THE ASIAN EDUCATIONAL THERAPIST

ISSN: 2972-4104, Volume 1, Issue 1, Page 3 - 22

REVIEW ARTICLE

Sensory Abilities/Disabilities: An Application of the Sensory Profile-Caregiver Questionnaire to better understand the Sensory-Motor Domain-Specific Abilities in the CHC Model Version 2.1

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Article DOI: https://doi.org/10.64663/aet.23

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Cite as: Liu, W., & Xie. G. H. (2023). Sensory abilities/disabilities: An application of the Sensory Profile-Caregiver Questionnaire to better understand the sensory-motor domain-specific abilities in the CHC model version 2.1. The Asian Educational Therapist, 1(1), 3 - 22.

ABSTRACT

As practicing educational therapists, both authors have chosen to focus their paper more on pragmatic issues related to sensory abilities and/or disabilities along with the theory-to-practice theme relevant to current practice of educational therapy. In this paper, the authors explored both sensory abilities and disabilities through the administration of the Sensory Profile (Dunn, 1999) in their attempt to understand the Sensory-Motor Domain-Specific Abilities within the Cattell-Horn-Carroll (CHC) framework/theory of broad and narrow cognitive abilities. By operationalizing the definitions of the relevant broad and narrow cognitive abilities into broad goals and specific objectives respectively, the authors believe it will enable educational therapists to decide how to design and what to include in an appropriate sensory-based treatment plan for those who need it.

Keywords: *CHC Theory/Model, Cognitive Abilities, Sensory Abilities/Disabilities, Sensory Profile-Caregiver Questionnaire*

1. INTRODUCTION

Aristotle (b.384 BC-d.322 BC), a Greek philosopher, is known to be the first person who attempted to make a list of human senses in his classical work *De Anima* (cited in Hicks, 2015, & Shields, 2016). In fact, Aristotle was also the first person to name the five basic human senses (known as exteroceptors today), which include sight (visual), smell (olfactory), hearing (auditory), touch (haptic/tactile), and taste (gustatory). These exteroceptors take a variety of forms, e.g., the photoreceptors which comprised of retinal rods and cones, are for sight, and the cutaneous receptors, which consist of Pacinian corpuscles, Meissner's corpuscles and Merkel's tactile disks, are for touch. Much later, additional four more senses were included in Aristotle's list (see Hicks, 2015, & Shields, 2016, for detail). These senses were further differentiated and soon the list expanded to include a total of 21 or more (sometimes 33) senses, but the number of senses also depends very much on the varied opinions of different neurologists. For instance, Cohen's (1995) definition of senses has gone beyond the physiological phenomenon or nerve sensor definition, and he put the number of senses at 53. Cohen (1995) classified the senses under the following four categories:

(1) Radiation senses: These are the senses of colour, of moods that are associated with colour, and also of temperature.

(2) Feeling senses: Cohen (1995) described these senses as sensitivity to gravity, air and wind pressure, as well as motion.

(3) Chemical senses: These are related to the hormonal sense, e.g., pheromones, hunger for food, quench for water or grasp for air.

(4) Mental senses: This fourth category include senses related to external and/or internal pain, mental or spiritual distress, sense of self that includes friendship, companionship and power, and psychic capacity.

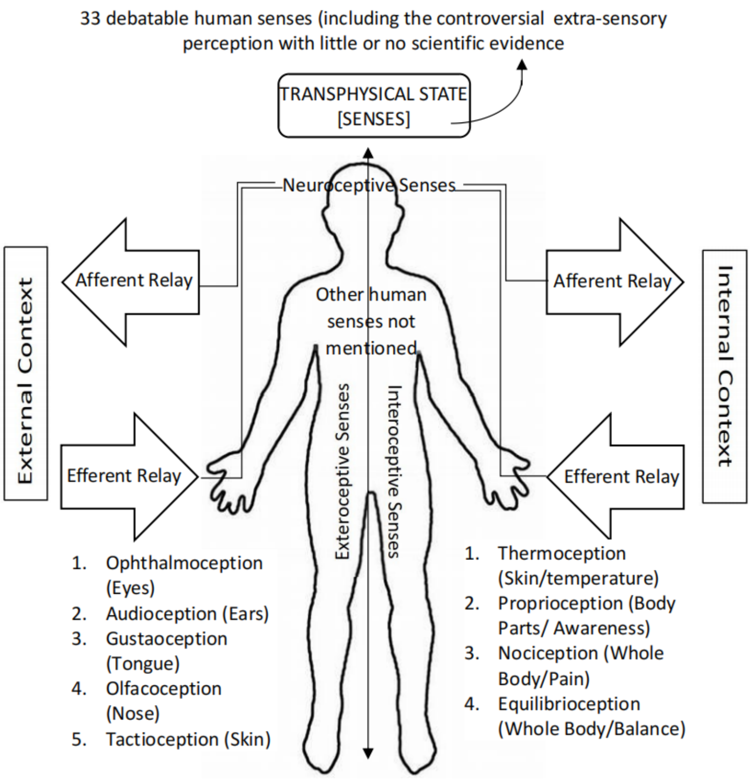

Figure 1. Sensory-Motor System

A list of these generally accepted senses in human can be seen in Figure 1 (courtesy of Paediatric Therapy Centre, 2023) which shows the sensory-motor cycle. All the senses play an integrated important role to ensure the survival of a human being through neuroceptive senses - also known as neuroception, which “takes place in primitive parts of the brain, without our conscious awareness” (Porges, 2004, p. 19), is a term coined by Porges (2004) - which describes “how neural circuits distinguish whether a situation or an individual is safe, in danger, or something is threatening his/her life” (Porges, 2004, p. 19). For instance, neuroception explains why a child is happy to have a parent’s hug but perceives a stranger’s hug as an assault. In another example, an infant coo when with its mother but cries at the sight of a stranger. Known as the Polyvagal Theory, it posits that the brain structures in mammals (particularly the primates) have evolved to manage both social and defensive behaviors (see Porges, 2004, for detail) through the senses, i.e., sensory abilities.

2. SENSORY ABILITIES

When the term ‘sensory abilities’ (also known as sensory processing abilities) is mentioned, the usual response from a man-in-the-street is that there are the five senses: to see, to hear, to touch, to smell and to taste. These exteroceptive senses refer to the five sensory organs: eyes, ears, skin, nose and tongue. However, it is not exactly what the authors of this paper have in mind nor are they going to focus in this present discussion. They refer these sensory abilities (or sensory processing abilities) to the **functions of five unique sensory organs that “receive, transmit, and interpret stimuli from the environment” (Nurse Key, 2017, para. 1; see Figure 2 below)**.

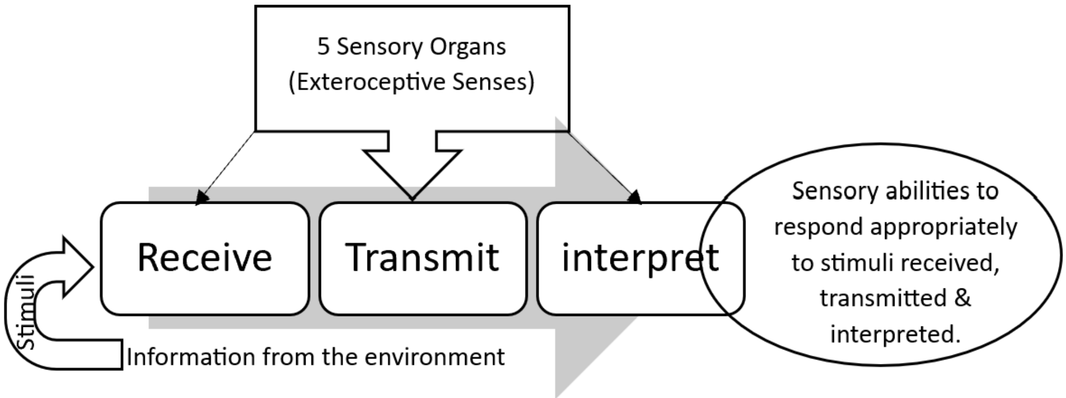

Figure 2. Sensory Abilities = Functions of the 5 Sensory Organs

However, currently, it is generally accepted that there are eight main types of sensory processing that are as follows:
(1) Exteroception, i.e., the five common senses: vision (ophthalmoception), auditory system (audioception), tactile or haptic system (tactioception), olfactory system (olfalcoception) and taste or gustatory (gustaoception) system;
(2) Proprioception, i.e., it refers to the internal awareness of body that helps to maintain posture and motor control as well as how one moves about and occupies space;
(3) Vestibular system, i.e., it refers to the inner ear spatial recognition, which keeps a person balanced and coordinated;
(4) Interoception, i.e., the sense of what happens in the body, e.g., the feeling of hot or cold as well as the feeling of emotions.

All these multiple sensory modality inputs are processed and managed by the brain into usable functional outputs (Stein & Rowland, 2011; Stein, Stanford, & Rowland, 2009).

The Sensory Nervous System (SNS) registers and processes explicit (from the immediate environment) and/or implicit sensory inputs (a.k.a. sensory stimulation) (from within an individual's psychological and/or emotional state of mind) by handling the information from the sensory receptors, which will transmit the information through its efferent relay system to the SNS, which in turn, will respond to it through its afferent relay system to elicit a response (e.g., answering a question asked by the teacher) or reaction (e.g., shouting at a culprit who attempt to rob) to the stimuli (see Diagram 1 shown earlier, courtesy of Paediatric Therapy Centre, 2023) (also see The Star Institute, 2020, & Therapy Solutions for Kids, 2023, for detail and other examples).

As mentioned above, sensory stimulation (i.e., sensory inputs) is linked to three key domains of developmental milestones in children: emotional, cognitive and physical. Any delay or impairment in two or more of these three domains can lead to global developmental delay. Educational therapists working with such children often use repetitive activities to stimulate their senses so that infants and toddlers can learn and reach their developmental milestones.

The sensory processing can affect the way an individual (be s/he a child, adolescent or adult) learns, uses language, socializes with others, and problem-solves in the daily routine of his/her life (see The Star Institute, 2020, & Therapy Solutions for Kids, 2023, for detail). Sensory-motor (a.k.a. sensorimotor) functioning is the integration of the various senses and the musculoskeletal system to raise an awareness as well as adaptation to the world around the individual (Mcilroy, 2022). For instance, "by the end of the first-year babies achieve sensory integration. They are then able to process information from multiple senses together – especially vision and hearing" (Mcilroy, 2022, para. 7). The development of sensory abilities is the sensational exploration of the world or, in other words, exploring through the senses (see Children's Hospital of Richmond@Virginia Commonwealth University, 2023, for more detail). This sensational exploration requires a person to employ appropriate social skills when interacting with other people in a given social context (e.g., greeting a teacher in classroom or a colleague in office) and these skills require activation of various senses involved.

3. SENSORY DISABILITIES

From the moment a stimulus (or event/episode) is picked up by a sensory receptor (e.g., someone saw a drunkard driving his car onto the sidewalk and knocking down several pedestrians), the sensory input is registered and being processed or transmitted by the efferent relay system to the brain (e.g., the occipital lobe makes sense of what was seen) which interprets the episode as 'danger', 'urgent' and 'immediate help needed', the person (agent) receiving the sensory input (sensory stimulation) via the efferent relay system to the SNS would respond via the afferent relay system from the SNS in the way s/he sees fit, e.g., flee from the danger zone, shout for help, rush to help the injured, etc.

The process that is described above is what the authors of this paper termed as the Sensory Relay Cycle. From the sensory stimulation through the sensory processing to sensory interpretation and sensory behavioral response, it shows how the sensory message elicits a response or reaction (within the split of second) from the receiver based on his/her interpretation of the event according to his/her perception, controlled attention (or attentional control; Astle & Scerif, 2009), prior knowledge and/or experience (e.g., binge drinking can make a driver drunk), and speed of response (involving the equation where Latency + Processing Time = Response Time[1], i.e., L+PT=RT), before the receiver could respond (neuromotor) to the incident as witnessed. This description of the sensory relay cycle from the triggering event to the responding act can be simplified as follows: Stimulus → Sensory

[1] Latency (L)=the time the message is in transit between two points, i.e., initiator and receiver; Processing Time (PT)=the time the message takes to be processed; and Response Time (RT)=the sum of L and PT.

Stimulation → Sensory Processing → Sensory Interpretation → Sensory Behavioral Response. The entire Sensory Relay Cycle is also presented diagrammatically in Figure 3.

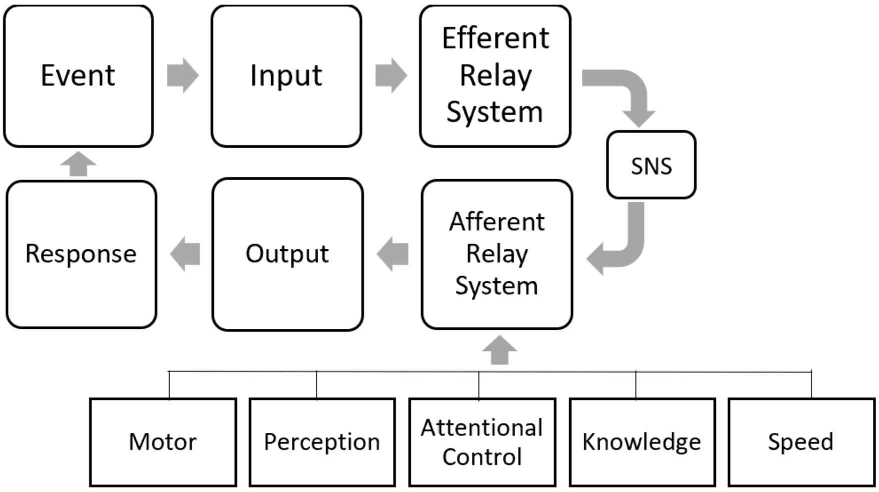

Figure 3. Sensory Relay Cycle

From the above description, sensory abilities (I.e., neuroceptive senses) certainly play a very important role in relaying explicit/implicit information accurately and fluently to the SNS in order to elicit an appropriate and swift response to the information received, transmitted and interpreted (see Figure 2). Neuroception will search for cues of safety and also watch for signs of danger to help an individual orientate and take action to safeguard his/her survival.

However, supposedly, things went haywire in the SNS (i.e., neuroceptive senses are not functioning properly), the person who witnessed the event as described above did not react appropriately, one can imagine the serious outcome(s) of the incident (e.g., the witness also got knocked down by the drunk driver, more innocent lives lost, damaged public property, and the list can go on). Slowness, lack of awareness, distortion in perception, misinterpretation and inappropriateness in sensory response can lead to all kinds of sensory disabilities, collectively known as sensory processing disorder (also used to be known as sensory integration disorder), which include sensory discrimination disorder, sensory modulation disorder and sensory-based motor disorder (Miller et al., 2007; Schoen, Miller, & Sullivan, 2014). Currently, the sensory processing disorder is still not officially recognized or included in the *Diagnostic and Statistical Manual of Mental Disorders-5th edition* (DSM-5) (American Psychiatric Association, 2013).

The symptoms of sensory processing disorder can include sudden mood swings and strange or anomalous behavior. There are reported cases of children and adults with challenging sensory issues who might avoid bright lights or loud noises as they find the lights/noises irritating, and such stimuli can agitate them into behaving abnormally (e.g., flapping their hands, hitting their ears, and vocal stimming noted in individuals with autism), walk around crashing into furniture or other things, throw into anger fits (temper tantrums), or seem to be clumsy in whatever tasks they have been assigned to do. "Faulty neuroception might lie at the root of several psychiatric disorders, including autism, schizophrenia, anxiety disorders, depression, and reactive attachment disorder" (Porges, 2004, p. 19).

4. SENSORY PROFILE-CAREGIVER QUESTIONNAIRE

As a result of a wide range of sensory challenges, educational therapists need screening or assessment tools to help them to identify these issues of concern experienced by their clients. There are many sensory profiles, inventories, questionnaires and/or checklists already available online for free, while others, especially the formal or standardized ones, can only be purchased by qalified professionals. To the educational therapists, these diagnostic tools are incredibly powerful and useful to help children, adolescents and adults to identify and recognize the sensations they are sensitive to, indifferent to (or totally unaware), seeking/carving for or avoiding (or not noticing), and, more importantly, what can be done about it. For parents and teachers working with children with sensory challenges, such an issue of concern can have a huge impact on associated behaviors.

Among the many sensory screening and assessment tools, the Sensory Profile-Caregiver Questionnaire (SP-CQ; Dunn, 1999) is the authors' choice as it "provides a standard method for professionals to measure a child's sensory processing abilities and to profile the effect of sensory processing on functional performance in the daily life of a child" (p. 1). The SP-CQ consists of 125 items that are categorized under three sections (see Figure 4). Each section is briefly described below (Dunn, 2008, p. 2).

Section 1: Sensory Processing

There are six item categories in this first section. They represent the six types of sensory processing used in daily life: (I) auditory processing; (ii) visual processing; (iii) vestibular processing; (iv) touch processing; (v) multisensory processing; and (vi) oral sensory processing. The movement processing (proprioception) is not included in the SP-CQ, but it is listed in the Sensory Profile-Adolescent/Adult version (Brown & Dunn, 2002). Closer to the movement processing is the vestibular processing.

The vestibular processing as a sensory subsystem, according to Braley (2014), is concerned with **balance** and movement, and it is centered in the inner ears, where the vestibular organs are located deep inside. When a person moves his/her heads, the fluid in these vestibular organs also moves and shifts, constantly providing vital sensory information about the position of his/her head and body in space, i.e., the spatial awareness. Once, the person starts to move about and act as required by a certain task, proprioception (also known as **kinesthesia)** comes into play. Proprioception (i.e., movement processing in AA-SP) refers to the ability to sense movement, action, and location. It is present in a person's every muscle movement. Without it, one would not be able to move without thinking about the next step Brennan, 2021).

Section 2: Modulation

There are five item categories in this second section. They represent the various combinations of sensory inputs used in daily life: (I) sensory processing related to endurance/tone; (ii) modulation related to body position and movement; (iii) modulation of movement affecting activity level; (iv) modulation of sensory input affecting emotional responses; and (v) modulation of visual input affecting emotional responses.

Section 3: Behavioral and Emotional Responses

There are three item categories in this third section. They represent emotional and behavioral responses that indicate sensory processing abilities: (I) emotional/social responses; (ii) behavioral outcomes of sensory processing; and (iii) thresholds for response.

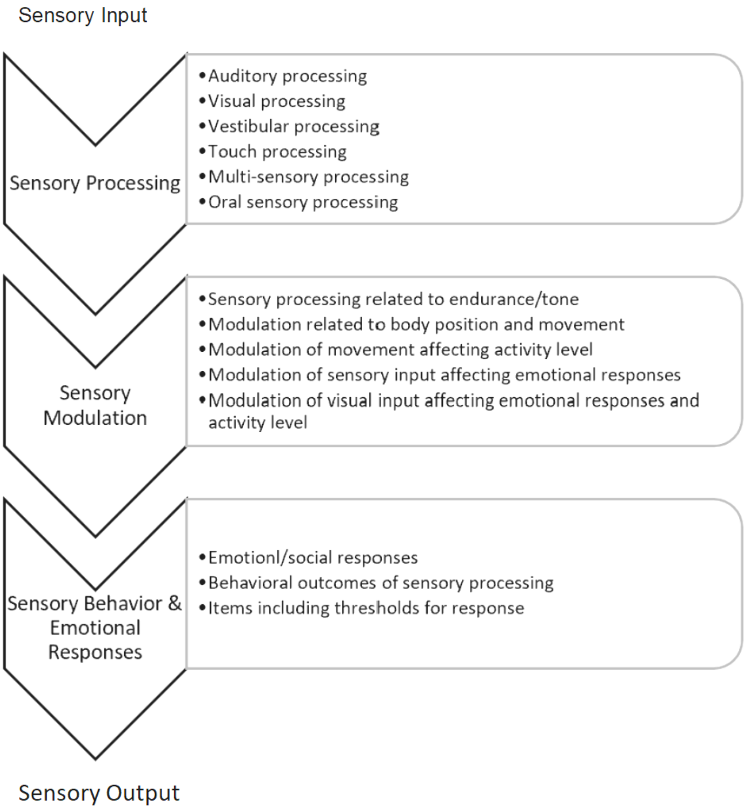

Figure 4. Three Main Sections of the SP-CQ

In addition, there are four quadrants or patterns of sensory processing in the SP-CQ as mentioned in Dunn's model of sensory processing (Dunn, 1997; also see PsychCorp, 2005, for detail): (I) L*ow Registration; (ii) Sensation Seeking; (iii) Sensory Sensitivity;* and (iv) S*ensation Avoiding (see Figure 5)*. Dunn's model consists of two axes comprising of the x-axis of the behavioral response (BR) and the y-axis of the neurological threshold (NT) (Dunn, 1997). These four quadrants resemble to some extent the characteristics as described in Eysenck's Introversion/Extraversion (I/E) model of personality (Sato, 2005) and also the somatosensory event-related potentials (SERP) and their gating (Davies & Gavin, 2007).

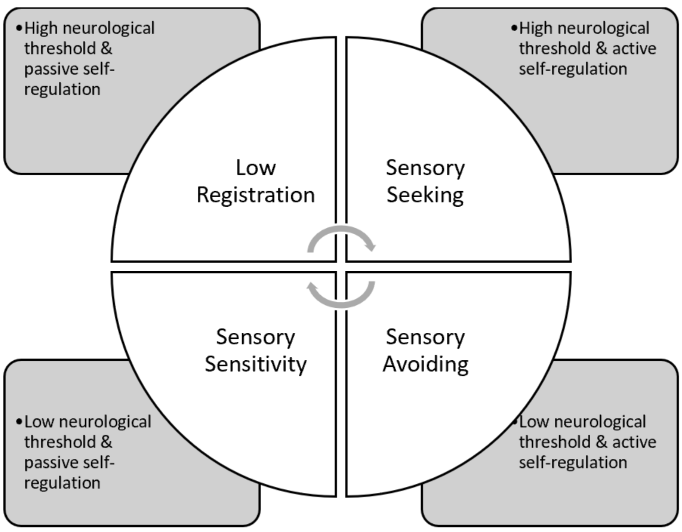

Figure 5. The 4 Quadrants in the SP-CQ

Quadrant 1: Low Registration (LR)

This first sensory quadrant measures an individual's awareness of all available types of sensation. A person with LR does not recognize or process all of the incoming sensory input, and s/he does not compensate by attempting to increase more sensory input to meet his/her needs. Hence, the person appears to be uninterested or inattentive to his/her immediate surrounding.

Quadrant 2: Sensation Seeking (SSk)

This second sensory quadrant measures an individual's interest in and pleasure with all sensory types. A person with SSk is identified as sensation seeking and s/he does not recognize or process all of the incoming sensory information. In contrary to LR, s/he carves for this sensory input to meet his/her needs. The person may be seen as hyperactive, frequently touches others or engages in unsafe activities without considering the risk or danger involved.

Quadrant 3: Sensory Sensitivity (SSt)

This third sensory quadrant measures an individual's ability to notice all sensory types. A person with SSt can be overwhelmed by sensory information, but s/he does not actively try to avoid the over-stimulation. Instead, the person may display frustration. S/He is distracted easily, feels irritable, stays cautious, and feels uncomfortable places with loud noises or bright lights.

Quadrant 4: Sensation Avoiding (SA)

This fourth and last sensory quadrant measures an individual's need for controlling the amount and sensory type available at any time. A person with SA feels overwhelmed by sensory information and will actively avoid the sensory stimulation. S/He may run away from loud, busy environments, cover his/her ears when over-stimulated by noise, or wear boots to avoid the feet getting wet from the puddles after a heavy downpour.

Moreover, the results obtained from the SP-CQ administration, based on Dunn's (1997) sensory processing framework, can show an interplay between the neurological thresholds (y-axis[2]) and self-regulation (x-axis) of emotional- behavioral responses (see Figure 5) in order to explain how sensory information is processed. According to Dunn (2007), the y-axis of neurological threshold (low or high) is an individual's "personal range of threshold for noticing and responding to different sensory events in everyday life" (Cho, 2022, para. 1). Anyone with a low sensory threshold level would notice and/or respond to sensory stimuli more frequently than others because his/her "neurological system activates easier and more readily to sensory events" (Cho, 2022, para. 1). On the other hand, anyone with a high sensory threshold level would frequently "misses stimuli that others notice easily because their neurological system requires stronger stimuli to activate" (Cho, 2022, para. 1).

Cho (2022) described self-regulation of behavioral/emotional responses as "a continuum of behavioral construct" (para. 1) with one end that indicates passive self-regulation, i.e., an individual allows sensory experiences to happen and then reacts (see Dunn, 2007, for detail). For example, a child having to stay at one corner of the classroom, where s/he feels like being bombarded with many sensory inputs, that causes him/her feel uncomfortable. In no time, the child would feel so frustrated that s/he might react by hitting himself/herself or screaming at the top of his/her voice. The other end of the behavioral continuum indicates active self-regulation, which an individual engages in behaviors to manage or

[2] The x- and y- axes are the authors' conceptual explanation for the interplay between self-regulation and neurological threshold.

control sensory inputs. Cho (2022) provided an example: “adjusting one’s position to get a manageable amount of sensory input” (para. 1).

From the intersection of the two axes of neurological threshold and self-regulation, the resulting four sensory quadrants or patterns are as follows:
(1) SSk has high threshold and active self-regulation strategy;
(2) SA has low thresholds and active self-regulation strategy;
(3) SSt has low threshold and passive self-regulation strategy; and
(4) LR has high threshold and passive self-regulation strategy.

Therefore, children, adolescents and/or adults, who display extreme reactions or adverse responses to sensory stimuli, are likely to experience uncalled disruption or interference with the activities of their daily living. High neurological threshold suggests an individual displays hyposensitivity (a condition known as sensory dormancy) that can result in a high probability of depression (Pfeiffer et al., 2005). In addition, sensory dormancy includes *la belle* indifference, lack of attention and concentration, lack of empathy, and craving for sensory stimuli. On the other hand, low neurological threshold indicates hypersensitivity (a condition known as sensory defensiveness) and is known to lead to anxiety (Pfeiffer et al., 2005). Dunn’s model of sensory processing has indeed provided useful assessment and helpful intervention strategies for educational therapists to apply in their professional practice in promoting positive participation of their clients in sensory-based activities.

5. A BRIEF INTRODUCTION TO CATTELL-HORN-CARROLL MODEL OF COGNITIVE ABILITIES

The Cattell-Horn-Carroll (CHC in short) framework of human cognitive abilities was originally conceived by McGrew and Woodcock (2001). It was later extended by Schneider and McGrew (2012) by amalgamating the Horn-Cattell Gf-Gc (based on the theory of fluid Gf and crystallized Gc intelligence) model (Cattell, 1941; Horn 1965) and Carroll’s (1993, 1997) 3-stratum model due to substantial similarities between the two theories (Willis et al., 2011). The cognitive abilities are divided into three strata based on Carroll’s 3-stratum theory (1993): Stratum 1 consists of narrow abilities; Stratum 2 consists of broad cognitive abilities; and Stratum 3 consists of general abilities.

Briefly described, the CHC model is a psychological theory on the structure of human cognitive abilities based on the work of three psychologists: Raymond B. Cattell (b.1905-d.1998), John L. Horn (b.1928-d.2006) and John B. Carroll (b.1916-d.2003). The CHC model or theory has been regarded as a monumental study in the development of human intelligence. With a large body of research that spans over 70 years, Carroll's 3-stratum theory was developed using the psychometric approach with an objective measurement of individual differences in cognitive abilities, and with the application of factor analysis (i.e., a statistical technique to uncover relationships between variables and the underlying structure of concepts, e.g., intelligence) (Keith & Reynolds, 2010). According to Neisser et al. (1996), this psychometric approach has consistently facilitated the development of reliable and valid measurement tools and it continues to dominate the field of intelligence research.

6. THE FOCUS ON THE SENSORY-MOTOR DOMAIN-SPECIFIC ABILITIES

There are six different categories of broad cognitive abilities within the CHC framework provided by Schneider and McGrew (2012) namely, (1) Acquired Knowledge; (2) Domain-Independent General Capacities; (3) Sensory-Motor Domain-Specific Abilities which is further divided into Sensory Category and Motor Category; and (4) General Speed (see Table 1).

Table 1. CHC Model Version 2.1 (Schneider and McGrew, 2012)

Acquired Knowledge	Domain-Independent General Capacities	Sensory-Motor Domain-Specific Abilities		General Speed
		Sensory	**Motor**	
Quantitative Knowledge (Gq)	Short-Term Memory (Gsm)	Auditory Processing (Ga)	Kinesthetic Abilities (Gk)	Processing Sped (Gs)
Reading & Writing (Grw)	Long-Term Storage & Retrieval (Glr)	Visual Processing (Gv)	Psychomotor Abilities (Gp)	Reaction & Decision Speed (Gt)
(Comprehension-Knowledge (Gc)	Fluid Reasoning (Gf)	Olfactory Abilities (Go)		Psychomotor Speed (Gps)
Domain Specific Knowledge (Gkn)		Tactile Abilities (Gh)		

Key: Shaded boxes: Functional Grouping of Broad Cognitive Abilities
Unshaded boxes: Conceptual Grouping of Broad Cognitive Abilities

In this paper, the authors have chosen to focus on the comparison between the Sensory Processing items in the SP-CQ and the broad and narrow cognitive abilities in the Sensory-Motor Domain-Specific Abilities in the version 2.1 of the CHC model (Schneider and McGrew, 2012, 2013), which consists of two subdomains: (1) Sensory and (2) Motor.

Sensory Subdomain

Unlike the six item categories in the SP-CQ Section 1 Sensory processing, there are four broad cognitive abilities under the Sensory Subdomain of the Sensory-Motor Domain-Specific Abilities in the CHC model version 2.1. They are as follows:
(1) Auditory Processing (Ga): This refers to the ability to discriminate, remember, reason, and work creatively (on) auditory stimuli, i.e., tones, environmental sounds, and speech units.
(2) Visual Processing (Gv): This refers to the ability to make use of simulated mental imagery to solve problems. It includes perception, discrimination and manipulation of images in the “mind’s eye” (see Zeman, 2021, for detail).
(3) Olfactory Abilities (Go): This refers to the ability to detect and process meaningful information in odors.
(4) Tactile Abilities (Gh): This refers to the ability to detect and process meaningful information in haptic (touch) sensations. It includes perception, discrimination and manipulation of touch stimuli.

Table 2 provides a summary of the comparison of the sensory processes under the Section 1 Sensory Processing in the SP-CQ and the broad and narrow cognitive abilities under the Sensory Subdomain in the Sensory-Motor Domain-Specific Abilities in the CHC model Version 2.1.

Table 2. Comparison of Sensory Abilities between the SP-CQ and the CHC Model

SP-CQ	CHC Model Version 2.1		
Section 1: Sensory Processing	**CHC Code**	**Broad Cognitive Abilities**	**Narrow Cognitive Abilities**
Auditory Processing	Ga	Auditory Processing	Ga-PC: Phonetic Coding Ga-US: Speech Sound Discrimination Ga-UR: Resistance to Auditory Stimulus Distortion Ga-UM: Memory for Sound Patterns Ga-U1/U9: Musical Discrimination & Judgment Ga-U8: Maintaining & Judging Rhythm Ga-UP: Absolute Pitch Ga-UL: Sound Localization
Visual Processing	Gv	Visual Processing	Gv-Vz: Visualization Gv-SR: Speeded Rotation Gv-CS: Closure Speed Gv-CF: Flexibility of Closure

			Gv-MV: Visual Memory Gv-SS: Spatial Scanning Gv-PI: Serial Perceptual Integration Gv-LE: Length Estimation Gv-IL: Perceptual Illusions Gv-PN: Perceptual Alterations Gv-IM: Imagery
Touch Processing	Gh	Tactile Abilities	The cognitive and perceptual aspects of this domain was not widely investigated.
Oral Sensory Processing (includes both smell and taste)	Go	Olfactory Abilities	Go-OM: Olfactory Memory

Motor Subdomain

Under the Motor Subdomain of the Sensory-Motor Domain-Specific Abilities in the CHC model version 2.1, the two broad cognitive abilities are as follows:
(1) Kinesthetic Abilities (Gk): This refers to the ability to detect and process meaningful information in proprioceptive sensations. At the time of the release of the CHC model version 2.1 in 2012, there were no well-supported narrow cognitive ability factors within Gk (Schneider & McGrew, 2012).
(2) Psychomotor Abilities (Gp): This refers to the ability to perform skilled physical body motor movements (e.g., moving fingers, hands, legs) with precision, coordination, or strength. Schneider and McGrew (2012) believed there were likely more narrow abilities in Gp than were listed in the CHC model version 2.1.

In sensory processing system, the two interoceptive senses that control body awareness, and balance and spatial orientation are proprioceptive senses and vestibular sense, respectively. Only Vestibular Processing (movement) is available in the 125-item SP-CQ, while the Movement Processing (proprioceptive sense) is found in the Sensory Profile-Adolescent/Adult (Brown & Dunn, 2002). According to Vasković (2023), the **vestibular processing system** is a somatosensory aspect of the sensory nervous system, which raises the awareness of the spatial position of the head and body (known as **proprioception**) as well as self-motion (known as **kinesthesia**). ”It is composed of central and peripheral portions” (Vasković, 2023, para. 1).

Table 3 below provides a summary of the comparison of the sensory processes under the Section 1 Sensory Processing in the SP-CQ and the broad and narrow cognitive abilities under the Motor Subdomain in the Sensory-Motor Domain-Specific Abilities in the CHC model version 2.1.

Table 3. Comparison of Sensory Abilities between the SP-CQ and the CHC Model

SP-CQ	**CHC Model Version 2.1**		
Section 1: Sensory Processing	**CHC Code**	**Broad Cognitive Abilities**	**Narrow Cognitive Abilities**
No equivalent of proprioception; Closer to it is Vestibular Processing in the SP-CQ (Dunn, 1999)	Gk	Kinesthetic Abilities (Proprioception)	The cognitive and perceptual aspects of this domain was not widely investigated.
Not in the SP-CQ; The term Movement Processing is only found in the Sensory Profile-Adolescent/Adult (Brown & Dunn, 2002)	Gp	Psychomotor Abilities (Physical body motor movement)	Gp-P3: Static Strength Gp-P6: Multi-limb Coordination Gp-P2: Finger Dexterity Gp-P1: Manual Dexterity Gp-P7: Arm-Hand Steadiness Gp-P8: Control Precision Gp-A1: Aiming Gp-P4: Gross Body Equilibrium

EXTENDING FROM THE SP-CQ TO THE CHC MODEL IN THE SENSORY-MOTOR DOMAIN

It is not sufficient to depend on the SP-CQ administration only to understand about sensory abilities/disabilities. The CHC model provides the much-needed extension of the current knowledge about sensory processing, modulation and emotional-behavioral responses from the Sensory Profile (Dunn, 1999) to a deeper exploration of broad and narrow cognitive abilities relevant to the Sensory-Motor Domain-Specific Abilities. In this way, with this understanding, educational therapists will know better how to apply the principles of sensorimotor learning (Wolpert, Diedrichsen, & Flanagan, 2011) when working with their clients with sensory disabilities.

Below is an elaboration of the broad and narrow cognitive abilities in the Sensory-Motor Domain-Specific Abilities in relation to the relevant item categories under the Section 1 Sensory Processing in the Sensory Profile (Dunn, 1999):

Auditory Processing (Ga)

This is first of the six item categories in the Sensory Profile (Dunn, 1999) Section 1 Sensory Processing on Auditory Processing, but it is not broken down further into its sub-processes. In the CHC framework, the Auditory Processing is represented by the CHC code Ga, which is defined as "[T]he ability to detect and process meaningful nonverbal information in sound" (Schneider & McGrew, 2013, p. 9). Moreover, the cognitive abilities in Ga depend on sound input and the functioning of the hearing apparatus to register, process and interpret these auditory stimuli. A key characteristic is the extent an individual can cognitively manage the competition between signal and noise in the perception of auditory information.

A sensory-motor based treatment plan (SMbTP) for Ga can be done by operationalizing (i.e., express or define aim, goal or objective in terms of the operations used to determine or prove it) its broad goals for Ga and specific objectives for the narrow cognitive abilities of Ga. The following broad goals for Ga are provided below:
Ga Goal-1: To interpret sounds or phonemes heard;
Ga Goal-2: To organize sounds under noisy background or distorting conditions in discriminating patterns in (a) sounds, (b) phonemes, and (c) musical structure;
Ga Goal-3: To analyze sound entities in terms of (a) sound elements, (b) groups of sounds, or (c) sound patterns;
Ga Goal-4: To manipulate sound entities in terms of (a) sound elements, (b) groups of sounds, or (c) sound patterns;
Ga Goal-5: To understand sound entities in terms of (a) sound elements, (b) groups of sounds, or (c) sound patterns; and/or
Ga Goal-6: To synthesize sound entities in terms of (a) sound elements, (b) groups of sounds, or (c) sound patterns.

Unlike the SP-CQ, the CHC framework shows a further breakdown in the broad cognitive ability of Auditory Processing (Ga) into the following narrow cognitive abilities with their respective specific objectives. Below are the narrow cognitive abilities of Ga:

- **Phonetic Coding (Ga-PC)**
  Ga-PC Objective 1: To (a) code, (b) process, and (c) be sensitive to nuances in phonemes or speech sounds in short-term memory; and or
  Ga-PC Objective 2: To (a) distinguish, (b) isolate, (c) blend, and/or (d) transform speech sounds.
- **Speech Sound Discrimination (Ga-US)**
  Ga-US Objective 1: To detect differences in speech sounds/phonemes under conditions of either (a) little or (b) no distraction or distortion; and/or

Ga-US Objective 2: To discriminate differences in speech sounds/phonemes under conditions of either (a) little or (b) no distraction or distortion.

- **Resistance to Auditory Stimulus Distortion (Ga-UR)**
  Ga-UR Objective: To (a) listen to and (b) understand speech or spoken language by overcoming the effects of either distortion or distraction.
- **Memory for Sound Patterns (Ga-UM)**
  Ga-Um Objective: To retain (a) tones, (b) tonal patterns, and/or (c) voices on a short-term basis.
- **Musical Discrimination and Judgment (Ga-U1/U9)**
  Ga-U1/U9 Objective: To (a) differentiate as well as (b) judge tonal patterns in music with respect to (i) melodic, (ii) harmonic, and (iii) expressive aspects based on the following criteria: (1) phrasing, (2) tempo, (3) harmonic-complexity, and (4) intensity variations.
- **Maintaining and Judging Rhythm (Ga-U8)**
  Ga-U8 Objective: To (a) recognize and (b) maintain a musical beat.
- **Absolute Pitch (Ga-UP)**
  Ga-UP Objective: To perfectly distinguish the pitch of tones.
- **Sound Localization (Ga-UL)**
  Ga-UL Objective: To localize heard sounds in a given space.

Visual Processing (Gv)

This is second of the six item categories in the Sensory Profile (Dunn, 1999) Section 1 Sensory Processing on Visual Processing, but it is not broken down further into its sub-processes. In the CHC framework, the Visual Processing is represented by the CHC code Gv, which is referred to "[T]he ability to make use of simulated mental imagery (often in conjunction with currently perceived images) to solve problems" (Schneider & McGrew, 2013, p. 9). Perception, discrimination and manipulation of visual images take place in what is known as the "mind's eye" (Schneider & McGrew, 2012). According to the online APA Dictionary of Psychology (American Psychological Association, 2023), the mind's eye is defined as "the mind's capacity to recall or create images based on visual experience" (para. 1). An impaired mind's eyes can result in aphantasia (see Zeman, 2021, for detail) and this condition is also evident in the spectrum of imagination in autism (see Xie & Deng, 2023, for detail). The narrow cognitive abilities in Gv are generally measured by tasks (viz., figural or geometric stimuli) that require perception and transformation of visual forms, images, shapes and/or, tasks. These, in turn, require an individual to maintain spatial orientation of visual items that may change or move through space.

A SMbTP for Gv can be done by operationalizing its broad goals for Gv and specific objectives for the narrow cognitive abilities of Gv. The broad goals for Gv are provided below:
Gv-Goal 1: To generate (a) visual images and/or (b) sensations;
Gv-Goal 2: To store (a) visual images and/or (b) sensations;
Gv-Goal 3: To retrieve (a) visual images and/or (b) sensations; and
Gv-Goal 4: To transform (a) visual images and/or (b) sensations.

Unlike the SP-CQ, the CHC framework shows a further breakdown in the broad cognitive ability of Visual Processing (Gv) into the following narrow cognitive abilities with their respective specific objectives. Below are the narrow cognitive abilities of Gv:

- **Visualization (Gv-Vz)**
  Gv-Vz Objective 1: To apprehend a (a) spatial form, (b) item, or (c) scene;
  Gv-Vz Objective 2: To match a (a) spatial form, (b) item or **(c)** scene with another (i) spatial item, (ii) form, or (iii) scene with the requirement to rotate it (one or more times) in either two or three dimensions.
  Gv-Vz Objective 3: To mentally (a) imagine, (b) manipulate or (c) transform either items or visual patterns (without having to concern about the response speed); and/or

Gv-Vz Objective 4: To "see" (predict) how these (a) items or (b) visual patterns would appear under altered conditions (e.g., parts are rearranged, replaced or moved).

- **Spatial Relations (Gv-SR)**
  Gv-SR Objective 1: To rapidly (a) perceive and (b) manipulate (mental rotation, transformations, reflection, etc.) visual patterns;
  Gv-SR Objective 2: To maintain orientation with respect to items in space; and/or
  Gv-SR Objective 3: To distinguish an item when viewed from different (a) angles and/or (b) positions.
- **Closure Speed (Gv-CS)**
  Gv-CS Objective 1: To take a short time to distinguish a familiar meaningful visual item from incomplete (i.e., it can be disconnected, partially obscured or vague) visual stimuli, without knowing in advance what the item is.
  Gv-CS Objective 2: To assume a target item to be represented in an individual's long-term memory (LTM) storage.
  Gv-CS Objective 3: To (a) "fill in" unseen/omitted parts in a disparate perceptual field and (b) form a single criterion/rule.
- **Flexibility of Closure (Gv-CF)**
  Gv-CF Objective 1: To distinguish a (a) visual figure and/or (b) pattern embedded in a complex (i) distracting and/or (ii) disguised visual pattern/array with prior knowledge of what the pattern is.
  Gv-CF Objective 2: To either (a) recognize or (b) ignore distracting background stimuli as part of the visual closure ability.
- **Visual Memory (Gv-MV)**
  Gv-MV Objective 1: To (a) form as well as (b) store a mental representation or image of a (i) visual shape and/or (ii) configuration (especially, during a short study period), over at least a few seconds; and/or
  Gv-MV Objective 2: To recognize or recall the mental representation/image of a (a) visual shape and/or (b) configuration later (during the test phase).
- **Spatial Scanning (Gv-SS)**
  Gv-SS Objective 1: To survey (visually explore) a wide or complicated spatial field or pattern promptly and accurately;
  Gv-SS Objective 2: To distinguish a particular configuration/pathway through the visual field; and/or
  Gv-SS Objective 3: To visually follow an indicated route/path through the visual field.
- **Serial Perceptual Integration (Gv-PI)**
  Gv-PP Objective: To distinguish (and also especially to name) a pictorial and/or visual pattern when parts of the pattern are presented quickly in serial order (e.g., portions of a line drawing of an animal are passed in sequence through a small 'window').
- **Length Estimation (Gv-LE)**
  Gv-LE Objective 1: To make an accurate estimation of visual lengths or distances without the help of measurement or measuring tools; and/or
  Gv-LE Objective 2: To make an accurate comparison of visual lengths or distances without the help of measurement or measuring tools.
- **Perceptual Illusions (Gv-IL)**
  Gv-IL Objective 1: To resist being affected by mistaken perception or illusory perceptual aspects of geometric figures in response to some characteristic of the stimuli); and/or
  Gv-IL Objective 2: To resist perceptual illusions (also known as an individual's 'response tendency').
- **Perceptual Alternations (Gv-PN)**
  Gv-PN Objective: To keep a consistent rate of alternating between different visual perceptions.
- **Imagery (Gv-IM)**
  Gv-IM Objective 1: To mentally encode/depict an absent (a) item, (b) idea, (c) event or (d) impression in the form of an abstract spatial form; and/or

Gv-IM Objective 2: To mentally manipulate an absent (a) item, (b) idea, (c) event or (d) impression in the form of an abstract spatial form.

Olfactory Abilities (Go)

In the SP-CQ, this is known as Oral Sensory Processing, which covers both smell and taste. It is the last of the six item categories in the Sensory Profile (Dunn, 1999) Section 1 Sensory Processing, but it is not broken down further into its sub-processes. In the CHC framework, the Olfactory Abilities is represented by the CHC code Go, which strictly focuses on smell alone with no taste (Gustatory Abilities or Gg? As its CHC code) being taken into consideration. The olfactory abilities depend on odorant receptors of the olfactory system (nasal chambers). According to Schneider and McGrew (2013), "Go refers not to sensitivity of the olfactory system but to the cognition one does with whatever information the nose is able to send" (p. 10). The cognitive and perceptual aspects of this domain had not yet been thoroughly researched when the CHC model version 2.1 was released (Schneider & McGrew, 2012).

A SMbTP for Go can be done by operationalizing its broad goals for Go and only one specific objective for the narrow cognitive ability of Go. The following broad goals for Go are provided below:
Go-Goal 1: To detect smell/odor through the nose;
Go-Goal 2: To sense the direction where the smell/odor is coming from;
Go-Goal 3: To discriminate between pleasant and unpleasant smells/odors;
Go-Goal 4: To use smell/odor to make a choice of preferred food; and/or
Go-Goal 5: To use smell/odor to sense danger in the environment (e.g., fire).

Like the SP-CQ, the CHC framework shows no further breakdown in the broad cognitive ability of Olfactory Abilities (Go). As mentioned earlier, at the moment, only one narrow cognitive ability with its specific objective has been listed in the CHC model version 2.1 for Go as follows:

- **Olfactory Memory (Go-OM)**
  Go-OM Objective: To establish memory for smells/odors.

Schneider and McGrew (2013) believed there should be more probable narrow cognitive abilities in Go such as "olfactory memory, episodic odor memory, olfactory sensitivity, odor specific abilities, odor identification and detection, odor naming, olfactory imagery" (p. 10).

Tactile Abilities (Gh)

This is generally known as Touch Processing (also known as Haptic Processing in literature) in the SP-CQ. It is the fourth of the six item categories in the Sensory Profile (Dunn, 1999) Section 1 Sensory Processing, but it is not broken down further into its sub-processes. In the CHC framework, the Tactile Abilities (also known as Haptic Abilities) is represented by the CHC code Gh, which are involved in the perception and judging of sensations that are received through tactile (touch) sensory receptors. That is to say Gh does not refer to sensitivity of touch but to the cognition an individual does with tactile sensations (Schneider & McGrew, 2013). According to Schneider and McGrew (2013), "[B]ecasue this ability is not yet well-defined and understood, it is hard to describe it authoritatively" (p. 10). The sense of **touch** or tactioceptive sense involves the skin which contains general receptors to detect touch, pain, pressure and temperature.

A SMbTP for Gh can be done by operationalizing its broad goals for Gh and specific objectives for the narrow cognitive abilities of Gh. The following broad goals for Gh are provided below:
Gh-Goal 1: To (a) perceive and (b) judge thermal stimulation,
Gh-Goal 2: To (a) perceive and (b) judge spatial stimulation, or
Gh-Goal 3: To (a) perceive and (b) judge patterns imposed on the skin.

At the time of the release of the CHC model version 2.1 in 2012, the cognitive and perceptual aspects of this domain was not widely investigated (Schneider & McGrew, 2012). However, Schneider and McGrew (2013) did highlight that the domain might include such probable narrow cognitive abilities as Tactile Memory, Texture Knowledge and Tactile Sensitivity. At the moment, there are still no confirmed narrow cognitive abilities of Gh.

Kinesthetic Abilities (Gk)

In the SP-CQ, only the Vestibular Processing is explicitly mentioned. It is the third of the six item categories in the Sensory Profile (Dunn, 1999) Section 1 Sensory Processing on Oral Sensory Processing, but it is not broken down further into its sub-processes. A close equivalent of Vestibular Processing in the SP-CQ is the Movement Processing in the Adolescent/Adult-Sensory Profile (AA-SP; Brown & Dunn, 2002). As mentioned earlier, Vestibular Processing, which receives sensory information from head movement and gravity to maintain balance, equilibrium, and movement through space, also includes both **proprioceptive senses** and **kinesthetic senses (see** Vasković, 2023, for detail). In the CHC framework, the Kinesthetic Abilities, which is represented by the CHC code Gk, depend on sensory receptors that detect bodily (a) position, (b) weight, and/or (c) movement of three musculoskeletal aspects: muscles, tendons, and joints. It refers to "[T[he ability to detect and process meaningful information in proprioceptive sensations" (Schneider & McGrew, 2013, p. 10). Schneider and McGrew (2013) elaborated further on proprioception as "the ability to detect limb position and movement via proprioreceptors … Gk refers not to the sensitivity of proprioception but to the cognition one does with proprioceptive sensations" (p. 10). At the time of the release of CHC model version 2.1, "[T]here were no well-supported narrow cognitive ability factors within Gk yet" (Schneider & McGrew, 2013, p. 10). Although Vestibular Processing (movement modality) covers proprioception and kinesthesia, there is no exact equivalent of Gk in the SP-CQ. However, it has been identified as Movement Processing in the AA-SP form (Brown & Dunn, 2002).

A SMbTP for Gk can be done according to the following broad goals for Gk as there were no specific objectives for the narrow cognitive abilities of Gk back in 2012. According to Schneider and McGrew (2012), the cognitive and perceptual aspects of Gk have yet to be widely studies. The following broad goals are provided below:
Gk-Goal 1: To control body movements
Gk-Goal 2: To coordinate body movements

Perhaps the Kinesthetic Sensitivity being a sensory acuity ability should be considered as a probable narrow cognitive ability in Gk. Schneider and McGrew (2013) defined it as "the ability to make fine discrimination in proprioceptive sensations (e.g., if and how much a limb moves)" (p. 10).

Psychomotor Abilities (Gp)

In the SP-CQ, there is no exact equivalent sensory processing (closest being the Vestibular Processing or Movement Processing in the AA-SP) for Psychomotor (Gp) mentioned in the CHC model version 2.1. Schneider and McGrew (2013) described it as "[T]he ability to perform physical body motor movements (e.g., movement of fingers, hands, legs) with precision, coordination, or strength" (p. 11). These movement or motor behaviors are typically the result of mental activity.

A SMbTP for Gp can be done by operationalizing its broad goals for Gp and specific objectives for the narrow cognitive abilities of Gp. The following broad goals for Gp are provided below (see Schneider & McGrew, 2013, p. 11):
Gp-Goal 1: To perform physical body motor movements with precision;
Gp-Goal 2: To perform physical body motor movements with coordination; and
Gp-Goal 3: To perform physical body motor movements with strength.

The CHC framework shows a further breakdown in the broad cognitive ability of Psychomotor Abilities (Gp) into the following narrow cognitive abilities with their respective specific objectives. Below are the narrow cognitive abilities of Gp (see Schneider & McGrew, 2013, p. 11, for detail):

- **Static Strength (Gp-P)**
  Gp-P3 Objective: To exert muscular force to move, i.e., (a) push, (b) lift, and/or (c) pull) a relatively (i) heavy or (ii) immobile object.
- **Multi-limb Coordination (Gp-P6)**
  Gp-P6 Objective: To make quick (a) specific or (b) discrete motor movements of the arms or legs (measured after the movement is initiated). Accuracy is not relevant here.
- **Finger Dexterity (Gp-P2)**
  Gp-P2 Objective: To make precisely coordinated movements of the fingers (with or without the manipulation of items).
- **Manual Dexterity (Gp-P1)**
  Gp-P1 Objective: To make precisely coordinated movements of (a) a hand, or (b) a hand and the attached arm together.
- **Arm-hand Steadiness (Gp-P7)**
  Gp-P7 Objective: To precisely and skillfully coordinate arm-hand positioning in space.
- **Control Precision (Gp-P8)**
  Gp-P8 Objective: To exert precise control over muscle movements, particularly when responding to environmental feedback (e.g., speed change or position of a manipulated item).
- **Aiming (Gp-AI)**
  Gp-AI Objective: To execute (a) precisely and (b) fluently a sequence of eye-hand coordination movements for positioning purposes.
- **Gross Body Equilibrium (Gp-P4)**
  Gp-P4 Objective 1: To maintain the body in an upright position in space; and/or
  Gp-P4 Objective 2: To regain balance after a disturbance to balance.

7. CONCLUSION

Figure 6 below provides a diagrammatic summary of what has been discussed in this paper.

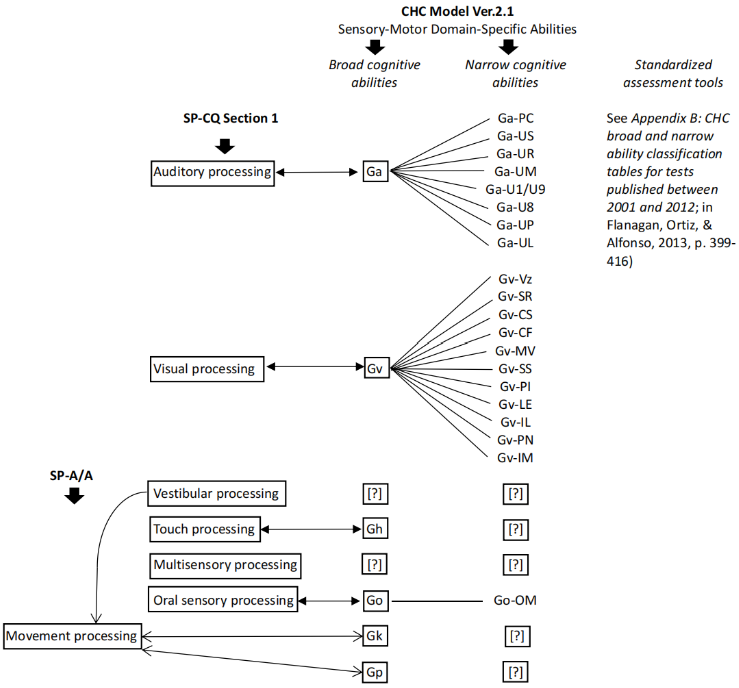

Figure 6. A Diagrammatic Summary

Educational therapists will find it most helpful as well as useful to them if they go beyond the SP-CQ results by taking an addition step to consider the various relevant broad and narrow cognitive abilities listed in the Sensory-Motor Domain-Specific Abilities provided in the CHC model version 2.1. When operationalizing the broad goals and specific objectives based on the CHC-based broad and narrow cognitive abilities respectively, educational therapists with their professional content knowledge and creativity can utilize them in deciding the kind of standardized assessment tool to use in their administration to determine the problem suspected and also in designing an appropriate treatment plan that can best meet their client's unique learning and behavioral needs (see Figure 6 above).

In the best practice of educational therapy, there remains much for everyone in the field to learn about the CHC model and understand how to apply it in their professional work. However, there is still a need to ensure a smooth process of transition from obtaining the screener subtest results (e.g., the different item categories in the SP-CQ) and match them with the CHC broad cognitive abilities. Next, under each CHC broad cognitive ability, there are several CHC narrow cognitive abilities. Each of them lists several age-appropriate specific standardized tests to be administered in order to identify the root causes of the problem concerned. With this detailed set of specific test results based on the CHC narrow cognitive abilities via interpretation of the results, a more targeted treatment plan with a higher level of effectiveness can be designed by an educational therapist to meet a client's learning and/or behavioral needs.

8. COMPETING INTERESTS

Authors have declared that no competing interests exist

9. ARTIFICIAL INTELLIGENCE DISCLOSURE

No generative AI or AI-assisted technologies were used in the preparation of this manuscript.

REFERENCES

Achieve Beyond Pediatric Therapy & Autism Services (2023). Vestibular sensory processing. In *Achieve Beyond blog*. Retrieved from: https://www.achievebeyondusa.com/vestibular-sensory-processing/.

American Psychological Association (2023). Mind's eye. In *APA dictionary of psychology*. Retrieved from: https://dictionary.apa.org/minds-eye.

American Psychiatric Association (2013). *Diagnostic and statistical manual of mental disorders (DSM-5)*. Washington, DC: American Psychiatric Association.

Astle, D. E., & Scerif, G. (2009). Using developmental cognitive neuroscience to study behavioral and attentional control. *Developmental Psychobiology,* 51 (2), 107-118.

Braley, P. (2014, March 9). The vestibular system. In *The Inspired Treehouse*. Retrieved from: https://www.theinspiredtreehouse.com/vestibular/.

Brennan, D. (2021, November 27). What is proprioception? In *WebMD*. Retrieved from: https://www.webmd.com/brain/what-is-proprioception/.

Brown, C., & Dunn, W. (2002). *Sensory Profile: Adolescent/adult*. Bloomington, MN: Pearson Inc.

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytic studies*. Cambridge, UK: Cambridge University Press.

Carroll, J. B. (1997). The three-stratum theory of cognitive abilities. In D. P. Flanagan, J. L. Genshaft, & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests and issues* (pp. 122–130). New York, NY: Guilford Press.

Cattell, R. B. (1941). Some theoretical issues in adult intelligence testing. *Psychological Bulletin*, *38*, 592.

Children's Hospital of Richmond@Virginia Commonwealth University (2023). *Sensory/social skills: 2 to 12 years*. Retrieved from: https://www.chrichmond.org.

Cho, M. (2022). Dunn's model of sensory processing. In *HOTheory*. Retrieved from: https://ottheory.com/therapy-model/dunns-model-sensory-processing

Cohen, M. J. (1995). *Reconnecting with nature*. Lexington, KY: Finney Company, Incorporated.

Davies, P. L., & Gavin, W. J. (2007). Validating the diagnosis of sensory processing disorders using EEG technology. *Amerian Journal of Occupational Therapy*, *61*, 176–189.

Dunn, W. (1997). The impact of sensory processing abilities on the daily lives of young children and their families: A conceptual model. *Infants & Young Children,* 9, 23-35.

Dunn, W. (1999). *The Sensory Profile user's manual*. San Antonio, TX: Psychological Corporation.

Dunn, W. (2007). Supporting children to participate successfully in everyday life by using sensory processing knowledge. *Infant and Young Children, 20*, 84-101.

Dunn, W. (2008). *Technical report: Sensory profile*. London, UK: Pearson Education.

Flanagan, D. P., Costa, M., Palma, K., Leahy, M. A., Alfonso, V. C., & Ortiz, S. O. (2018). *Cross-battery assessment, the cross-battery assessment software system, and the assessment–intervention connection*. New York, NY: Guilford Press.

Flanagan, D. P., Ortiz, S. O., & Alfonso, V. C. (2013). *Essentials of cross-battery assessment (3rd ed.)*. Hoboken, NJ: John Wiley & Sons.

Hicks, R. D. (Ed.). (2015). *Aristotle de anima*. Cambridge, UK: Cambridge University Press.

Horn, J. L. (1965). Fluid and crystallized intelligence: A factor analytic and developmental study of the structure among primary mental abilities. Unpublished doctoral dissertation. University of Illinois, Champaign, IL, USA.

Keith, T. Z., & Reynolds, M. R. (2010). Cattell–Horn–Carroll abilities and cognitive tests: What we've learned from 20 years of research. *Psychology in the Schools*, *47*(7), 635-650.

McGrew, K. S., LaForte, E. M., & Schrank, F. A. (2014). *Woodcock-Johnson IV: Technical manual*. Rolling Meadows, IL: Riverside

Mcilroy, T. (2022, November 15). The simple guide to sensory development in children. In *Empowered Parents*. Retrieved from: https://empoweredparents.co/sensory-development/.

Miller, L. J., Anzalone, M. E., Lane, S. J., Cermak, S. A., & Osten, E. T. (2007). Concept evolution in sensory integration: A proposed nosology for diagnosis. *American Journal of Occupational Therapy*, *61*, 135-140.

Neisser, U., Boodoo, G., Bouchard Jr, T. J., Boykin, A. W., Brody, N., Ceci, S. J., ... & Urbina, S. (1996). Intelligence: Knowns and unknowns. *American Psychologist*, *51*(2), 77.

Nurse Key (2017, April 16). *Chapter 42: Sensory abilities*. Retrieved from: https://nursekey.com/sensory-abilities/.

Pfeiffer, B., Kinnealey, M., Reed, C., & Herzberg, G. (2005). Sensory modulation and affective disorders in children and adolescents with Asperger's disorder. *The American Journal of Occupational Therapy*, *59*(3), 335-345.

Porges, S. W. (2004). Neuroception: A subconscious system for detecting threats and safety. *Zero to Three Journal*, *24*(5), 19-24.

PsychCorp (2005). *Technical report: Infant/toddler sensory profile*. Austin, TX: Harcourt Assessment, Inc.

Sato, T. (2005). The Eysenck personality questionnaire brief version: Factor structure and reliability. *Journal of Psychology*, *139*, 545–552.

Schneider, W. J., & McGrew, K. S. (2012). The Cattell-Horn-Carroll model of intelligence. In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (pp. 99–144). New York, NY: The Guilford Press.

Schneider, W. J., & McGrew, K. S. (2013). *The Cattell-Horn-Carroll (CHC) model of intelligence v.2.2: A visual tour and summary*. St Joseph, MN: Institute for Applied Psychometrics.

Schoen, S. A., Miller, L. J., & Sullivan, J. C. (2014). Measurement in sensory modulation: the sensory processing scale assessment. *The American Journal of Occupational Therapy*, *68*(5), 522-530.

Shields, C. J. (Ed.). (2016). *Aristotle: De Anima*. Oxford, UK: Oxford University Press.

Star Institute, The (2020). The sensory processing abilities. In *Two Fish Therapy*. Retrieved from: https://www.twofishtherapy.com/resources/sensory-processing-abilities/.

Stein, B. E., & Rowland, B. A. (2011). Organization and plasticity in multisensory integration: early and late experience affects its governing principles. *Progress in Brain Research*, *191*, 145-163.

Stein, B. E., Stanford, T. R., & Rowland, B. A. (2009). The neural basis of multisensory integration in the midbrain: Its organization and maturation. *Hearing Research,* 258(1/2), 4-15.

Therapy Solutions for Kids (2023, May 10). Early sensory skills: Activities for sensory skills development. In *Therapy solutions for kids*. Retrieved from: https://www.therapysolutionsforkids.com/early-sensory-skills-activities-for-sensory-skills-development/.

Willis, J. O., Dumont, R., & Kaufman, A. S. Factor-analytic models of intelligence. In Sternberg, R. J., & Kaufman, S. B. (Eds.). (2011). *The Cambridge handbook of intelligence*. (pp. 39–57). Cambridge University Press.

Vasković, J. (2023, April 12). Vestibular system. In *Kenhub*. Retrieved from: https://www.kenhub.com/en/library/anatomy/the-vestibular-system.

Xie, G. H., & Deng, M. J. (2023). *The spectrum of imagination in autism*. London, UK: Lambert Academic Publishing.

Zeman, A. (2021). Blind mind's eye. *American Scientist*, *109*, 110-117.