicating that each subtest measures a distinctively different sensory function | ‘Normally’ functioning infants ( $n=72$ )<br>9mo:<br>BSID-II (Motor scale only)<br>$r=0.160$<br>BSID-II (Mental scale only)<br>$r=-0.024$<br>Bates’ Infant Characteristic Questionnaire<br>$r=0.015$<br>FTII<br>$r=0.006$<br>These correlations suggest that the Test of Sensory Function in Infants measures distinct functions unrelated to measures of motor and cognitive functioning, temperament, and visual recognition memory                                                                                                                                                                                                         |
| Sensory Rating Scale                                               | –                                                                                                                         | –                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | –                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| The Infant/Toddler Sensory Profile                                 | Exploratory study and revision of content <sup>8</sup><br>Expert panel <sup>8</sup><br>Pilot study, $n=401$ <sup>52</sup> | NR                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Eighteen caregivers completed the Infant/Toddler Sensory Profile and the Infant/Toddler Symptom checklist<br>Twenty-eight items on the Infant/Toddler Sensory Profile correlated with the symptom checklist (five items with correlations above 0.50)<br>Low correlations between items related to sensation seeking, suggesting this is an area unique to the Infant/Toddler Sensory Profile<br>Author hypothesized that the Infant/Toddler Sensory Profile is a more comprehensive measure in the tested constructs and that both higher correlations (convergent validity) and lower correlations (discriminant validity) would be present |

BSID, Bayley Scales of Infant Development; FTII, Fagan Test of Infant Intelligence; NR, not reported.

applicable to each measure’s intended use. Evidence of content, construct, and concurrent validity is summarized in Table III. Of note, no studies evaluating content, construct, and/or concurrent validity of the Sensory Rating Scale were identified.

Both the Test of Sensory Function in Infants and the Infant/Toddler Sensory Profile have been reported to have excellent content validity according to expert panels who assessed congruence between test items and the intended domains measured. A panel of eight experts in the field of infant assessment in child development centres, programmes, and hospitals within the USA rated 75 to 85% of test items on the Test of Sensory Function in Infants as highly representative of the proposed construct being measured.<sup>4</sup> The Infant/Toddler Sensory Profile revised the content of the initial Sensory Profile questionnaire, designed for children 3 to 10 years of age by asking caregivers ( $n=100$ ) to answer relevant sections on the original tool.<sup>17</sup> Caregivers were asked to cross out items they perceived as inappropriate for the younger birth to 36 months age bracket, and were invited to make comments and suggestions on the items in the questionnaire. On the original assessment tool, 55 to 73% of items were reported by caregivers to be developmentally inappropriate for newborn to 18-month-old infants compared with 20% of the items for 19- to 36-month-olds.<sup>8</sup> The first draft of the Infant/Toddler

Sensory Profile was devised from this revised content of the Sensory Profile questionnaire. Five expert panels composed of five to seven members (discipline not documented) reviewed the first draft. Using Dunn’s Model of Sensory Processing, expert panels sorted each item into one of the four sensory processing patterns they believed it represented. Disagreement between panels was discussed until consensus was reached. After further review from two experts in the field, an 81-item version of the Infant/Toddler Sensory Profile was used in a pilot study.<sup>18</sup> From this study, 48 items of the 81-item version were identified as best characterizing sensory processing for children 7 to 36 months of age, and 36 items appeared relevant for children from birth to 6 months of age. These items formed the final version of the Infant/Toddler Sensory Profile questionnaire.

To measure construct validity, the Test of Sensory Function in Infants was compared with the cognitive and motor components of the Bayley Scales of Infant Development (2nd edition) and the Bates’ Infant Characteristic Questionnaire, which is designed to measure temperament and visual recognition memory. The authors reported low correlations with all the components on these assessments (0.16,  $-0.02$ , 0.02, and 0.01 respectively) and concluded that the Test of Sensory Function in Infants measures distinct functions unrelated to assessments of motor and cognitive functioning, temperament,

and visual recognition memory. To measure construct validity of the Infant/Toddler Sensory Profile questionnaire, 18 caregivers completed this questionnaire as well as the Infant/Toddler Symptom checklist. The Infant/Toddler Symptom Checklist has 17 to 31 items (depending on the age band of the child) and is designed to screen 7- to 30-month-old infants and toddlers for sensory and regulatory disorders who are behaviourally problematic and show disturbances in sleep, feeding, state control, self-calming, and mood regulation. Twenty-eight of the items on the Infant/Toddler Sensory Profile correlated with items on the Infant/Toddler Symptom Checklist; however, all of these items, excluding five, had correlations above 0.5. The lowest correlations were with items associated with the sensation-seeking pattern on the Infant/Toddler Sensory Profile. The author of the Infant/Toddler Sensory Profile questionnaire suggests that the sensation-seeking pattern is a unique area that the tool measures.

### Clinical use

Clinical use of the three assessment tools is summarized in Table IV. Both the Infant/Toddler Sensory Profile and the Test of Sensory Function in Infants are short assessments, taking 15 to 20 minutes. The Sensory Rating Scale does not indicate the length of time taken to administer the assessment. The Test of Sensory Function in Infants requires administration by a therapist and involves interaction and handling in a set sequence. It is designed to be completed in one sitting; therefore the time taken to administer this test may vary depending on the infant's cooperation in the assessment process. Recommended users of the Test of Sensory Function in Infants are paediatricians, psychologists, infant educators, and occupational and physical therapists.<sup>13</sup> Other early intervention professionals can administer the Test of Sensory Function in Infants; however, they are advised to consult with a therapist skilled in the area of sensory processing when interpreting and reporting results.<sup>19</sup>

The Infant/Toddler Sensory Profile is completed by the primary caregiver either at home or at the time of formal assessment. The estimated 20 minutes for completion is based upon the caregiver completing the questionnaire in one sitting. No formal training is required for use of any assessments included in this review. However, the Test of Sensory Function in Infants recommends knowledge and experience in the interpretation of test results in the domain of sensory functions and at least 2 hours of administration practice using the procedures outlined in the user's manual.<sup>13</sup> The Infant/Toddler Sensory Profile manual encourages users to orient themselves to the assessment's purpose, items, and rating scale before using it in clinical practice.

Costs associated with the Sensory Rating Scale are few. The scale is reproducible by an electronically available publication in the journal *Physical & Occupational Therapy in Pediatrics*.<sup>6</sup> The complete assessment kit for the Test of Sensory Function in Infants costs approximately US\$199 including the manual, all test items, and 100 scoring forms.<sup>20</sup> Addi-

tional scoring forms can be purchased for approximately US\$30 for 100 forms. The complete kit for the Infant/Toddler Sensory Profile costs approximately US\$193 including the manual, 25 caregiver questionnaires, and 25 summary score sheets.<sup>20</sup> Additional caregiver questionnaires can be purchased for approximately US\$56.75 for a pack of 25. Additional short profiles and summary score sheets can also be purchased.

### Reliability

Reliability is the process of determining whether an assessment is measuring something in a reproducible and consistent fashion.<sup>7</sup> Evidence of reliability is summarized in Table V. The test-retest reliability of the Test of Sensory Function in Infants was reported to be excellent in two out of the five components assessed (see Table V). No studies measuring test-retest reliability were available for the Sensory Rating Scale. The reliability for the 7 to 36 months age bracket was reported to be excellent for the sensory section scores (correlation 0.86) and adequate for the quadrant scores (correlation 0.74) on the Infant/Toddler Sensory Profile questionnaire, although this finding was based on Pearson's correlation, which is not a measure of reliability.

The Test of Sensory Function in Infants did not report intrarater reliability. This was estimated to be excellent, with interclass correlation coefficients ranging from 0.88 to 0.99.<sup>7</sup> Reporting percentage of agreement only on section scores and overall scores, the Sensory Rating Scale had varied intrarater reliability (61.1–75.8%) and only poor interrater reliability (49.4–62.4%). The authors suggest that the poor interrater reliability is due to differing knowledge between raters (parents), contextual differences in the child's behaviour with each rater, differences in raters' interpretations of the child's behaviours, or a combination of these factors.<sup>6</sup> Intra- and interrater reliability have not been reported for the Infant/Toddler Sensory Profile.

Internal consistency is described as the extent to which the items of an assessment work together to measure a specific construct. It is assumed that items measuring the same construct should correlate.<sup>21</sup> The most widely used method for estimating internal consistency is Cronbach's alpha. This is a function of the average intercorrelations of items and the number of items in the scale.<sup>21</sup> No reliability studies on the internal consistency of the Test of Sensory Function in Infants have been conducted. On the Sensory Rating Scale form A, overall internal consistency was considered excellent (0.83); however, it varied among the different components tested (see Table V). Form B scored greater internal consistency than form A both on total score (0.90) and on five out of the six components. The Infant/Toddler Sensory Profile had a low value for Cronbach's alpha on all sensory processing sections for children's ages from birth to 6 months (ranging from 0.17–0.57),<sup>8</sup> suggesting poor overall consistency. The quadrant scores for this age group showed adequate consistency for low registration, sensation seeking, and sensory sensitivity (0.62, 0.79, and 0.79 respectively) whereas sensation avoiding demonstrated poor internal consistency (0.56). Alpha coeffi-

**Table IV:** Clinical use of included infant sensory outcome measures

| Assessment                              | Time to administer (min) | Test procedure                                                                                                                                                                                                                                                                                                                                                           | Manual/equipment                                                                                                                                             | Training     | Scoring                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Interpretation of scores                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-----------------------------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The Test of Sensory Function in Infants | 20                       | Therapist observes and administers items in set sequence<br>Verbal directions delivered as specified for each item<br>Entire test should be given in one sitting<br>Infant held seated on the parent's lap for all items except 'reactivity to vestibular stimulation' subtest<br>Parents coached to administer some items if infant displays excessive stranger anxiety | Comprehensive manual/test kit (US\$199)<br>Test kit provides most equipment.                                                                                 | Not required | Multi-point scoring<br>Numerical rating scale with successive intervals<br>Numerical value for each item reflects the degree to which a skill has been developed<br>Subtest scores, five domains: reactivity to tactile deep pressure (five items); adaptive motor functions (five items); visual-tactile integration (five items); ocular-motor control (two items); reactivity to vestibular stimulation (seven items)<br>Subtest scores are the summed items for each subtest and are used to measure functioning level ('normal', 'at risk', or deficient')<br>Total test score provides a gross index of delay or normalcy for screening purposes (defined as 'normal', 'at risk', or deficient) | Reactivity to tactile deep pressure<br>0=adverse<br>1=mild defensive<br>2=integrated<br>Adaptive motor functions<br>0=no response<br>1=disorganized<br>2=partial<br>3=organized<br>Visual-tactile integration<br>0=hyperreactive<br>1=hyporeactive<br>2=normal<br>Ocular-motor control<br>0=no response<br>1=integrated<br>Reactivity to vestibular stimulation<br>0=adverse reaction<br>1=mildly defensive reaction<br>2=integrated response<br>Cut points for 'normal', 'at risk', and 'deficient' classifications for subtests and total test scores differ across four age brackets (4–6, 7–9, 10–12, and 13–18mo) |
| Sensory Rating Scale                    | Not reported             | Completed by at least one of the child's parents on the day of testing or within 1wk of testing.                                                                                                                                                                                                                                                                         | Electronically available publication in the journal <i>Physical and Occupational Therapy in Pediatrics</i> provides administration instructions <sup>6</sup> | Not required | Five-point rating scale<br>Six sections:<br>Touch; movement and gravity; hearing; vision; taste and smell; temperament and general sensitivity<br>Sections scored separately based on frequency of scores four and five.<br>Total Sensory Rating Scale score is the sum of all section scores                                                                                                                                                                                                                                                                                                                                                                                                         | Scores four and five are considered as high-risk scores for sensory defensive behaviours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |



Table IV: Continued.

| Assessment                         | Time to administer (min) | Test procedure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Manual/equipment                                                      | Training                                                                                                            | Scoring                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Interpretation of scores                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The Infant/Toddler Sensory Profile | 15                       | The caregiver who has daily contact with the child completes the questionnaire. This can be sent to the caregiver's postal address with a cover letter explaining the purpose of the instrument, completed by the caregiver at the time of the child's visit to the therapist, or be completed at the time of this visit with the assistance of the therapist (therapist does not indicate a correct response when assisting). Once completed, therapist scores each response on a five-point scale | Comprehensive manual/questionnaires (US\$193)<br>No special equipment | No formal training required. User's manual suggests orienting self to instrument's purpose, items, and rating scale | <p>Caregiver responses to each question range from:</p> <p>Almost always: when presented with the opportunity, your child almost always responds in this manner, 90% or more of the time</p> <p>Frequently: when presented with the opportunity, your child frequently responds in this manner, about 75% of the time</p> <p>Occasionally: when presented with the opportunity, your child occasionally responds in this manner, about 50% of the time</p> <p>Seldom: when presented with the opportunity, your child seldom responds in this manner, about 25% of the time</p> <p>Almost never: when presented with the opportunity, your child almost never responds in this manner, 10% or less of the time</p> <p>The therapist allocates an item score of one to five for each question:</p> <p>almost always, 1;<br/>frequently, 2;<br/>occasionally, 3;<br/>seldom, 4;<br/>almost never, 5</p> <p>If the caregiver places a mark between two responses, the more frequent score is recorded</p> <p>Sensory processing section raw scores are the sum of item scores for each section. There will be six of these</p> <p>Item scores correspond to one of four quadrants. The sum of corresponding items for each quadrant is the quadrant raw score totals. There will be four of these</p> | <p>Quadrant raw score totals are matched with a corresponding classification system</p> <p>Birth–6mo: two classification groups:</p> <ol style="list-style-type: none"> <li>1. Consult and follow up for scores outside plus or minus the SD score</li> <li>2. Typical, scores at or between plus or minus the SD score from the mean</li> </ol> <p>7–36mo, three classification groups:</p> <ol style="list-style-type: none"> <li>1. Definite difference, scores outside <math>\pm 2</math> SD from the mean</li> <li>2. Above +2SD, less than others</li> <li>Below –2SD, more than others</li> <li>3. Probable difference, scores within the 1–2SD range of the mean</li> </ol> <p>At or below 2SD above the mean, but higher than 1SD above the mean, less than others</p> <p>At or above 2SD below the mean, but lower than 1SD below the mean, more than others</p> |

**Table V:** Reliability of assessment tools

| Assessment                                            | Test-retest                                                                                                                                                                                       | Intratrater                                                                                                                                                                                                                                                                                                                                                                          | Interrater                                                                                                                                                                                                    | Internal consistency (Cronbach's alpha)                                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The Test of Sensory Function in Infants <sup>13</sup> | 4–6mo (n=21)                                                                                                                                                                                      | No study identified                                                                                                                                                                                                                                                                                                                                                                  | 4–6mo (n=5)<br>7–9mo (n=19)<br>10–12mo (n=10)<br>13–18mo (n=7)<br>ICC=0.88–0.99                                                                                                                               | No study identified                                                                                                                                                                                                                                                                                                                                           |
|                                                       | 7–9mo (n=2)                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | 10–12mo (n=0)                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | 13–18mo (n=3)                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | Reactivity to tactile deep pressure<br>ICC=0.77                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | Adaptive motor functions<br>ICC=0.64                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | Visual-tactile integration<br>ICC=0.84                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | Ocular-motor control<br>ICC=0.96                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | Reactivity to vestibular stimulation<br>ICC=0.26                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | Total test<br>ICC=0.81 <sup>13</sup>                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | Reactivity to tactile deep pressure<br>SROC=0.74                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | Adaptive motor<br>SROC=0.54                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | Visual-tactile<br>SROC=0.67                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | Ocular-motor control<br>SROC=0.67                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
| Sensory Rating Scale <sup>6</sup>                     | Reactivity to vestibular stimulation<br>ICC=0.63                                                                                                                                                  | Mothers and fathers analysed separately<br>Exact percentage of agreement for both mother and father for section scores and total Sensory Rating Scale score ranged from 61.1 to 75.8%<br>Percentage of agreement within one score and agreement of low scores (1–3) and high scores (4 and 5) was greater than 87% for mothers and fathers<br>Mothers, $r=0.89$<br>Fathers, $r=0.95$ | Mothers' scores were compared with fathers' scores<br>Exact percentage of agreement for section scores and total Sensory Rating Scale ranged from 49.4 to 62.4%<br>Total Sensory Rating Scale score: $r=0.43$ | Form A (0–8mo):<br>touch, 0.57;<br>movement/gravity, 0.81;<br>hearing, 0.54;<br>vision, 0.56;<br>taste/smell, 0.46;<br>temperament/general sensitivity, 0.77;<br>total, 0.83<br>Form B (9mo–3y):<br>touch, 0.75;<br>movement/gravity, 0.75;<br>hearing, 0.65;<br>vision, 0.54;<br>taste/smell, 0.52;<br>temperament/general sensitivity, 0.82;<br>total, 0.90 |
|                                                       | Total test<br>ICC=0.78 <sup>53</sup>                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       | Percentage of agreement for the total test classification categories between test and retest was adequate (81%). Percentages of agreement for subtest classification categories were low (58–68%) |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
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|                                                       |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |
|                                                       |                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                               |

Table V: Continued.

| Assessment                                  | Test-retest                                                                                                                                                                                                                                                                                                   | Intrarater          | Interrater          | Internal consistency (Cronbach's alpha)                                                                                                                                                                                                                                                                                                                      |
|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Infant/Toddler Sensory Profile <sup>8</sup> | (7–36mo, n=32)<br>Only correlation coefficients used<br>Sensory section scores, 0.86<br>Quadrant scores, 0.74<br>ICCs or $\kappa$ values are appropriate statistical methods for measuring inter- and intrarater reliability, not percentage of agreement between raters or Pearson's correlation coefficient | No study identified | No study identified | 7–36mo<br>Coefficient alpha<br>Sensory section scores:<br>general, 0.6310;<br>auditory, 0.6961;<br>visual, 0.5453;<br>tactile, 0.7149;<br>vestibular, 0.4234;<br>oral sensory, 0.5518<br>Quadrant scores:<br>low registration, 0.6997;<br>sensation seeking, 0.8580;<br>sensory sensitivity, 0.7165;<br>sensation avoiding, 0.6970;<br>low threshold, 0.8307 |

ICC, intraclass correlation coefficient; SROC, Spearman's rank order correlation coefficient.

cients on the sensory processing sections for children's ages 7 to 36 months translated to adequate internal consistency for general, auditory, and tactile processing (0.63, 0.70, and 0.71 respectively), whereas visual, vestibular, and oral sensory processing sections had poor internal consistency (0.55, 0.42, and 0.55 respectively). The quadrants of low registration, sensory sensitivity, and sensation avoiding for children's ages 7 to 36 months reported adequate consistency, whereas sensation seeking showed excellent internal consistency (Table V). The low-threshold score, used when characterizing a low-threshold condition, has excellent internal consistency (0.83).

## CONCLUSION

Based on the results from this systematic review, there appear to be only three assessments that can be used to evaluate sensory processing within the first 2 years of life. Of these three assessments, it is difficult to identify which is the best for accurately capturing the construct of sensory processing. This difficulty is in part due to the challenge of defining constructs in sensory processing. The assessments included in this review measured slightly different components hypothesized to reflect sensory processing capacities; therefore directly comparing the assessments can be difficult. In particular, the Sensory Rating Scale and Infant/Toddler Sensory Profile are both parent-reported questionnaires, whereas the Test of Sensory Function in Infants is a performance-based assessment. The parent-rated questionnaires may be considered more time efficient as parents can complete these in their own time. These questionnaires also provide information across varied contexts whereas the performance-based assessment provides information only within the assessment room, which is then used to make speculations as to how the child's performance might affect daily functioning. If a choice between the two parent-rated questionnaires was made purely on the clinimetric studies reported, we would recommend using the Infant/Toddler Sensory Profile as it has undergone more rigorous evaluation than the Sensory Rating Scale. In addition, the items and scoring structure of the Infant/Toddler Sensory Profile questionnaire are based on the theoretical principles of neuroscience, sensory processing, and occupational performance, which can assist the clinician in theory-based decision making. The four quadrant scores derived from the Infant/Toddler Sensory Profile questionnaire provide a rich description of how neurological processes may influence personal tendencies to produce a range of observable behavioural responses. Reliability measures varied from poor to adequate across the different studies in all three assessments, with some assessments not reporting any data on particular reliability components. If time allows, ideally one would administer both the Infant/Toddler Sensory Profile questionnaire and the Test of Sensory Function for Infants to reliably determine problem areas of sensory processing during infancy, and match parent report with a performance-based standardized assessment. Other assessments that possess sound psychometric properties, yet were not included in this review as they are not commercially available, may also be considered when evaluating sensory processing in infancy.<sup>22,23</sup> In addition, the information extrapolated from

the most reliable and accurate assessment of sensory processing in infancy needs to be analysed alongside other measures of performance such as parent interview, skilled observation of the child's behaviour, neurodevelopment testing results, and other relevant background information. Integrating these pieces of information enables the clinician to determine the extent to which sensory processing patterns and/or dysfunction(s) are influencing daily functioning, and guides intervention planning and treatment to optimize participation and developmental outcome.

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