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Interoception Toolkit: A Resource For Occupational Therapy Practitioners To Use With Children And Their Families

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INTERCEPTION TOOLKIT: A RESOURCE FOR OCCUPATIONAL THERAPY
PRACTITIONERS TO USE WITH CHILDREN AND THEIR FAMILIES

by

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A Scholarly Project

Submitted to the Occupational Therapy Department

Of the

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in partial fulfillment of the requirements

for the degree of Doctor's of Occupational Therapy

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This scholarly project, submitted by Heidi Lynn Janssen, OTDS in partial fulfillment of the requirement for the Degree of Occupational Therapy Doctorate from the University of North Dakota, has been read by the Faculty Advisor under whom the work has been done and is hereby approved.



Faculty Advisor

4-18-22

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Title Interoception Toolkit: A Resource for Occupational Therapy Practitioners
 to Use with Children and Their Families

Department Occupational Therapy

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS.....	v
ABSTRACT.....	vi
CHAPTERS	
I. INTRODUCTION.....	1
II. REVIEW OF THE LITERATURE.....	7
III. METHODOLOGY.....	19
IV. PRODUCT DESCRIPTION.....	22
V. SUMMARY.....	25
REFERENCES.....	29
APPENDIX.....	38
Appendix A: Product.....	39

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ABSTRACT

Purpose: Interoception refers to one's ability to sense the internal condition of the body, including sensory messages from body parts and internal organs (Craig, 2002). In the past 30 years, scientists and researchers have discovered a powerful connection between interoceptive appraisal skills and self-regulation, emotional identification, emotional regulation, social skills, and nearly every task in daily life (Mahler, 2017). The purpose of this project is to provide practitioners with an educational platform that describes the sensorimotor skill of interoception applied throughout the occupational therapy process.

Methods: The development of this product was initiated with a thorough review of literature to identify areas of need. Types of sources included online databases such as CINAHL, Pubmed, Google Scholar, and the University of North Dakota Scholarly Commons. Key resources that informed the project discussed the neuroscience of interoception (Critchley et al., 2014; Stern et al., 2017; Quadt, Critchley, & Garfinkel, 2018), interoception and self-regulation, (Füstös et al., 2012; Mahler, 2017), interoception and emotion (Mahler, 2017; Nummenmaa et al., 2014; Herbert et al., 2011; Mahler 2019), interoception and occupations/tasks (Williams & Shellenberger, 1996), and the relationship between interoception and contextual factors (Dean et al., 2010; Zhou et al., 2021; Stern et al., 2017). After careful review of theories and models, the Ecological Model of Human Performance (EHP) was chosen to guide the development and content within the product. EHP emphasizes the dynamic, interdependent relationship between a person's skills/abilities and the contexts in which they are embedded in (Dunn, 2017).

Results: An interoception toolkit and manual for practitioners was created. This toolkit and manual has six sections: *Introduction to the Manual*, *Introduction to Interoception*, *Evaluation/Assessment of Interoception*, *Interoception Intervention Framework*, *Documentation and Outcomes*, and *Opportunities for Specialized Interoception Programming*.

Conclusion: This educational platform was created to increase awareness of, and increase the use of interoception-based practices in pediatric occupational therapy. It is anticipated that this product will address a need for innovative, evidence-based occupational therapy interventions that target self-regulation, emotional regulation, social skills, and self-care skills for children.

CHAPTER I

Introduction

Problem Statement

In westernized medicine and culture, there is a dominant belief in the experience of self-regulation and emotion as a phenomenon that occurs within the brain, independently from the body (Zhou, Critchley, Garfinkel, & Gao, 2021). Within the past 50 years, the profession of occupational therapy has approached self-regulation and emotional regulation through the lens of sensorimotor and perceptual experiences that are largely influenced by the organization of the central nervous system (Parham & Mailloux, 2020). Through these discoveries, self-regulation and emotional experiences have been liberated from the narrowed lens of being a primarily a brain-based phenomenon to a brain-body interdependent phenomenon. With this, researchers have acknowledged the importance of the five external senses—vision, olfaction, tactile sense, auditory sense, and gustatory sense—along with two internal senses—the vestibular system and the proprioceptive system, and most recently, an eighth sense: interoception.

Interoception refers to one's ability to sense the internal condition of the body, including messages from the organs and skin (Mahler, 2017). Interoception is an incredibly complex and nuanced type of sensory-perception, yet researchers have made groundbreaking discoveries in regards to its role with self-regulation, emotional identification, emotional regulation, social skills, and nearly every task in daily life (Mahler, 2017). At this time, interoception as a sensorimotor skill is quickly gaining

attention in occupational therapy research. Many researchers are in the process of investigating the role of interoception with daily occupations. Additionally, experts in the field of sensory processing are currently enhancing or developing sensory processing assessments to investigate interoception-based skills.

In occupational therapy practice, pediatric practitioners, globally speaking, are in the beginning stages of incorporating interoception into the occupational therapy process. Notably, Dr. Kelly Mahler (OTR/L) has created numerous interoception publications and courses, an interoception curriculum, and commercially available resources for practitioners and families. These include *The Interoception Curriculum: A Step-By-Step Framework for Developing Mindful Self-Regulation* (Mahler, 2019), *My Interoception Workbook: A Guide for Adolescents, Teens, and Adults* (Mahler, Rothschild, & Alma, 2019), and *Interoception- The Eighth Sensory System* (Mahler, 2017) to name a few. With this, there are opportunities for expansion and enhancement of interoception-based materials and programming to include exploration of learning materials for children with language-processing disabilities, cognitive disabilities, and perceptual differences. Additionally, younger children who have a difficult time communicating sensations may benefit from alternative types of interoception frameworks. There is a need for enhancement of accessibility for various performance ranges, as well as practitioner education on clinical application of interoception-based programming throughout the OT process.

Purpose Statement

The purpose of this scholarly project is to provide practitioners with an educational platform that describes the sensorimotor skill of interoception applied

throughout all aspects of the occupational therapy process. The overarching goal of the product is to provide practitioners with an interoception educational manual and intervention toolkit that is applicable to a wide variety of person factors, contextual factors, and types of tasks to enhance performance range in children who struggle with interoception. Overall, it is anticipated that these skills will enable practitioners to integrate knowledge of interoception into the OT process, in order to impact the performance range of children who struggle with sensory processing, self-regulation, emotional regulation, and social skills.

Project Objectives

This manual serves as an educational platform for occupational therapy practitioners that describes the sensorimotor skill of interoception applied throughout the OT process. The manual outlines terminology related to interoception, and describes cognitive, sensorimotor, and psychosocial person factors that influence performance range outcomes. The manual describes the relationship between interoception and contextual factors, including cultural, social, temporal, and physical contexts. Educational information is provided to foster the development of clinical reasoning skills applied during evaluation, assessment, goal development, intervention, and discharge. Overall, it is anticipated that these skills will enable practitioners to integrate knowledge of interoception into the OT process, in order to impact the performance range of children who struggle with sensory processing, self-regulation, emotional regulation, and social skills.

Theoretical Framework

After extensive review of occupation-based theories and frames of references, the Ecological Model of Human Performance (EHP) was selected as the theoretical framework to guide the content of this scholarly project. The core constructs within EHP includes the dynamic relationship between person factors, contextual factors, and task factors that create a performance range that is unique to the individual (Dunn, 2017). Within this model, dysfunction occurs when a person's desired tasks lie outside of their current performance range, as a result of a dynamic relationship between person, context, and task factors (Dunn, 2017).

According to Dunn (2017), person factors include a combination of sensorimotor, cognitive, and psychosocial skills. Person factors also include the person's wants, needs, and desires that impact performance range outcomes. As an ecological model, emphasis is placed on the importance of natural environments and contexts. Specifically, a person is embedded within a set of external contexts with their own associated meanings. These include one's physical context, social context, cultural context, and temporal contexts. Person factors and contextual factors interact dynamically and are ever-evolving. Tasks include actions or behaviors that are goal-oriented and that serve meaning and importance to the person completing them. Performance range includes a combination of tasks that an individual is able to complete independently. Some tasks may exist outside of the person's performance range. In this case, independence and satisfaction with performance range is determined by the individual (Dunn, 2017).

Occupational therapy practitioners target aspects of the person, their context, or the tasks through the use of five different intervention approaches. Throughout this

process, occupational therapists need to be aware of the dynamic, ever-changing, and interdependent relationship between person factors, contextual factors, and task factors. In pediatric occupational therapy, specifically with sensory interventions and interoception work, an occupational therapist influences sensorimotor skills of the person or child primarily through a focus on the context/environment (Parham & Mailloux, 2020). This emphasis of the interdependence between person factors as they exist within their contexts is what makes EHP the best choice for this scholarly project (Dunn, 2017).

Key Terminology

The following terms are referenced throughout the scholarly project.

- Interoception- one's ability to sense the condition of the inside of the body, including the organs and skin (Craig, 2002; Mahler, 2017). In occupational therapy practice, interoception is becoming increasingly recognized as one of the body's senses, and is a key player in self-regulation, emotional regulation, social experiences, and performance range with daily occupations.
- Interoceptive accuracy- One's ability to successfully modulate interoceptive cues and create an appropriate self-regulation response that is consistent with the demands of one's environment/context.
- Self-regulation- Self-regulation refers to a person's ability to adjust/modify their behaviors to meet the demands of a task within a set of physical, social, cultural, and/or temporal context parameters (Suedel, 2021). Self-regulation behaviors occur in response to interoceptive cues regarding the body's current state of homeostasis.

- Emotion- A feeling that is perceived through a combination of sensory experiences and psychophysiological responses that inform behavioral responses (Critchley & Garfinkel, 2017).
- Emotional-regulation- Emotional regulation refers to one's ability to successfully regulate emotions in order to meet the demands of a task within a set of physical, social, cultural, and/or temporal context parameters (Suedel, 2021).

Conclusion

The purpose of this project is to enhance the sensorimotor skill of interoception in occupational therapy practice by providing practitioners with knowledge of implementing interoception concepts throughout the OT process. By increasing the focus on interoception-based concepts, practitioners will be better equipped to teach self-regulation, emotional regulation, and social skills to children.

CHAPTER II

Review of Literature

Overview of Terms

When considering a child's ability to be successful with their daily occupations, there is a shift from focusing on pure behavior as it exists as a singular phenomenon, to a focus on an underlying need or difference in the child's sensory system that impacts behavior as an outcome (Williams & Shellenberger, 1996). The five senses—sight, smell, touch, hearing, and taste enable a person to gather information about the external world around them. In addition to the five senses, health sciences and allied professions have acknowledged the powerful influence of two other senses -- the vestibular system and the proprioceptive system— defined as the sense of head position in space and the sense of limb and whole body movement in space, respectively. In the past 20 years, scientists and researchers have acknowledged the presence of an eighth sense, which has a profound impact on a person's ability to function in daily living.

The term *interoception* refers to one's ability to sense the condition of the inside of the body, including the organs and skin (Craig, 2002). Interoceptive cues can be classified under two categories—homeostatic cues and affective cues (Hample & Mahler, 2021). Homeostatic cues provide a person with information about physiological processes within the body, which includes hunger, thirst, fullness, need for restroom, pain, and illness to name a few. Affective cues provide a person with information that assists in recognizing, interpreting, and perceiving emotions. For example, information

about the emotion of fear might include tense muscles, a rapid heart rate, and stomach pain/discomfort (Mahler, 2017; Hample & Mahler, 2021).

Person Factors

The neurology of interoception.

Like other sensory systems, the organs of the body contain receptors that take in sensory information and relay those messages back to the brain. The area of the brain that receives interoceptive cues is called the insular cortex, also referred to as the insula (Mahler, 2017; Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004; Jackson, Parkinson, Kim, Schüermann, & Eickhoff, 2011; Jung, Ryu, Lee, Wallraven, & Chae, 2017; Quadt, Critchley, & Garfinkel, 2018; Stern et al., 2017; Wang et al., 2019). Through recent research and advancements in technology, the role of the insula has become better understood. Through the use of functional magnetic resonance imaging (fMRI) technology, scientists have determined that increased activity in the insula leads to higher interoceptive accuracy (Critchley et al. 2004; Jackson et al., 2011; Jung et al., 2017; Mahler, 2017; Quadt, Critchley, & Garfinkel, 2018; Stern et al., 2017; Wang et al., 2019). Additionally, interoceptive accuracy is positively correlated with a higher volume of gray matter in the insula (Critchley et al., 2004). When the insula receives sensory messages from the body, it carefully filters, or modulates the incoming information to determine if a counter action is needed in order to bring the body back to a feeling of homeostasis (Füstös, Gramann, Herbert, & Pollatos, 2012; Mahler, 2017).

A hierarchy of performance skills—sensory processing.

The sensory system is constantly receiving, interpreting, and modulating information from the outside and inside of a person's body in order to help the person

achieve safety and homeostasis. Through the five external senses—sight, smell, touch, hearing, and taste—a person carefully gathers information about the outside world. Using the three internal senses—the vestibular sense, proprioception, and interoception—a person gathers information about their current body condition/location in space. Successful sensory experiences enable a person to feel safe, move about their environment successfully, and complete meaningful and important tasks (Williams & Shellenberger, 1996). Without successful sensory modulation and limited self-insight from interoceptive cues, self-regulation becomes a greater challenge.

According to Dunn's Model of Sensory Processing (Dunn, 1997), children who struggle with sensory processing will have a significantly different threshold of response to a sensory stimulus, as well as a significantly different type of self-regulation strategy as compared to children who do not struggle with sensory processing. Often, the dynamic relationship between these two variables will create a maladaptive response that negatively impacts a child's performance range, or occupational performance outcomes. The threshold of response can range from a low/sensitive threshold, to a high threshold. Self-regulation strategies can either be categorized as active or passive (Dunn, 1997). Heterogeneity may exist when categorizing each type of sense. For example, a child may actively seek tactile experiences, but may also demonstrate an avoidance to a certain type of texture, such as play dough (Dean, Little, Wallisch, & Dunn, 2019)

All eight senses can be categorized by the threshold of response as well as the self-regulation strategy—including interoceptive experiences. According to Hample and Mahler (2021-online course), a child may be underresponsive to interoceptive cues—in other words, the interoceptive cues are too small to notice. This may manifest in

occupational challenges such as frequent bowel and bladder accidents, limited awareness of hunger/thirst cues, and not noticing emotions until they are intense to name a few (Hample & Mahler, 2021; Mahler, 2017). On the opposite end of the spectrum, a child can be overresponsive to interoceptive cues and may have intense sensitivity to interoceptive experiences. For example, a child with this type of threshold and self-regulation response may become extremely fearful of going to the bathroom, resulting in constipation (Hample & Mahler, 2021; Mahler, 2017). In regards to affective types of cues, the child may feel their heartrate increasing during an emotional fluctuation, which may cause them to feel more anxious than the initial sensory stimulus caused them to feel. When sensory processing differences create maladaptive self-regulation strategies, the child's performance range will be negatively impacted.

Interoception and self-regulation.

Successful self-regulation depends on the success of appropriately modulating sensory information, including interoceptive cues (Mahler, 2017). Self-regulation is described as a person's ability to adjust/modify their behaviors to meet the demands of a task within a set of physical, social, cultural, and/or temporal context parameters (Suedel, 2021). Self-regulation behaviors occur in response to sensory cues and feedback from the environment/context. For example, successful self-regulation promotes sustained attention to a task, appropriate expression of emotion, and appropriate expression of energy level to name a few (Mahler, 2017; Suedel, 2021). Self-regulation strategies follow an interoceptive cue from the body, therefore, effective self-regulation cannot occur without effective interoceptive signals (Mahler, 2017).

Interoception and emotion.

When the brain interprets and processes emotions, it carefully gathers information from a combination of sources. These include the nervous system, the sensory system, and more specifically—the interoceptive system. Interoception and emotion are so closely tied together that it is reflected in everyday language, such as using the word “heated” to describe the emotion of anger, or “brokenhearted” to describe sadness (Mahler, 2017). Emotions are felt in the body through interoceptive cues and other sensations, and interpreted in a combination of locations in the brain.

FMRI imaging and body mapping from other studies of emotion contributes to this assumption. In a study conducted by Nummenmaa et al. (2004), it was found that each emotion triggers a specific area of the body and there is some degree of universality in terms of where emotions are felt in the body. This study further supports the hypothesis that interoceptive signals are core to the emotional experience, and that the embodiment of emotion is critical to emotional processing and regulation (Nummenmaa, Glerean, Hari, & Hietanen, 2004).

In numerous studies, it has become apparent that higher interoceptive accuracy is positively correlated with more intense processing of emotions (Mahler, 2017; Füstös et al., 2012; Herbert, Herbert, & Pollatos, 2011; Nummenmaa et al., 2014). Additionally, individuals with higher interoceptive accuracy were shown to also have higher scores for recognizing and understanding emotions (Herbert et al., 2011). Not only does interoceptive accuracy correlate with a better understanding of emotions, it also correlates with better facilitation of cognitive reappraisal of negative emotions (Füstös et al., 2012).

Prominent researchers of interoception and emotion suggest that higher interoceptive awareness and accuracy is a key foundational skill of good emotional regulation.

Psychological, mood, and substance-abuse disorders associated with symptoms of depression, dissociation, and difficulty regulating emotions have been examined in relation to interoceptive awareness and accuracy. Evidence suggests that individuals with depressive symptoms are more likely to dissociate their attention away from stressful interoceptive signals (Stern et al., 2017). In a randomized control trial of women involved in a substance-abuse recovery program, the experimental group of participants that used mindfulness-based interoceptive practices demonstrated a decrease in substance craving and reduced use in response to social pressure as compared to traditional treatment methods. Additionally, the experimental group demonstrated decreased eating disorder symptoms, depression, anxiety, and physical symptoms of substance withdrawal (Price, Wells, Donovan, & Rue, 2012).

As stated previously, interoceptive awareness and accuracy are foundational skills that assist with successful emotional regulation (Füstös et al, 2012; Herbert et al., 2011; Nummenmaan et al., 2014; Mahler, 2017). Dr. Kelly Mahler, OTR/L, an expert on interoception, asserts that good interoceptive awareness provides an individual with clues about body state, which assists with emotional identification. When the individual notices the body signal, they can connect it to the emotion, which ultimately facilitates the urge to act to achieve homeostasis (Mahler, 2017). Addressing interoception through occupational therapy intervention contributes to positive self-regulation and emotional regulation experiences (Mahler, 2017; Hample & Mahler, 2021).

Interoception and alexithymia.

In interoception and emotion-based research, a construct called “alexithymia” is frequently mentioned. Alexithymia is described as an inability to process, recognize, or describe one’s emotions (Sifneos, 1973). Alexithymia is a barrier to emotional regulation, social wellness, and community integration (Tang, Hu, Yang, & Xu, 2020). In a sample of college students that were assessed during the COVID-19 pandemic, the prevalence of alexithymia potentially enhances the presence of depression and PTSD symptoms during times of increased stress (Tang et al., 2020). Alexithymia has also been found to be positively correlated with burnout and lower academic performance (Romano, Buonomo, Callea, & Fiorilli, 2019). Alexithymia is frequently correlated with a diagnosis of autism spectrum disorder (ASD) and Asperger’s syndrome. Research has shown that alexithymia, rather than a diagnosis of ASD solely, is the greatest predictor of emotional regulation difficulties (Kinnaird, Stewart, & Tchanturia, 2019). Further research is needed, but it can be hypothesized that interventions that target interoception may also benefit individuals with alexithymia.

Interoception and intuitive decision-making.

Intuitive decision-making, flexibility of thought, and “gut feelings” are dependent on interoceptive cues from the body (Mahler, 2017). In a study completed by Dunn et al. (2010), researchers examined the relationship between somatic responses, interoceptive accuracy, and intuitive decision-making. Researchers found that higher interoceptive accuracy is positively correlated with more successful intuitive decision-making during a gambling intuition task. Flexibility of thought is a key performance skill that impacts many tasks in everyday life. In another study of risky decision-making amongst traders in

a London trading market, traders who scored higher in interoceptive accuracy were more profitable in their trading endeavors (Kandasamy et al., 2016). Through this evidence, it is evident that intuitive decision-making is informed by interoceptive cues (Mahler, 2017; Dunn et al., 2010; Kandasamy et al., 2016).

Task

Interoceptive accuracy, both for homeostatic signals and affective signals, plays a significant role in all aspects of a child's daily occupations and successful developmental progression. Inaccurate assessment and appraisal of interoceptive cues can result in acute stress responses, chronic stress responses, and ultimately unsuccessful role fulfillment and global development (Hample & Mahler, 2021).

Appraisal of homeostatic interoceptive cues.

Homeostatic interoceptive cues include hunger, thirst, need for bathroom, temperature control, pain responses, and reproductive needs to name a few (Hample & Mahler, 2021). Children have different activity demands depending on their physical, cognitive, and psychosocial level of development. For example, consider a 6-year-old child who is playing with same-aged peers. During play, the 6-year-old child does not properly notice and respond to the interoceptive cue to use the restroom, resulting in a urinary accident. At this developmental stage, the task expectation during social participation is that the child is able to use the bathroom instead of having accidents, which results in a feeling of shame, embarrassment, and sympathetic nervous system activation (Erickson, 1963). Successful appraisal of homeostatic cues is imperative to successful developmental progression.

Appraisal of affective interoceptive cues.

Affective interoceptive cues provide a person with information regarding their current emotional state. As with homeostatic interoceptive cues, correct appraisal of affective cues results in successful task experiences. For example, the task of education requires that a child is able to transition between tasks with some degree of flexibility in routines so as to prevent intense maladaptive emotional outcomes that are developmentally inappropriate. A child who is unaware of subtle affective cues that precede a maladaptive outcome, such as tense muscles, increased heart rate, and increased breathing, will be unable to effectively make a change or self-regulate. This results in a maladaptive outcome that is inappropriate for the child's developmental level, resulting in unsuccessful role fulfillment and wellness (Mahler, 2017; Hample & Mahler, 2021).

Contextual Factors

Social context & temporal context—the interaction of interoception & development.

Social norms, expectations, and behaviors are continuously learned throughout a child's life through feedback from a combination of external and internal sensory stimuli (Dean et al., 2019). For example, a child's earliest experience with social interaction is through visually seeing their caregiver, being held by their caregiver (tactile), and learning the smell of their caregiver to name a few. Additionally, they are soothed through vestibular input from their caregiver, which they start to associate with a sense of safety and connection. Learning social norms, expectations, and behaviors is a sensory experience, which includes the interoceptive system.

As a child reaches early childhood, the initiation of self-regulation begins. Children are encouraged to self-regulate their homeostatic needs as well as their affective needs. Failure to do so results in a negative interaction with their social context, as in the example of having an accident in front of peers. Over time, positive and negative social experiences shape the intuition and behaviors of a child (Dean et al., 2019). Social experiences require some degree of intuitive decision-making, flexibility, and action responses that cannot always be concretely explained (Dunn et al., 2010). Intuitive decision-making is an interoceptive process. Success in social contexts is dependent the correct appraisal of interoceptive cues (Mahler, 2017).

Cultural context.

The interpretation of brain/body processes, emotions, and sensorimotor experiences is shaped by the cultural context that a person is surrounded by. For example, in westernized medicine, emotion is generally considered to be a mental function that exists within the brain, and is separate from the body. Treatment interventions include cognitive, behavioral, and pharmaceutical approaches. In eastern medicine, especially Traditional Chinese Medicine (TCM), the body, brain, emotion, and consciousness are inseparable. Even though neurological imaging studies have demonstrated a distinct connection between the body and the mind, a person's perception of interoception is greatly influenced by their cultural context (Zhou et al., 2021).

Physical context.

The physical context can either support or inhibit successful appraisal of interoceptive cues. Specifically, the availability of materials/objects that support self-regulation influences the performance range of the individual. For example, in a

elementary education classroom setting, access to the restroom enhanced by reminders from the teacher facilitates successful homeostatic self-regulation with toileting (Mahler & Hample, 2021). In another example, interoceptive awareness and self-regulation can be enhanced by visuals within the classroom, as in the example of using the *Zones of Regulation* program—a visual cognitive behavioral strategy for children and teachers that helps to identify energy levels to enhance self-regulation (Kuypers, 2011). In fact, interoception is one of the only senses that activates the occipital lobe in conjunction with the sensorimotor cortex (Stern et al., 2017). This suggests that visual cues within the physical environment are a major support to the successful appraisal of interoceptive cues.

Performance Range

Decreased IA leads to dysregulation of the bodily state, the sensory system, attention, energy, and emotion (Mahler, 2017). Specifically, this can manifest in several occupational challenges due to a combination of various activity demands for interoceptive accuracy. These person factors and activity demands interact dynamically within the child's physical, social, cultural, and temporal contexts, leading to dysfunction that impacts the holistic development of the child or person.

Statement of Need

Interoceptive awareness serves as the foundational skill for success with self-regulation, emotional identification, emotional regulation, emotion identification of others, reading body language, engaging in social interactions, and ultimately community integration. Currently, there is limited programming in occupational therapy practice for

interoceptive awareness and accuracy that addresses a wide variety of person and contextual factors.

CHAPTER III

Methodology

This scholarly project and manual serve as an educational platform that educates occupational practitioners on the sensorimotor skill of interoception applied throughout the OT process. A needs assessment was conducted as a mechanism to explore the sensorimotor skill of interoception and how this interacts with a child's contexts and tasks to influence a performance range. The purpose of the needs assessment was to examine the neuroscience of interoception, outcomes of poor interoceptive accuracy, diagnoses associated with differences in interoception, how interoception interacts with one's contexts, and the relationship between tasks and interoception.

An extensive literature review was completed using various types of sources that includes online databases, published books, personal communications, online courses, and government-based websites. Online databases include: CINAHL, Pubmed, Google Scholar, and the University of North Dakota Scholarly Commons. An abundance of research regarding the neuroscience of interoception was located via these databases. Despite this, these databases had little to no publications regarding interoception specific to occupational therapy practice. Since occupational therapy-specific research was limited, evidence was obtained from allied health professions, including psychology and neuroscience. Key publications that informed the project included the exploration of the neuroscience of interoception (Critchley et al., 2014; Stern et al., 2017; Quadt, Critchley, & Garfinkel, 2018) interoception and self-regulation (Füstös et al., 2012; Mahler, 2017),

interoception and emotion (Mahler, 2017; Nummenmaa et al., 2014; Herbert et al., 2011; Mahler 2019), interoception and occupations/tasks (Williams & Shellenberger, 1996), and the relationship between interoception and contextual factors (Dean et al., 2010; Zhou et al., 2021; Stern et al., 2017)

Key words and phrases included “interoception”, “interoceptive awareness”, “emotional regulation”, “social skills”, “sensory processing”, “mindfulness”, “alexithymia”, and “trauma”. Inclusion criteria included peer reviewed journal publications, narrative reviews from experts in the field, original research papers, and experiential trials using participants of all ages and genders. Exclusion criteria included articles older than 2010 (unless it is a seminal article), articles not published in English, and articles that examined medication for interoception without being supplemented by other types of therapeutic intervention.

Personal communications with clinical experts in sensory integration, sensory processing, and social-emotional learning were used as a mechanism to determine clinical needs for interoception programming. Several interviews were conducted with Stephanie Suedel, MOTR/L to inform the statement of need, the framework of the product, and much of the content included in the scholarly project. In addition to this, emails were exchanged with an expert in the field, Dr. Kelly Mahler, OTR/L to ensure that the project built on existing interoception materials without duplicating them.

To enhance the achievement of education-based goals, educational materials were developed to adhere to principles of adult learning (Bastable, Myers, and Arnaud, 2020). Specifically, this includes use of content that is guided through self-directed learning, reference points and tables for quick application in practice, and the inclusion of content

that is relevant to occupational therapy stakeholders. Learning objectives were developed using *Bloom's Taxonomy* and were included in an instructional design plan to ensure that the educational platform achieved its purpose (Bastable & Rabbia, 2020).

To inform best ethical practice, a consultation with Devon Olson, MLIS was completed to ensure that all content within the product adheres to copyright laws and regulations. Additional ethical practices included the consideration of accessibility when creating the interoception framework in order to meet the needs of children with many different person and contextual factors. This was demonstrated through careful research of cultural symbolism, cultural ideologies of interoception and mindfulness, and an interoception framework that is accessible to many different ages of children.

After careful review of occupation-based models, the Ecological Model of Human Performance (EHP) was selected as the most appropriate model to guide the development of the product. EHP best describes the dynamic relationship between the person and the tasks embedded in the environment, which interact to create a performance range outcome (Dunn, 2017). In this project, the person component encompasses a child and their sensorimotor, cognitive, and psychosocial performance skills, including interoceptive awareness. The context refers to the cultural, temporal, social, and physical environments that a child is enmeshed in which support or inhibit the achievement of tasks. Interoception performance skills are enhanced through adapting/modifying the child's context or establishing/restoring the child's performance skills. The ultimate goal is to enhance the amount of tasks that a child can complete successfully—which is characterized as the performance range.

CHAPTER IV

Product Description

The purpose of this product is to provide education to occupational therapy practitioners regarding the sensorimotor skill of interoception, so that they may integrate principles of interoception into all aspects of the occupational therapy process. This manual is intended to be used in pediatric occupational therapy practice with children who have sensory processing differences that impact functional outcomes. The product has six sections: *Introduction to the Manual*, *Introduction to Interoception*, *Evaluation/Assessment of Interoception*, *Interoception Intervention Framework*, *Documentation & Outcomes*, and *Opportunities for Specialized Interoception Programming*.

The product begins with an introduction to the eighth sensory system: interoception. Practitioners are provided with information about the current state of evidence surrounding interoception, including its neurological foundation and how it functions in the body. The manual describes how interoception impacts self-regulation, emotional identification, emotional regulation, social skills, and many other functional outcomes for children. Practitioners are introduced to the interdependent relationship between the interoceptive skills of a person and how this may interact with their physical, cultural, social, and temporal contexts. Interoception precautions are carefully emphasized prior to the evaluation section.

In Section III, practitioners are then guided through the process of evaluating and assessing the sensorimotor skill of interoception. Practitioners are introduced to an interoception evaluation template that discusses important questions to explore during the evaluation process. This template is guided by the contents of the selected ecological model, EHP (Dunn, 2017). Additionally, the manual includes a table of currently available assessments for the skill of interoception with references.

Section IV provides practitioners with an intervention toolkit that includes establish/restore and adapt/modify interventions for interoceptive awareness and appraisal (Dunn, 2017). Included in this section is a framework for establishing/restoring the sensorimotor skill of interoception with children, using a hierarchical approach. Each stage of the hierarchy is described in detail and includes a practical example applied to each stage. Practitioners are also introduced to various adapt/modify approaches for interoceptive awareness, in the instance that establish/restore approaches are not appropriate or applicable.

In Section V, documentation procedures specific to interoception are outlined, along with observations that indicate that a child is making process. Specifically, this includes examples of descriptors that demonstrate the functional purpose of interoception skills. Additionally, the table includes documentation descriptors that demonstrate some form of objective/subjective measurement. Practitioners are also provided a list of subtle indicators of change that are evident in functional outcomes. This section is intended to be used as a quick reference guide to enable practitioners to feel comfortable with the process of integrating interoception into the OT process using practical applications that have the highest degree of relevance for stakeholders.

Lastly, practitioners are invited to explore potential opportunities for the integration of interoception-based interventions into other aspects of service delivery. The purpose of this section is to enable practitioners to foster a curious, innovative mindset that will enhance their own practice, as well as the scope of the profession of occupational therapy.

This manual has been guided by the Ecological Model of Human Performance (EHP) (Dunn, 2017). EHP has been carefully selected as the most appropriate model for this product due to the nature of the relationship between a child's sensorimotor, cognitive, and psychosocial skills and their physical, temporal, cultural, and social contexts (Dunn, 2017). The ecological focus of this model most appropriately aligns with pedagogical learning and child development (Bastable, Myers, and Arnaud, 2020). This is reflected in the proposed interoception intervention framework, as well as all other aspects of the manual. In addition to EHP, Dunn's Model of Sensory Processing is used to describe the nature of interoceptive signals and self-regulation strategies (Dunn, 1997). The full product has been included in Appendix A.

CHAPTER V

Summary

The purpose of this scholarly project was to develop an educational platform for occupational therapy practitioners, regarding the sensorimotor skill of interoception applied throughout the occupational therapy process. The overarching goal of the manual is to enable occupational therapy practitioners to feel confidence when applying interoception-based practice into all aspects of the OT process, so that they may enhance the lives of children with sensory processing differences. Content within the manual was informed by an extensive literature review, and guided through the lens of the Ecological Model of Human Performance (EHP) (Dunn, 2017), Dunn's Model of Sensory Processing (Dunn, 1997), and the stages of the occupational therapy process (American Occupational Therapy Association, 2020).

Implications for Occupational Therapy

It is anticipated that this product will fill a gap in services currently provided in pediatric occupational therapy practice. At this time, there are limited interoception-based strategies used for the purpose of developing self-regulation skills, emotional identification, emotional regulation, and social skills in occupational therapy practice. Additionally, current interoception-based programming is heavily language-based and is difficult to use with children who have language processing disabilities and cognitive disabilities. This product will expand the reach of interoception-based supports to children with various levels of ability.

Implementation

The practitioner manual will be available for open access through the University of North Dakota Scholarly Commons. Because this manual will be available through digital access, there are no fees or costs associated with the product. This enhances the accessibility of the product to occupational therapy practitioners, which aligns with the core values and purpose of the product.

Strengths

Strengths of the product include: all of the contents of the product were guided by an extensive review of literature to determine areas of need in pediatric occupational therapy practice and interoception-based supports. The concept of interoception is relatively new in psychology and occupational therapy practice, research, and academics. Despite this, there is a beginning body of evidence to suggest its efficacy for use with many different types of populations. Another strength of this product includes the practicality of application to pediatric occupational therapy processes. This product was made with the intention that occupational therapy practitioners may be able to immediately implement these skills into current practice. Interoception-based supports are discussed in relation to functional outcomes and degree of relevance to stakeholders (children, families, and funding sources).

Limitations

The initial version of the practitioner toolkit is currently in the preliminary stages of implementation in a pediatric clinical setting, and there is no qualitative or quantitative analysis occurring at this time. This product addresses a narrow client population, which includes practitioners who work with children. While this practitioner manual enhances

the availability of interoception-based frameworks for children, it does not address adult client populations.

Recommendations

It is recommended that this manual and toolkit be implemented in a pediatric occupational therapy setting along with other evidence-based interventions for self-regulation, emotional regulation, and social skills. Another recommendation that may enhance the sustainability of the product includes the development and analysis of qualitative and quantitative questionnaires for practitioners as well as for parents/caregivers of children. Careful analysis of questionnaire data will ensure that the interoception framework and educational contents within the manual are effective and informative.

A third recommendation includes further research and application of interoception-based programming into other aspects of service delivery and with other populations. For example, this may include pacing strategies and energy conservation interventions in adult physical dysfunction, and mindfulness and interoception-based strategies for inpatient adolescent mental health to name a few. There is a strong need for further research in these areas to ensure that principles of evidence-based practice are being followed.

Conclusions

Inside Interoception: Enhancing Self-Regulation and Emotional Regulation Using the Eighth Sensory System serves as an educational platform for occupational therapy practitioners. It is intended to be used in pediatric occupational therapy practice. The

overarching goal of this product is to provide practitioners with educational information regarding the sensorimotor skill of interoception, so that they may implement interoception-based techniques and strategies throughout the entire OT process. It is anticipated that this product will expand the reach of interoception-based strategies and supports used in occupational therapy practice and will positively impact children with a wide variety of sensorimotor skills, cognitive factors, and contextual factors.

References

- American Occupational Therapy Association (2020). Occupational therapy practice framework: Domain and process (4th ed.). *American Journal of Occupational Therapy*, 74(Suppl. 2), 7412410010. doi: <https://doi.org/10.5014/ajot.2020.74S2001>
- Ardizzi, M., Ambrosecchia, M., Buratta, L., Ferri, F., Peciccia, M., Donnari, S., Mazzeschi, C., & Gallese, V. (2016). Interoception and positive symptoms in schizophrenia. *Frontiers in Human Neuroscience*, 10(379). pp. 1-10. doi: 10.3389/fnhum.2016.00379
- Arnold, A. J., Winkielman, P., & Dobkins, K. (2019). Interoception and social connection. *Frontiers in Psychology*, 10(2589). doi: 10.3389/fpsyg.2019.02589
- Bagby, R. M., Parker, J. D., & Taylor, G. J. (1994). The twenty-item Toronto Alexithymia Scale I. Item selection and corss-validation of the factor structure. *Journal of Psychosomatic Research*, 38(1), 23-32.
- Barrett, L. F., Quigley, K. S., Bliss-Moreau, E., & Aronson, K. R. (2004). Interoceptive sensitivity and self-reports of emotional experience. *J Pers Soc Psycho.*, 87(5). pp. 684-697.
- Bastable, S. B., Myers, G. M., & Arnaud, L. M. (2020). Developmental stages of the learner. In Bastable, S. B., Gramet, P. R., Sopxzyk, D. L., Jacobs, K., & Braungart, M. M. (Eds.), *Health Professional As Educator: Principles of*

Teaching and Learning. pp. 185-237. Burlington, MA: Jones & Bartlett Learning, LLC.

- Bastable, S. B., & Rabbia, J. (2020). Behavioral objectives and teaching plans. In Bastable, S. B., Gramet, P. R., Sopxzyk, D. L., Jacobs, K., & Braungart, M. M. (Eds.), *Health Professional As Educator: Principles of Teaching and Learning*. pp. 467-505. Burlington, MA: Jones & Bartlett Learning, LLC.
- Beaudry-Bellefeuille, I., Lane, S. J., & Lane, A. E. (2019). Sensory integration concerns in children with function. *The American Journal of Occupational Therapy*, 73(3). pp. 1-13. <https://doi.org/10.5014/ajot.2019.030387>
- Connell, L., Lynott, D., & Banks, B. (2018). Interoception: The forgotten modality in perceptual grounding of abstract and concrete concepts. *Philosophical Transactions B: Royal Society Publishing*, 373(20170143). doi: <http://dx.doi.org/10.1098/rstb.2017.0143>
- Craig, A. D. (2002). How do you feel? Interoception: The sense of the physiological condition of the body. *Nature Reviews Neuroscience*, 3(8). pp. 655-666.
- Critchley, H. D., & Garfinkel, S. N. (2017). Interoception and emotion. *Current Opinion in Psychology*, 17. pp. 7-14. doi: <https://dx.doi.org/10.1016/j.copsyc.2017.04.020>
- Critchley, H. D., Wiens, S., Rotshtein, P., Öhman, A., & Dolan, R. J. (2004). Neural systems supporting interoceptive awareness. *Nature Neuroscience*, 7(2), 189-195
- Dean, E. E., Little, L. M., Wallisch, A., & Dunn, W. (2019). Sensory processing in everyday life. In *Willard and Spackman's Occupational Therapy (13th ed.)*. pp. 942-964. Baltimore, MD: Wolters Kluwer

- Dunn, B. D., Galton, H. C., Morgan, R., Evans, D., Oliver, C., Meyer, M., Cusack, R., Lawrence, A. D., & Dalgleish, T. (2010). Listening to your heart: How interoception shapes emotion experience and intuitive decision making. *Psychological Science, 21*(12), 1835-1844. doi: 10.1177/0956797610389191
- Dunn, W. (1997). The impact of sensory processing abilities on the daily lives of young children and their families: A conceptual model. *Infants and Young Children, 9*
- Dunn, W. (2017). The ecological model of occupation. In Hinojosa, J., Kramer, P., & Brasic Royeen, C. (Eds.), *Perspectives on Human Occupation: Theories Underlying Practice* (pp. 207-235). Philadelphia, PA: F. A. Davis Company
- Dunn, W., Brown, C., & McGuigan, A. (1994). The ecology of human performance: A framework for considering the effect of context. *American Journal of Occupational Therapy, 48*, 595-607. <https://doi.org/10.5014/ajot.48.7.595>
- Dunn, W., Smith Myles, B., & Orr, S. (2002). Sensory processing issues associated with Asperger syndrome: A preliminary investigation. *American Journal of Occupational Therapy, 56*, 97-102.
- Erickson, E. H. (1963). *Childhood and Society* (2nd ed.). New York: NY: Norton
- Füstös, J., Gramann, K., Herbert, B. M., & Pollatos, O. (2012). On the embodiment of emotion regulation: Interoceptive awareness facilitates reappraisal. *Social Cognitive and Affective Neuroscience*. doi: 10.1093/scan/nss089
- Gibson, J. (2019). Mindfulness, interoception, and the body: A contemporary perspective. *Frontier Psychology 10*. doi: 10.3389/fpsyg.2019.02012

- Grynberg, D., & Pollatos, O. (2014). Perceiving one's body shapes empathy. *Psychology and Behavior, 140*. pp. 54-60. doi:
<https://dx.doi.org/10.1016/j.physbeh2014.12026>
- Hample, K., & Mahler, K. (2021). Toileting, interoception & nutrition: An evidence-based approach for promoting toileting success and independence. [Online course]. <https://www.kelly-mahler.com/product/course-replay-toileting-interoception-nutrition/>
- Herbert, B. M., Herbert, C., & Pollatos, O. (2011). On the relationship between interoceptive awareness and alexithymia: Is interoceptive awareness related to emotional awareness? *Journal of Personality, 79*(5). pp. 1149-1175.
- Jackson, S. R., Parkinson, A., Kim, S. Y., Schürmann, M., & Eickhoff, S., B. (2011). On the functional anatomy of the urge-for-action. *Cognitive Neuroscience, 2*(3-4). pp. 227-257. doi: <http://dx.doi.org/10.1080/17588928.2011.604717>
- Jung, W., Ryu, Y., Lee, Y., Wallraven, C., & Chae, Y. (2017). Role of interoceptive accuracy in topographical changes in emotion-induced bodily sensations. *PLoS ONE 12*(9). doi: <https://doi.org/10.1371/journal.pone.0183211>
- Kandasamy, N., Garfinkel, S. N., Page, L., Hardy, B., Critchley, H. D., Gurnell, M., & Coates, J. M. (2016). Interoceptive ability predicts survival on a London trading floor. *Scientific Reports, 6*(32986). pp. 1-7. doi: 10.1038/srep32986
- Keiver, A., Pollatos, O., Vermeulen, N., & Grynberg, D. (2015). Interoceptive sensitivity facilitates both antecedent- and response-focused emotion regulation strategies. *Personality and Individual Differences, 87*. pp. 20-23. doi:
<http://dx.doi.org/10.1016/j.paid.2015.07.014>

- Khoury, N. M., Lutz, J., & Schuman- Olivier, Z. (2018). Interoception in psychiatric disorders: A review of randomized controlled trials with interoception-based interventions. *Harv Rev Psychiatry*, 26(5). pp. 250-263. doi: 10.1097/HRP .000000000000170
- Kinnaird, E., Stewart, C., & Tchanturia, D. (2019). Investigating alexithymia in autism: A systematic review and meta-analysis. *Journal of European Psychology*, 55. pp. 80-89. doi: 10.1016/j.eurpsy.2018.09.004
- Kuypers, L. M. (2011). *The zones of regulation: A curriculum designed to foster self-regulation and emotional control*. Santa Clara, CA: Think Social Publishing.
- Laughter, S., Mitchell, V., Nguyen, N., & Kim, C. (2020). Interrelationship between sensory modulation, altered interoceptive awareness, and anxiety and impacts on quality of life. *Occupational Therapy: Graduate Capstone Projects*, 18. doi: <https://doi.org/10.33015/dominican.edu/2020.OT.08>
- Lefranc, B., Martin- Krumm, C., Aufauvre-Poupon, C., Berthail, B., & Trousselard, M. (2020). Mindfulness, interoception, and olfaction: A network approach. *Brain Sciences*, 10(921). doi: 10.3390/brainsci1012 0921
- Little, L. M., Benton, K., Manuel-Rubio, M., Saps, M., & Fishbein, M. (2019). Contribution of sensory processing to chronic constipation in preschool children. *The Journal of Pediatrics*, 210. pp. 141-145. doi: <https://doi.org/10.1016/j.jpeds.2019.03.020>
- Ma-Kellams, C. (2014). Cross-cultural differences in somatic awareness and interoceptive accuracy: A review of the literature and directions for future

- research. *Frontiers in Psychology*, 5(1379). pp. 1-9. doi:
10.3389/fpsyg.2014.01379
- Mahler, K. (2016). The comprehensive assessment for interoceptive awareness (2nd ed.) [assessment]. Shawnee, KS: AAPC Publishing.
- Mahler, K. J. (2017). Interoception: The eighth sensory system: Practical solutions for improving self-regulation, self-awareness and social understanding / Kelly Mahler ; foreword by A. D. “Bud” Craig. Shawnee Mission, Kansas: AAPC Publishing
- Mahler, K. (2019). *The interoception curriculum: A step-by-step framework for developing mindful self-regulation*. United States of America.
- Mahler, K. J. (2021). An interoception-based approach for supporting traumatized learners [online course]. <https://www.kelly-mahler.com/product/on-demand-course-an-interoception-based-approach-for-supporting-traumatized-learners/>
- Mahler, K., Rothschild, C., & Alma, J. (2019). *My interoception workbook: A guide for adolescents, teens and adults*. United States of America.
- Mehling, W. E., Price, C., Daubenmier, J. J., Acree, M., Bartmess, E., & Steward, A. (2012). The multidimensional assessment of interoceptive awareness (MAIA). *PLoS One*, 7(11), e48230. Doi: 10.1371/journal.pone.0048230
- Noel, J., Lytle, M., Cascio, C., & Wallace, M. T. (2018). Disrupted integration of exteroceptive and interoceptive signaling in autism spectrum disorder. *Autism Res.*, 11(1). pp. 194-205. doi: 10.1002/aur.1880
- Nummenmaa, L., Glerean, E., Hari, R., & Hietanen, J. K. (2014). Bodily maps of emotions. *PNAS*, 111(2). pp. 646-651. doi:
www.pnas.org/cgi/doi/10.1073/pnas.1321664111

- Parham, L. D. & Mailloux, Z. (2020). Sensory integration. In Clifford O'Brien, J. & Kuhaneck, H. (Eds.), *Case-Smith's Occupational Therapy for Children and Adolescents* (pp. 516-549). St. Louis, Missouri: Elsevier, Inc.
- Perry-Parrish, C., Copeland-Linder, N., Webb, L., & Sibinga, E. M. S. (2016). Mindfulness-based approaches for children and youth. *Current Problems Pediatric Adolescent Health Care*, 46, pp. 172-178. doi: <http://dx.doi.org/10.1016/j.cppeds.2015.12.006>
- Price, C., Wells, E. A., Donovan, D. M., & Rue, T. (2012). Mindful awareness in body-oriented therapy as an adjunct to women's substance use disorder treatment: A pilot feasibility study. *Journal of Substance Abuse Treatment* 43(1). pp. 94-107. doi: 10.1016/j.jsat.2011.09.016
- Quadt, L., Critchley, H. D., & Garfinkel, S., N. (2018). The neurobiology of interoception in health and disease. *Ann. N. Y. Acad. Sci.*, 1428. pp. 112-128. doi: 10.1111/nyas.13915
- Reiffe, C., Oosterveld, P., & Meerum Terwogt, M. (2006). An alexithymia questionnaire for children: Factorial and concurrent validation results. *Personality and Individual Differences*, 40, 123-133.
- Romano, L., Buonomo, I., Callea, A., & Fiorilli, C. (2019). Alexithymia in young people's academic career: The mediating role of anxiety and resilience. *The Journal of Genetic Psychology*, 180(4-5). pp. 157-169. doi: <https://doi.org/10.1080/00221325.2019.1620675>

- Salter Ainsworth, M. D., Blehar, M. C., Waters, E., and Wall, S. N. (2015). *Patterns of attachment: A psychological study of the strange situation*. New York, NY: Psychology Press.
- Scheffers, M., Hoek, J., Bosscher, R. J., Van Duijin, M. A. J., Schoevers, R. A., and van Busschback, J. T. (2017). Negative body experience in women with early childhood trauma: associations with trauma severity and dissociation. *European Journal of Psychotraumatology*, 8(1322892). pp. 1-9. doi: <https://doi.org/10.1080/20008198.2017.1322892>
- Schulz, A. & Vögele, C. (2015). Interoception and stress. *Frontiers in Psychology* 6(993). doi: 10.3389/fpsyg.2015. 00993
- Sifneos, P. E. (1973). The prevalence of alexithymic characteristics in psychosomatic patients. *Psychother. Psychosom.*, 22. pp. 255-262. doi: 10.1159/000286529
- Stern, E. R., Grimaldi, S. J., Muratore, A., Murrough, J., Leibu, E., Fleysher, L., Goodman, W. K., & Burdick, K. E. (2017). Neural correlates of interoception: Effects of interoceptive focus and relationship to dimensional measures of body awareness. *Human Brain Mapping* 38. Wiley Periodicals, Inc. doi: 10.1002/hbm.23811
- Suedel, S. (2021). Understanding my self-regulation signals. [Home Programming Educational Materials]. Copy in possession of author.
- Tang, W., Hu, T., Yang, L., & Xu, J. (2020). The role of alexithymia in the mental health problems of home-quarantine university students during the COVID-19 pandemic in China. *Personality and Individual Differences*, 165(110131). pp. 1-7. doi: <https://doi.org/10.1016/j.paid.2020.110131>

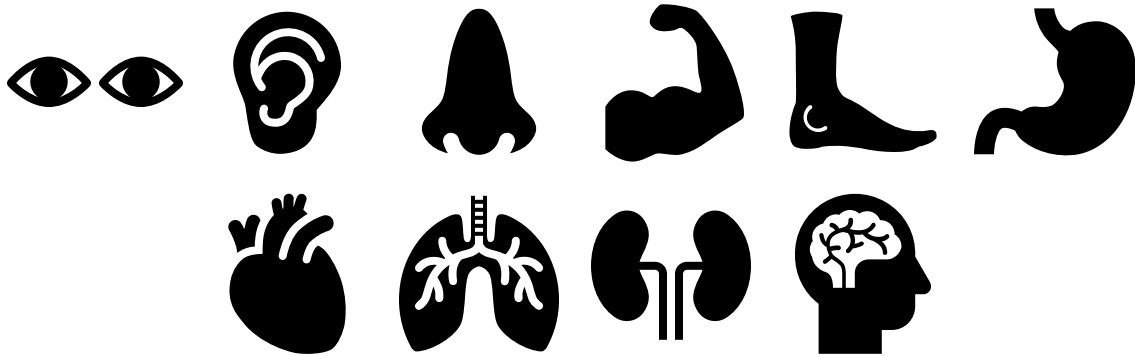
- Tsakiris, M., & Critchley, H. (2016). Interoception beyond homeostasis: Affect, cognition and mental health. *Philosophical Transactions B: The Royal Society Publishing*, 371(20160002). doi: <https://dx.doi.org/10.1098/rstb.2016.0002>
- Tsakiris, M., Tajadura-Jiménez, and Costantini, M. (2011). Just a heartbeat away from one's body: interoceptive sensitivity predicts malleability of body-representations. *Royal Society*, 278. pp. 2470-2476. doi: 10.1098/rspb.2010.2547
- Uljarevic, M. & Hamilton, A. (2012). Recognition of emotions in autism: A formal meta-analysis. *Journal of Autism and Developmental Disorders*, 43(7), 1517-1526. doi: 10.1007/s10803-012-1695-5
- Wang, X., Wu, Q., Egan, L., Gu, X., Liu, P., Gu, H., Yang, Y., Luo, J., Wu, Y., Gao, Z., & Fan, J. (2019). Anterior insular cortex plays a critical role in interoceptive attention. *eLife*, 8(42265). doi: <https://doi.org/10.7554/eLife.42265>
- Williams, M. S., & Shellenberger, S. (1996). "How Does Your Engine Run?" A leader's guide to the alert program for self-regulation. Albuquerque, NM: Therapy Works, Inc.
- Zhou, P., Critchley, H., Garfinkel, S., & Gao, Y. (2021). The conceptualization of emotions across cultures: A model based on interoceptive neuroscience. *Neuroscience and Biobehavioral Reviews*, 125. pp. 314-327. doi: <https://doi.org/10.1016/j.neubiorev.2021.02.023>

APPENDIX

APPENDIX A

Product

Inside Interoception: Enhancing Self-Regulation and Emotional Regulation Using the Eighth Sensory System



By: Heidi Janssen, OTDS

Table of Contents

Section I: Introduction to the Manual.....	1
Theoretical Framework.....	2
Section II- Introduction to Interoception.....	4
Person Factors.....	6
Context/Environment Factors.....	7
Task Factors.....	10
Performance Range Statement.....	12
Interoception Precautions.....	13
Section III- Evaluation/Assessment of Interoception.....	15
Goal Writing.....	20
Section IV- Interoception Intervention Framework	22
Establish/Restore Interventions.....	23
Adapt/Modify Interventions.....	26
Section V-Documentation and Outcomes.....	29
Section VI- Opportunities for Specialized Interoception Programming.....	32
References.....	35

Section I: Introduction to the Manual



Overview

Welcome to *Interoception in Motion: A Practitioner's Guide for Enhancing Interoception Skills with Children*! The purpose of this manual is to provide occupational therapy practitioners with knowledge regarding the performance skill of interoception, so that they may integrate interoception-based strategies into all aspects of the occupational therapy process. This framework is intended to be used in pediatric occupational therapy practice, with children who have sensory processing difficulties.

Theoretical Framework

The Ecological Model of Human Performance

The contents of this manual have been guided by the Ecological Model of Human Occupation (EHP) (Dunn, 2017). According to Dunn (2017), the core constructs within EHP include the person, their contexts, and a constellation of tasks embedded within the contexts. This creates a performance range spectrum, in which tasks that fall inside of the performance range are those that the person is able to do, and tasks that fall outside of the performance range are those that the person is unable to currently do. An occupational therapist can support the client's performance range by targeting aspects of the person, their contexts, or the tasks (Dunn, 2017).

According to Dunn (2017), person factors consist of the sensorimotor, psychosocial, and cognitive skills of the person. Contextual factors include a person's physical, social, cultural, and temporal contexts in which they are embedded in. Because EHP is an ecological model, there is an emphasis on the importance of a person's context in enabling or disabling the availability of tasks (Dunn, 2017).

In pediatric occupational therapy practice, occupational therapists enhance the performance range of children by creating an environment that enriches the development of their skills. For example, providing a child with novel play experiences will enhance their sensorimotor development and interoceptive skills through neuroplasticity (Parham & Mailloux, 2020). In addition to this, an occupational therapist may influence a child's social context through educational home programming materials for parents as a way to enhance generalization of concepts into the home. The emphasis on the child's environment/context, along with the interdependent nature of person factors, contextual factors, and task factors is what makes EHP the most appropriate choice for this manual.

Dunn's Model of Sensory Processing

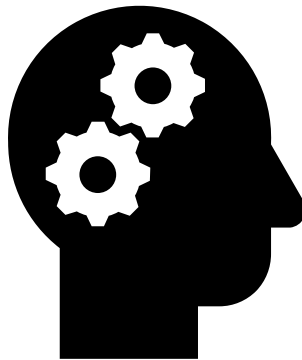
According to Dunn's Model of Sensory Processing (1997), a child's sensory processing can be explained by the neurological threshold of response, as well as the type of regulation strategy that is used. The threshold of response varies on a spectrum of low/underresponsive to high/overresponsive. Self-regulation strategies vary on a spectrum of passive responses to active responses. Differences in the threshold of response as well as the type of self-regulation strategy used can create a maladaptive

outcome that significantly impacts a child's performance range and occupational performance (Dunn, 1997).

Dunn's Model of Sensory Processing effectively describes the threshold of response, the self-regulation strategies for interoceptive cues, and how this dynamic relationship impacts performance range outcomes. According to Hample and Mahler, (2021, online course), a child may be underresponsive or overresponsive to interoceptive cues. Functional outcomes of underresponsivity include not noticing interoceptive cues at all, or only noticing them when they become very intense. For example, in toileting tasks, a child who is underresponsive to interoceptive cues may not notice the urge for the restroom until it is too late, resulting in an accident (Hample & Mahler, 2021). On the other hand, a child who is overresponsive to interoceptive cues may feel the urge for the bathroom frequently, resulting in many bathroom break requests that disrupt learning and engagement in the classroom setting (Hample & Mahler, 2021). As such, the neurological threshold of response for interoceptive cues provides a child with insight that elicits a counter action, or self-regulation strategy (Dunn, 1997). This points to the critical, interdependent relationship between interoceptive cues and self-regulation strategies.

A child may not fall under one category for every type of interoceptive experience. For example, urination and bowel signals may fall under the sensory avoider category, while emotion signals may fall under the low registration category. These categorizations may also shift throughout the intervention process, especially if the child has dissociated from their interoceptive cues. An occupational therapist's role is to consistently evaluate changes in the child's progress and shift their approach to intervention as needed.

Section II: Introduction to Interception



What is Interoception?

In the past 30 years, scientists and researchers within the fields of neuroscience, occupational therapy, nutrition, and many other health professions have acknowledged the presence of eight senses. The five senses—sight, smell, touch, hearing, and taste enable a person to gather information about the external world around them. In addition to these senses, researchers have asserted the powerful influence of two other senses—the vestibular system and the proprioceptive system—as foundational skills for many higher level skills and activities of daily living (Williams & Shellenberger, 1996; Parham & Mailloux, 2020). Despite this, there was still a missing piece to the puzzle, as there was no way to describe feelings originating from internal organs and systems within the body. A trend in research on somatic experiences led to the discovery of an eighth sense: *interoception*.

Interoception: As one of the body's eight senses, interoception is described as a person's ability to sense the internal condition and state of their body (Craig, 2002).

Interoception includes body feelings that assist with regulation of homeostasis, as well as body cues that assist with self-regulation, emotional regulation, and social skills (Hample & Mahler, 2021; Mahler, 2017; Craig, 2002). Some examples include hunger, thirst, need for restroom, breathing, heartrate, tense muscles, and body sensations felt during emotional activation (Hample & Mahler, 2021; Mahler, 2017; Craig, 2002).

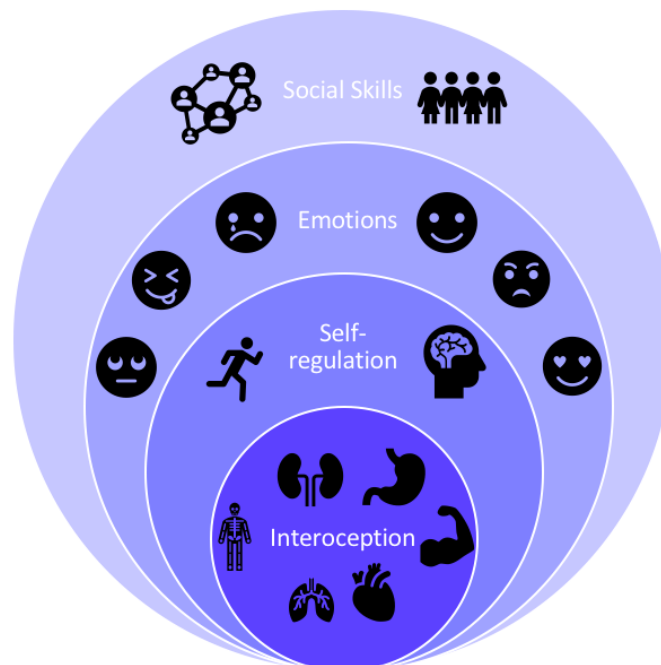


Figure 1- Interoception as a core skill for other sensorimotor skills, including self-regulation, emotional regulation, and social skills.

Person Factors

The Neurology of Interoception

Through recent advancements in technology, scientists and researchers have been able to pinpoint interoceptive processes in the brain and body. Like other sensory systems, the internal organs of the body contain interoceptive receptors that relay information back to the brain. Interoceptive receptors are located on internal organs, muscles, and skin (Mahler, 2017). Interoceptive messages are relayed via the central nervous system or the endocrine system, where they are then processed by the insular cortex, or the insula for short (Mahler, 2017; Critchley, Wiens, Rotshtein, Öhman, & Dolan, 2004; Jackson, Parkinson, Kim, Schüermann, & Eickhoff, 2011; Jung, Ryu, Lee, Wallraven, & Chae, 2017; Quadt, Critchley, & Garfinkel, 2018; Stern et al., 2017; Wang et al., 2019; Craig, 2002)

Studies using functional magnetic resonance imaging (fMRI) have shown that increased interoceptive functioning is correlated with greater activity in the insular cortex (Critchley et al. 2004; Mahler, 2017; Jackson et al., 2011; Jung et al., 2017; Quadt, Critchley, & Garfinkel, 2018; Stern et al., 2017; Wang et al., 2019). Additionally, individuals with higher interoceptive accuracy also tend to have a higher volume of gray matter in the insular cortex (Critchley et al. 2004; Mahler, 2017).

A Hierarchy of Performance Skills

A child's central nervous system is constantly processing sensory stimuli from the environment, as well as from their own body (Parham & Mailloux, 2020). This information provides them with important feedback about their current state of homeostasis and their degree of safety in the environment, which then enables them to have successful occupational experiences. According to Williams and Shellenberger (1996), if any part of a child's sensory system is functioning improperly, it will impact their primitive reflex maturity, body awareness, attention, behavior, and activities of daily living (Williams & Shellenberger, 1996).

Interoception, Self-Regulation, Emotion, and Social Skills

A child's sensory system, specifically interoception, prompts them to "feel" different feelings that will often trigger a self-regulation strategy. Self-regulation is defined as one's ability to adjust/modify their behaviors to meet the demands of a task within a set of physical, social, cultural, and/or temporal context parameters (Suedel, 2021). Successful self-regulation within one's contexts is dependent on successful interoceptive appraisal.

Self-regulation can occur as a result of homeostatic interoceptive cues, as well as affective interoceptive cues (Hample & Mahler, 2021). Homeostatic interoceptive cues include those that inform basic physiological needs, such as hunger, thirst, need for restroom, sensory overwhelm, and pain to name a few (Hample & Mahler, 2021). For example, the interoceptive feeling of thirst prompts the self-regulation strategy of taking a drink (Mahler, 2017). When the interoceptive cue for thirst is underresponsive, the

consequence is dehydration. Correct appraisal of homeostatic interoceptive cues is a critical performance skill for many tasks, especially health management, ADLs, and IADLs to name a few.

Self-regulation strategies can also occur as a result of affective interoceptive cues—defined as one's ability to feel the physiological processes associated with emotional experiences. For example, this can include a strong discomfort in the chest and a "lump in the throat" when feeling sadness. For a child, the self-regulation strategy that follows this feeling can include crying to release "feel good" hormones that create a positive interoceptive experience, which brings the body back to a feeling of homeostasis (Füstös, Gramann, Herbert, and Pollatos, 2012). According to Nummenmaa, Glerean, Hari, and Hietanen, (2014) the emotional experience is heavily dependent on the somatic experience, or interoceptive cues. If a child has over or underresponsivity to interoceptive cues, they will have difficulty identifying and understanding emotions (Mahler, 2017; Herbert, Herbert, and Pollatos, 2011).

Identifying and understanding emotions is the preceding step to successfully regulating emotions (Füstös et al., 2012). Successful appraisal of interoceptive cues informs these processes. Many children who are not in-tune to their interoceptive experiences are not aware of instances in which small emotions start to build up throughout the day. This leads to emotion extremes, in which one moment they are "holding it together", but in the next moment, they demonstrate an intense maladaptive outcome (Mahler, 2017). Interoceptive awareness helps children learn about triggers, and helps them identify coping strategies that promote positive interoceptive experiences.

Successful appraisal of interoceptive cues also promotes positive social interactions and social skills. This process begins at birth when caregivers, family members, and close friends interact with the infant. These early interactions either create positive or negative interoceptive experiences within the infant's social context. As the child develops, they learn more about social skills through modeling from their caregivers based on an abundance of interoceptive experiences. Positive interoceptive experiences typically reinforce a social action/skill, while negative interoceptive experiences typically discourage a social action/skill (Braungart, Braungart, & Gramet, 2020; Bandura, 1977; Bandura, 2001). When a child has distorted interoceptive cues, they will not receive sufficient feedback about how they are impacting other people in their social context. This may result in maladaptive outcomes and a negative dynamic relationship between a child and their social context.

Context/Environment

Children are experiential and play-based learners (Bastable, Myers & Arnaud, 2020). The development of their sensorimotor, cognitive, and psychosocial skill development is dependent on supports/barriers from their contexts, and the tasks that are available to them.

Cultural Context

A child's perception of interoceptive experiences is heavily shaped by the cultural contexts in which they are embedded in (Zhou, Critchley, Garfinkel, & Gao, 2021). There are a combination of surface level as well as deep levels of cultural factors that influence interoception. For example, a person may follow the model of westernized medicine, eastern medicine, holistic medicine, or a combination of many different types. These philosophies differ in their view of the mind, the body, the spirit, and disease/illness. This also affects how interoceptive awareness is conceptualized, perceived, and carried out in daily living.

Eastern Medicine & Interoception	Western Medicine & Interoception
<ul style="list-style-type: none"> • The body, emotion, mind, and spirit are inseparable and are treated holistically • Healing subtle and/or intense imbalance between the body, mind, spirit proactively • Grounded in philosophy • Focuses on the “why” of energy imbalance • Interoception is very similar to mindfulness, embodiment, and the brain/body energy connection 	<ul style="list-style-type: none"> • The body, emotion, mind, and spirit can be isolated and treated singularly • Healing/fixing of “disorder” and illness when it disrupts daily living • Grounded in science and evidence • Focuses on the “how” of dysfunction • Interoception is a part of brain neurology as the eighth sensory system

Table 1- Views of interoception skills- eastern and western medicine models

Cultural factors are not always surface-level and observable by other people. They can include subtle beliefs, core values, and ways of living. Cultural factors are very heavily tied to interoception, as they influence a child's interaction with symbolism and language that communicates interoceptive awareness. For example, one culture may associate “thumbs up” with a good interoceptive feeling, while another culture may view a “thumbs up” with a negative connotation— as it can be considered profane. Part of the occupational therapist's role is to ask culturally-rich questions when appropriate to gather insight so that programming is individualized and supports the client in the best way possible.

Social & Temporal Context

A child learns about social norms, expectations, and appropriate behaviors through continuous exteroceptive and interoceptive feedback. Throughout development, infants and children acquire an abundance of interoceptive experiences that teach them what is considered right or wrong in social situations (Mahler, 2017). Good interoceptive experiences will reinforce a social action/skill. Uncomfortable interoceptive experiences will discourage a social action/skill. Over time, these experiences will fine tune social skills to create the most successful social experiences and feelings—directed by a child's "gut feelings". When a child has difficulties with sensory processing and specifically in interoception, the distorted feelings will not provide them with adequate feedback about how they are impacting people in their environment. This may cause more maladaptive outcomes in social situations (Mahler, 2017).

Social context outcomes have an interdependent relationship with a child's temporal context, which consists of their developmental level and associated expectations. Effectively appraising interoceptive cues assists with successful interaction between a child's social and temporal context. For example, a child who does not feel the urge to go to the bathroom until it is too late will experience maladaptive outcomes in front of their peers, in the instance where they have an accident. The interaction between interoceptive skills and a child's development is a crucial interaction to address for optimal performance range.

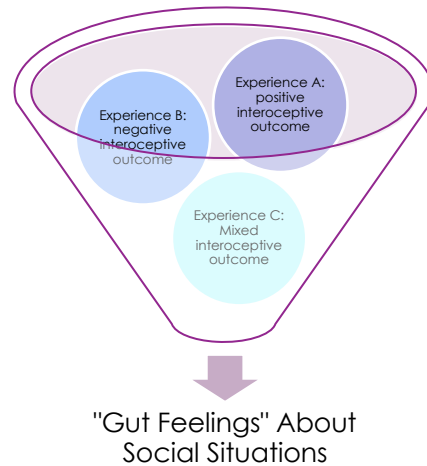


Figure 2- A combination of interoceptive experiences provide a blueprint for how to act in social situations.

Physical Context

A child's physical context plays an incredibly important role in the development of interoceptive accuracy skills. Currently, the evidence states that interoceptive processing not only activates the insular cortex, but it also activates the occipital lobe and visual system (Stern et al., 2017). This suggests that interoceptive processes can be enhanced by other senses, including the visual system. Because children are experiential and play-based learners, an occupational therapist's role is to adjust the environment to support the development of interoception to the highest degree possible.

Task Factors

Interoception is the body's eighth sense, and it is a skill that influences nearly every task. The following table lists tasks that include activity demands for interoceptive accuracy in order to have a successful performance range. This is not a comprehensive list, but it provides some insight into specific activity demands that involve interoception.

Occupation/Task	Task Demand Related to Interoception
ADLs	
Bathing/Showering	<ul style="list-style-type: none"> • Noticing when clean/dirty
Toileting/Toilet Hygiene	<ul style="list-style-type: none"> • Underresponsivity to need for bathroom cues • Overresponsivity to need for bathroom cues
Dressing	<ul style="list-style-type: none"> • Noticing/responding to body temperature and regulating it
Eating/swallowing	<ul style="list-style-type: none"> • Noticing/responding to hunger and satiety cues
Personal Hygiene and Grooming	<ul style="list-style-type: none"> • Noticing/responding to being dirty/clean • Using "gut feelings" and interoception to get a "feel" for the social norms regarding grooming/hygiene
IADLs	
Care of Pets and Animals	<ul style="list-style-type: none"> • Interoception as a foundational skill for empathy
Safety Awareness	<ul style="list-style-type: none"> • Using "gut feelings" (interoceptive cues) to anticipate safety hazards
Health Management	
Social and Emotional Health Promotion and Maintenance	<ul style="list-style-type: none"> • Interoception as a foundational skill for emotional wellbeing and social wellbeing
Symptom and Condition Management	<ul style="list-style-type: none"> • Noticing changes in health condition based on subtle interoceptive cues
Physical Activity	<ul style="list-style-type: none"> • Using interoceptive cues to adjust/modify intensity of exercise, so as to not cause harm

Nutrition Management	<ul style="list-style-type: none"> • Noticing body cues that result from various foods. i.e. healthy food choices = comfortable interoceptive cues and homeostasis; unhealthy food choices = uncomfortable interoceptive cues. • Increased interoceptive awareness assists in maintaining healthy portions.
Rest & Sleep	
Rest and Sleep; Sleep Preparation; Sleep Participation	<ul style="list-style-type: none"> • Noticing body cues regarding brain/body energy level • Choosing an appropriate sleep preparation routine based on current body state
Education	
Education Participation	<ul style="list-style-type: none"> • Using interoceptive cues as a foundational skill for self-regulation skills for optimal learning state
Play	
Play Exploration	<ul style="list-style-type: none"> • Interoceptive accuracy leads to more mental/emotional flexibility and less rigidity during play, leading to more opportunities for play exploration
Play Participation	<ul style="list-style-type: none"> • Using "gut feelings" (interoception) to learn social and cultural norms through play • Maintaining boundaries with other children during parallel play using interoceptive cues • Poor interoceptive accuracy leads to a higher degree of self-direction and desire for control during play participation, often causing poor self-regulation, emotional, and social outcomes
Social Participation	

Community Participation	<ul style="list-style-type: none"> • Interoceptive accuracy leads to better flexibility during routines within the community • Interoceptive accuracy leads to having better flexibility during transitions
Family Participation	<ul style="list-style-type: none"> • Interoceptive accuracy contributes to positive social interactions and outcomes → “gut feelings” about social situations
Friendships	<ul style="list-style-type: none"> • Interoceptive accuracy contributes to positive social interactions and outcomes → “gut feelings” about social situations
Peer Group Participation	<ul style="list-style-type: none"> • Interoceptive accuracy contributes to positive social interactions and outcomes → “gut feelings” about social situations • Identifying self-regulation cues such as impulsivity, brain/body speed, language skills, etc. and making adjustments as needed

Table 2- Examples of tasks that are impacted directly by interoception skills (AOTA, 2020).

Performance Range

Decreased interoceptive accuracy is directly related to dysregulation of the bodily state, the sensory system, attention, energy, and emotion (Mahler, 2017). This becomes evident in many different task outcomes, such as toileting, eating, self-regulation, emotional regulation, and social skills to name a few. Inaccurate interoceptive appraisal interacts negatively with a child’s cultural, social, temporal, and physical environments.

Establishing/Restoring Interoception Skills

Neuroplasticity is one of the leading core constructs that guides sensory integration and sensory processing approaches (Parham & Mailloux, 2020). It is hypothesized, based on neuroscience research, that interoception is no different than other sensory systems in this respect. Brain imaging studies using fMRI have shown that the size of the insular cortex is positively correlated with a person’s level of interoceptive accuracy. Additionally, research shows that mindfulness and meditation techniques are

shown to increase interoceptive accuracy and appraisal (Critchley et al. 2004; Mahler, 2017; Jackson et al., 2011; Jung et al., 2017; Quadt, Critchley, & Garfinkel, 2018; Stern et al., 2017; Wang et al., 2019). While interoception is a relatively new concept in the world of occupational therapy practice, there is promising evidence that outlines the need for this type of skill, as it underlines many common functional outcomes.

Interoception Precautions

Precaution #1: Overresponsive Interoception

When a child is overresponsive to interoceptive cues, they will often demonstrate hypersensitivity to body sensations. In some cases, this can trigger a cycle of anxiety about sensations, leading to further dysregulation. As such, the use of interoceptive interventions will need to be highly monitored and adapted as needed.

Interoception-based interventions provide a child with information that helps to bring awareness to triggers and assists with the development of sensory coping strategies (Suedel, personal communication). Additionally, mindfulness-based interoception activities may be beneficial for some children when redirecting persistent anxious thinking (Perry-Parrish, Copeland-Linder, Webb, & Sibinga, 2016). Cautious use of interoception-based activities with children who are overresponsive to interoceptive cues may still be beneficial on an individualized basis.

Precaution #2: Trauma and Interoception

According to Mahler (2021-online course), children who have experienced persistent trauma that significantly impacts function will often have distorted interoceptive cues and sensory processing differences. Oftentimes, this is because of the brain/body's response to chronic traumatic interoceptive experiences. These interoceptive experiences are uncomfortable, and the child learns to dissociate from these feelings as a self-protection strategy (Mahler, 2021). When completing interventions to improve interoception, a child may experience initial discomfort that creates maladaptive responses as an outcome. As they become in-tune to their interoceptive experiences, and learn to create new "feel good" interoceptive experiences, these outcomes will start to dissipate (Mahler, 2021).

Precaution #3: Honoring All Interoceptive Experiences

When children co-regulate with adults throughout their development, they learn about themselves based on words/actions of those whom they have attachments with (Salter Ainsworth, Blehar, Waters, & Wall, 2015). If a child communicates an interoceptive experience to a trusted adult, and the adult denies their reality, it may hinder the development of self-trust. Engaging in interoceptive interventions requires a shift in mindset in order for self-trust to be developed.

Interoceptive Observation From Child	Caregiver Response- Self-Trust Supporting	Caregiver Response- Self-Trust Inhibiting
"I feel sick at school."	"Which body parts feel big feelings the most?" "What happened before your body started feeling sick?"	"You're not sick. You're just avoiding your schoolwork."
Child is up-regulated and seeking lots of unsafe movement, but states that they are moving at the right speed.	"I noticed your legs are very fast, and you're crashing into other people and things a lot. Is this speed successful? Is it safe?"	"No, you're moving too fast. You need to slow down."
"I'm not hungry."	"Is your tummy feeling a little feeling or a big feeling?"	"You skipped breakfast and lunch today. You're definitely hungry."

Table 3- How caregivers can support or inhibit the development of interoception and self-trust.

Section III: Evaluation and Assessment of Interception



Occupational Profile (Subjective Assessment)- Determining the Client and Their Family's Wants, Needs, and Priorities

In the first stage of the evaluation process, the occupational therapy practitioner gathers information to determine the client and their family's priorities (Dunn, 2017). Oftentimes, interoception skills are hidden within performance range outcomes—meaning that it is difficult to isolate the skill of interoception. It is important to assess how interoception-based skills are impacting a child's roles, routines, habits, and rituals, as well as their immediate family/caregivers. The occupational therapist carefully determines the client's strengths and areas of improvement that are impacting performance range. The following table represents a resource to use as a mechanism to gain insight into a patient's occupational profile.

Interoception Evaluation and Assessment	
Data	Areas to Explore to Gather Insight Into Interoception (Note: There may be many more questions in these categories for a holistic assessment, but these paint a picture of interoceptive strengths and abilities)
Client/Family's Priorities	<ul style="list-style-type: none"> • What tasks does the child currently complete successfully? • What tasks does the child struggle with? • What tasks are important to the child? • What tasks are important to the child's family/caregiver? • What tasks does the child need to be able to do, that they currently don't do?
Client's Social Context	<ul style="list-style-type: none"> • Who does the child live with? • Where does the child go to school/daycare? • What activities is the child in? • Does the child feel safe/secure within their social contexts?
Client's Cultural Context	<ul style="list-style-type: none"> • What family values and beliefs interact with the child's current performance range? • What model of parenting do the child's caregivers follow (behavioral continuums, sensory-based, etc.)? • How does the organizational structure of the family impact the child? • How does the child's family feel about mindfulness & interoception practices? • What model of medicine does the family tend to follow (eastern, integrated, western, etc.)? • What religious/spiritual beliefs may impact the perception of interoception?

Client's Physical Context	<ul style="list-style-type: none"> • What type of visuals, charts, or images are currently used to help the child with interoceptive awareness? • How are self-care areas (bathroom, kitchen, bedroom, etc.) set up to support interoception and self-regulation? • Does the child have access to self-regulation objects or spaces (bathroom, low-stim space, food, etc.)?
Client's Temporal Context	<ul style="list-style-type: none"> • What are the developmental age expectations of the child's interoceptive skills (toileting, self-care, self-regulation skills, emotion-regulation skills, mental flexibility, etc.)? • Has the child recently had any adverse childhood events? • Has the child experienced any major life transitions recently?
Sensorimotor Skills	<ul style="list-style-type: none"> • Does the child recognize when they are too hot or too cold? • How well does the child recognize when they are tired? • What does the child do to fall asleep? • How well does the child recognize safety considerations? • Does the child ever over-exert him/herself physically without noticing? • When handling objects/items in play, how well does the child grade their force? • Does the child recognize when they are playing too big, fast, or loud? • Does the child frequently misidentify bodily cues (i.e. reporting pain when it's actually muscle fatigue?)
Cognitive Skills	<ul style="list-style-type: none"> • How does the child's cognition compare to the developmental expectations? • To what degree does the child demonstrate mental flexibility with changes in routine? • To what degree does the child demonstrate the ability to use intuitive decision making?
Psychosocial Skills	<ul style="list-style-type: none"> • How well does the child make friends and maintain friendships? • How well does the child respect personal space of others? • How well does the child maintain conversations for their age? • How well does the child identify the emotions of others?

	<ul style="list-style-type: none"> • How well does the child tolerate transitions to/from tasks, physical spaces, or people? • How well does the child recognize subtle changes in emotion? • Does the child experience intense emotional changes quickly? • How well does the child communicate their emotions? • How well does the child self-calm?
Client's Strengths	<ul style="list-style-type: none"> • What does the child do very well? • What is a preferred play activity for the child?
Client's Areas of Improvement	<ul style="list-style-type: none"> • What does the child struggle with? • Does the child have any fear responses to things they need to do?

Table 4- Occupational profile questions, specifically pertaining to interoception (Dunn, 2017).

From these questions, a practitioner can use professional reasoning to assess how the child's interoceptive accuracy impacts their overall performance range.

Interoception Assessments

Currently, there are no standardized assessments to objectively measure and isolate the skill of interoceptive accuracy. Despite this, there are many assessments that provide insight into the areas that impact performance range listed in table 4. The following table lists several qualitative and quantitative assessments to gather insight into the skill of interoception.

Assessment	Purpose and Application	Population
The Comprehensive Assessment for Interoceptive Awareness (Mahler, 2016)	-Asks questions pertaining to homeostasis self-regulation, emotional identification, emotional regulation, and social skills	-Individuals who can comprehend verbal questions -Can be used for very young children with adaptations
The Multidimensional Assessment of Interoceptive Awareness (MAIA) (Mehling, Price, Daubenmier, Acree, Bartmess, & Stewart, 2012)	-Provides an overall picture of interoceptive accuracy -32 item checklist	-Adults

<p>The Toronto Alexithymia Scale Adult Version (TAS-20), (Bagby, Parker, & Taylor, 1994) & The Toronto Alexithymia Scale Pediatric Version, (Rieffe, Oosterveld, & Meerum Terwogt, 2006).</p>	<p>-Measures the degree to which an individual is able to identify and describe their own emotions. -Does not include homeostatic regulation questions (eating, toileting, self-care, etc.).</p>	<p>-Adult version -Pediatric version</p>
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Table 5- Table of Assessments Available for Interoception Skills

Objective Observational Assessments for Interoception

Currently, there are very little known ways to measure interoception objectively through clinical observation. In interoception research, the most common objective assessments used include heart beat tests, in which the participant tries to guess their heart rate. This number is then compared to their actual heart rate using pulse oximeters and heart rate monitors. The degree of heart rate guess accuracy is hypothesized to reflect interoceptive accuracy (Tsakiris, Tajadura-Jiménez, and Costantini, 2011).

Interoception itself is difficult to measure as a stand-alone variable. Without access to advanced technology to measure brain activity, occupational therapists have to depend on functional outcomes as an objective measure. Leaders of interoception interventions in occupational therapy frequently use language, verbal expression of bodily/affective states as a qualitative indicator of change. While this is excellent for subjective measurements, it is difficult to justify objectively in evaluations, assessments, interventions, and discharge summaries. Additionally, it is difficult to complete with small children, those with low cognition, auditory processing difficulties, deafness, and general processing difficulties. As with many other types of sensory processing goals, interoception is best measured as a performance skill that impacts a functional outcome.

Creating Measurable Goals for Interoception

Sensory processing goals, specifically regarding the skill of interoceptive appraisal, do not have a universally accepted measurement tool. For example, in physical dysfunction service delivery, an occupational therapist can objectively measure progress using a goniometer for range of motion or a dynamometer for grip strength. Sensory processing skills do not have a measurement device, other than the therapist's observation and subjective questionnaires. Sensory processing goals are best measured through functional outcomes. The following table provides some indicators in each category of RUMBA format to assist with goal writing in pediatric occupational therapy practice, specifically related to interoception.

Format	Indicators in Each Category
R- Relevant	<p>Self-care/ADL outcomes</p> <ul style="list-style-type: none"> -toileting (noticing toileting cues, no aversive responses to toileting cues, etc.) -eating (noticing hunger/thirst cues) -dressing (self-regulating body temperature with clothing) -Sleep -Other <p>Social/emotional outcomes</p> <ul style="list-style-type: none"> -Self-regulation -Emotional identification of self -Emotion identification of others -Social skills -Personal space/body language -Recognizing sympathetic nervous system up-regulation or down-regulation -Transitions between tasks, people, or physical spaces
U- Understandable	-Understandable for the client or their caregivers
M- Measurable	<ul style="list-style-type: none"> -Amount of cueing from therapist -Amount of assist from therapist -# of opportunities -# of strategies -# of verbal descriptors to describe interoception
B- Behavioral	<p>Terms:</p> <ul style="list-style-type: none"> -<u>Notices</u> body/interoception cues -<u>Identifies</u> body/interoception cues -<u>Responds</u> to body/interoception cues -<u>Self-Regulates</u> with (x assist)
A- Achievable	Any timeframe that is appropriate for the client

Table 6- RUMBA goal format for interoception goals

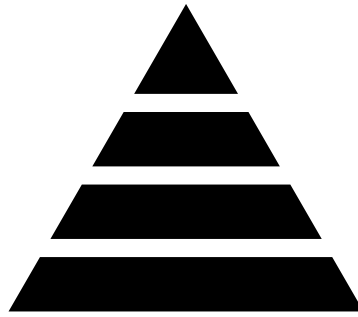
Examples of Self-care/ADL Interoception Goals:

- Interoception & underresponsivity: Pt will demonstrate successful appraisal of interoceptive cues, as evidenced by noticing/responding to [hunger/thirst; need for bathroom/itch/pain, etc.] during daily activities with 90% success rate for developmental level.
- Interoception & underresponsivity: Pt will demonstrate successful appraisal of interoceptive cues, as evidenced by noticing/responding to [seasonal weather changes; external temperature changes, etc.] and selecting appropriate attire during daily routines with 90% success rate
- Interoception & overresponsivity: Pt will demonstrate successful modulation of homeostatic interoceptive cues in daily living tasks and activities to complete without aversive response or overreaction x 90% of trials: sleeping, feeding, and toileting tasks
- Interoception & Adapt/Modify Techniques: Pt will demonstrate ability to follow a home program with [visual reminders; timed reminders; tactile reminders] for successful appraisal of homeostatic interoceptive cues during daily routines with x90% adherence

Examples of Self-Regulation, Emotional Identification, Emotional Regulation Goals:

- Interoception & Self-regulation: Pt will demonstrate successful appraisal of interoceptive cues, as evidenced by noticing/responding to brain/body self-regulation cues with [min/mod/max] assist/cueing from therapist/caregiver x90% of trials
- Interoception & Self-regulation: Pt will demonstrate the ability to use interoceptive cues to inform proper selection of self-regulation coping strategies during occupation, as evidenced by trialing [# OF SELF-REGULATION STRATEGY(IES)] spontaneously, with minimal assist/cueing from therapist x90% of trials

Section IV- Interception Intervention Framework



Establishing/Restoring the Skill of Interoception

Included in this section is a framework for the purpose of enhancing awareness and appraisal of interoception skills. This framework may be successful with any age, but functions best with children ages 2-12. This framework follows a hierarchical order of operations, starting with the bottom of the pyramid. The child moves up the pyramid based on attainment of the previous level.

In this framework, interoception concepts are introduced through experiential play, which is consistent with the physical, cognitive, and psychosocial developmental expectation of children ages 2-11 (Bastable, Myers, & Arnaud, 2020). Interoception concepts include words or phrases that describe the body state during certain actions, movements, and activities using various metaphors and symbols that a child around the age of 2 or older can understand. In this framework, the child learns the meaning of the interoception concept first. Then, the child actively participates in experiential play to practice embodying that concept. Once they are consistently able to embody that concept with 100% accuracy, the concept shifts focus from the external world to the internal body. Once they understand how to apply the concept to the internal body, they may be able to describe interoceptive feelings using the concept.

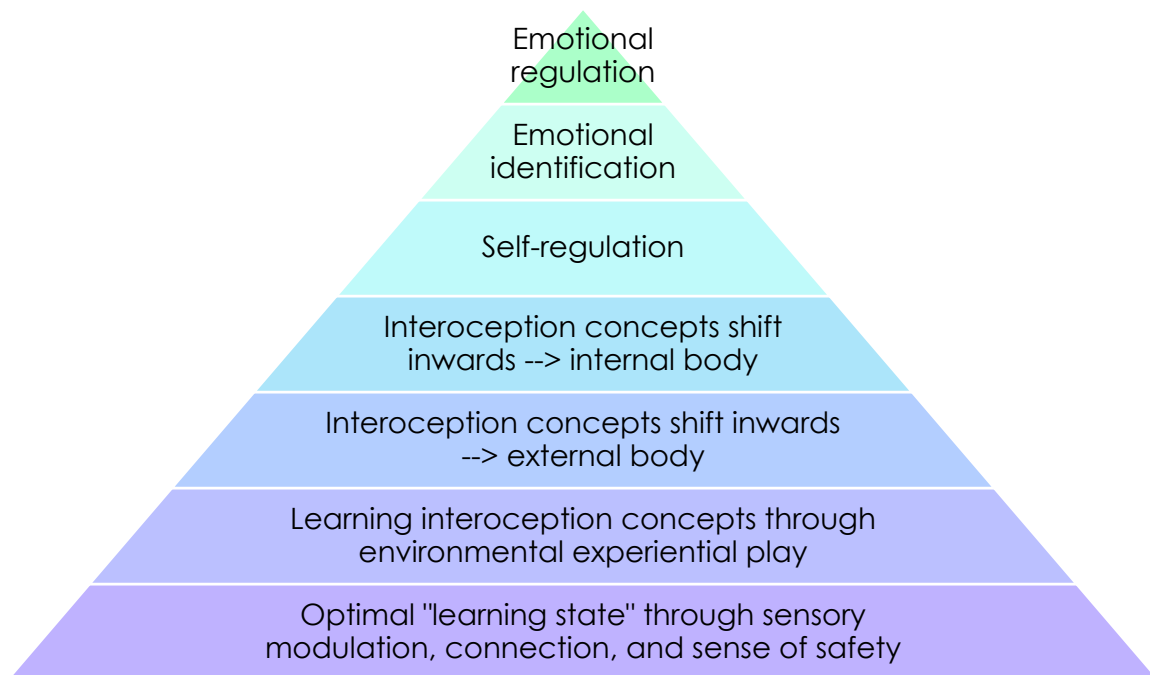


Figure 3- A hierarchy of skills to develop interoception

To illustrate this hierarchical process, the example of "elephant/mouse" will be outlined. Elephant and mouse is an interoceptive concept that describes the intensity of movement, intensity of actions, and the intensity of feelings in everyday activities. "Elephant" refers to big movements, big actions, and big feelings. "Mouse" refers to small movements, small actions, and small feelings.



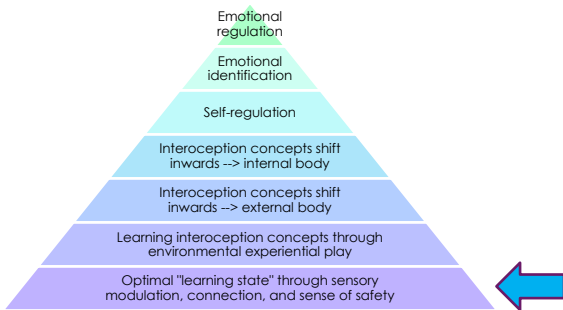
Elephant:
BIG moves
BIG actions
BIG feelings



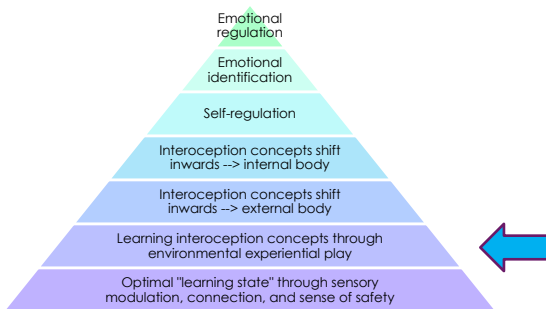
Mouse:
Little moves
Little actions
Little feelings

Example: "Use big elephant moves with your legs while skating!"
"I noticed that you are using a big elephant voice"
"Are you having big elephant feelings right now?"

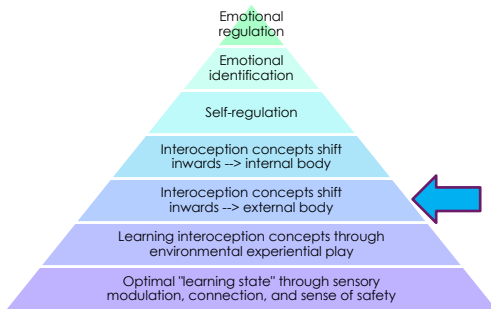
Example: "Use little tiny mouse moves while using scissors."
"Thank you for using a tiny mouse voice while your brother sleeps."



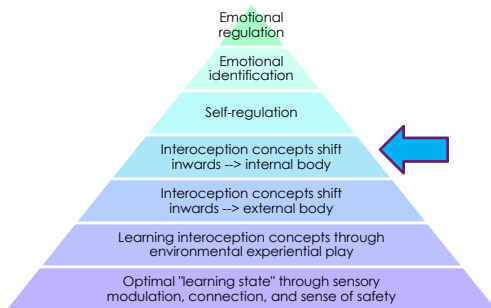
Stage 1: In this stage, the occupational therapist supports the child in achieving an optimal state of arousal and organization for learning (Suedel, 2021). This may be achieved through play and movement activities that integrate many senses. In this state, the nervous system has shifted away from sympathetic nervous system up-regulation. The child demonstrates excellent engagement with the therapist or the tasks in the session. The child experiences a feeling of safety and security.



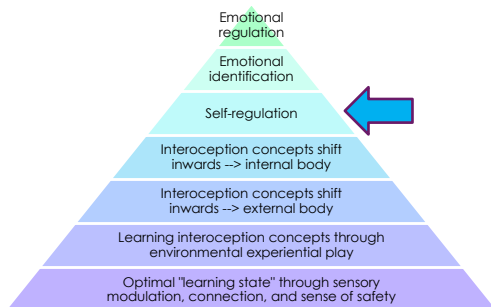
Stage 2: This is one of the longer stages of the interoception curriculum, as the child learns and integrates the concepts throughout all three domains of Bloom's Taxonomy, including the affective domain, the cognitive domain, and the kinesthetic domain (Bastable & Rabbia, 2020). The practitioner engages the child with these concepts through many different play-based activities, and creates home programs for the child's caregivers, so that they may be able to integrate the same language in the child's home. In this stage, the concepts of "elephant" and "mouse" are explained to the child. The therapist creates play-based activities, in which the child practices "elephant moves" and "mouse moves". Once the child understands "elephant" and "mouse" in all three domains of Bloom's Taxonomy, and is able to integrate into their daily activities, the concepts shift to stage 3.



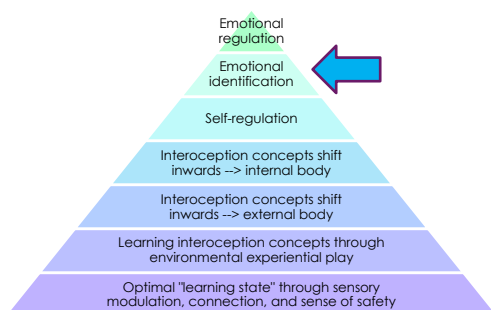
Stage 3: By this stage, the child is able to integrate "elephant" and "mouse" into all activities in daily life. Once they are able to do this, the interoception concepts start to shift inward to describe body states/feelings of the limbs and head. For example, the legs can feel "big elephant feelings" while the head can feel "tiny mouse feelings". The child may start to complete body scans and check-ins with the therapist/caregivers to build awareness to interoception feelings within the specified body parts.



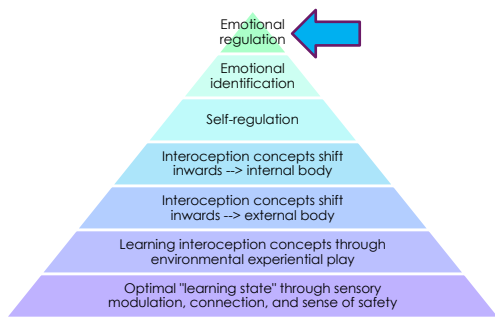
Stage 4: By this stage, the child has begun to describe interoceptive feelings of the external body parts, including the limbs and the head. In stage 4, the concepts shift even further to the internal body, which includes the internal organs and physiological processes (heartrate, breathing, eating, temperature, going to the bathroom, etc.). The occupational therapist may provide education on these internal structures and how they function prior to applying interoception concepts to them. The child may describe feeling a "big elephant feeling" in their tummy, but a "tiny mouse feeling" in their heart/chest.



Stage 5: Now that the child has been provided with interoceptive descriptors to describe interoceptive sensations, they may now start to apply these descriptors to various self-regulation strategies. For example, they may feel that there is a "big elephant" feeling in their bladder, which prompts the self-regulation strategy of going to the bathroom. Interoceptive concepts can also be used as the self-regulation prompts themselves. For example, if a child is doing "big elephant moves" while using scissors, the occupational therapist may prompt them to use "tiny mouse moves" to enhance safety.



Stage 6: By this stage, the child has been actively practicing self-regulation strategies to meet their needs and to meet the demands of the tasks and contexts in which they engage in. Stage 6 shifts to emotion identification using interoceptive cues. In this stage, the child uses previous interoceptive concepts to self-identify when they feel an emotional shift start to happen. For example, they may start to feel a new sensation of "big elephant feelings" in their chest in response to something that happened with a peer. The occupational therapist and the child can practice many different emotional identification games using previously learned interoception concepts. For older children, identification of emotional triggers may also occur in this stage.



Stage 7: Once a child has been able to practice identifying emotions while tying them to interoceptive feelings, they are now at a stage in which they can start to regulate emotions. This occurs through attainment of all previous levels in the interoception framework hierarchy. The occupational therapist may support the child in this stage by helping them identify “big elephant feelings” and “little mouse feelings”, and activities that help to create positive interoceptive experiences when the child has “big elephant emotions”.

“Elephant” and “mouse” are two interoceptive concepts that were described through the hierarchy above. These are not meant to be the only interoception concepts taught, especially because there are many different ways to describe body sensations other than through the use of “big” and “little”. Other interoceptive cues may be created by the occupational therapist to describe speed of movements/actions, energy levels, force gradation/weight, and activation/deactivation of specific body parts to name a few. The selection of metaphors, phrases, or analogies is to be created with discretion from the occupational therapist.

Important Reminders

With this interoception framework, it is important to use discretion when correcting a child for reporting an interoceptive sensation that appears to be inconsistent with the therapist's observations. Denying one's lived experience repeatedly may inhibit the development of self-trust and true self-regulation. Using this proposed framework, the only instance in which a correction is warranted is if they are misunderstanding the meaning of a concept. For example, if a child thinks that being a “mouse” means using fast movements instead of little movements, the occupational therapist may use probing questions to help the child self-discover their error. In any other instance, a child's interoceptive experience should be honored as they report it, as this will promote self-trust and self-regulation.

Adapting/Modifying the Context/Task to Support Interoception

Ideally, this type of intervention approach is used after the practitioner has tried to support the establishment or restoration of the sensorimotor skill of interoception. If needed, the practitioner may need to shift focus towards supporting the child's performance range through a focus on the context or task. Specifically, this may occur if limited interoception skills are a threat to the child's wellbeing. For example, if a child is having accidents at school due to underresponsive interoceptive awareness, the occupational therapist will need to intervene quickly with an adaptive approach to protect their psychosocial wellbeing. The following table provides several examples of

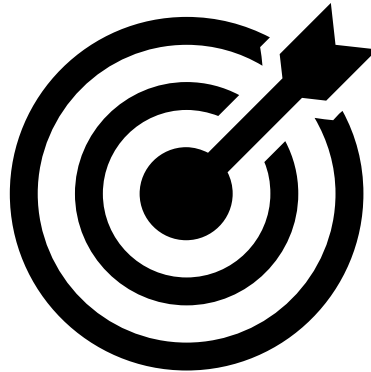
adaptations. It should be noted that this table is not exhaustive, and there are many examples not mentioned.

Task/Occupation	Adaptation to Context to Support Interoception	Adaptation to Task to Support Interoception
Toileting & Urge for Restroom (Hample & Mahler, 202)	<ul style="list-style-type: none"> -Access to restroom at all times (physical context) -Access to a restroom that is physically accessible (physical context) -Frequent timepoints in daily routine for automatic bathroom break (temporal context) -Normalizing the use of the bathroom (social & cultural context) -Normalizing talking about toileting concerns with trusted caregivers (social & cultural context) -Use of technology reminders to have a bathroom break (physical context) 	-Timers used during bathroom breaks to ensure that the child empties their bladder/bowel completely
Dressing & Body Temperature Regulation	-Use of social stories to help child pick an outfit that is suitable for the temperature (Suedel, 2022) (physical & social context)	
Eating & Hunger	<ul style="list-style-type: none"> -Access to nutritious food at all times (physical context, cultural context) -Frequent timepoints in daily routine for automatic snack breaks (temporal context) -Food exploration through play with no pressure (physical, social, & cultural context) 	-Using serving sizes to guide satiety cues (with guidance from a nutritionist if needed)
Safety Awareness	-Physical setup of environment- removal of dangerous objects and structures (physical context)	-Adapting the types of tools that are used for the task at hand

	-Use of supervision (social context)	
Social and Emotional Health Promotion and Maintenance	-Use of picture visuals that a child can use to communicate their current affective state (physical & social context)	-Teaching concepts surrounding emotions with social stories and quick guides (i.e. depressed eyebrows, squinted eyes, and a tense forehead means that somebody may be angry)
Physical Activity	-Use of picture visuals of exercises that are in different zones of intensity (physical context)	-Use of pulse oximeter to provide the child with information that enhances awareness of exercise intensity
Rest & Sleep	-Use of nighttime routines and timeframes to help a child understand when it is time to go to bed (temporal context)	

Table 7- Examples of ways to adapt/modify the task or the context to support a child's interoceptive skills

Section V- Documentation and Outcomes



Interoception interventions and documentation follows a similar type of format as other sensory processing interventions. The follow table serves as a reference point for easy documentation of interoceptive interventions and progress. Documentation that demonstrates a functional purpose of the interoception intervention, as well as some form of objective or subjective measurement will have the highest degree of relevance for stakeholders.

<p>Documentation demonstrates functional purpose of interoception sensorimotor skills</p>	<p>“intervention to improve interoceptive accuracy for functional outcomes, including _____”</p> <ul style="list-style-type: none"> -Ability to notice/respond to messy hands/face -Ability to notice/respond to clothing out of place -Ability to notice/respond to self-regulation cues -Ability to notice/respond to hunger/thirst cues -Ability to notice/respond to need for restroom cues -Ability to notice/respond to affective cues for better emotional regulation -Other
<p>Documentation demonstrates some form of objective/subjective measurement</p>	<ul style="list-style-type: none"> -Amount of cueing from therapist -Amount of assist form therapist -% Accuracy/consistency with therapist observation -# of opportunities -# of strategies -# of verbal descriptors to describe interoception <p>Terms:</p> <ul style="list-style-type: none"> -<u>Notices</u> body/interoception cues -<u>Identifies</u> body/interoception cues -<u>Responds</u> to body/interoception cues -<u>Self-Regulates</u> with (x assist)

Table 8- Documentation quick reference guide

Therapist Observations of Progress and Outcomes

One of the most challenging aspects of integrating interoception work into the occupational therapy process is that it is difficult to isolate and measure as a variable. For example, interoception skills are often communicated through functional communication, which many children struggle with. As stated previously, this makes functional outcomes difficult to measure using a valid and reliable objective measurement. As such, there are several markers of progress that occur throughout the interoception framework process that indicate positive change. These may include:

- The child attempts to shift their actions, movements, or task strategies after being prompted with an interoception concept cue (i.e. elephant/mouse).
- The child uses an interoception concept without being prompted by the therapist.
- The child pauses independently before completing an action, movement, or task.
- The child is able to identify sympathetic nervous system triggers before, during, or after they occur.
- The child uses cognitive appraisal and metacognitive strategies to prepare for an action, movement, or task.
- The child reports an interoceptive sensation independently, without being prompted.
- The child starts to use interoceptive sensations to process through emotions.
- The child engages in empathy-based language when describing social situations.
- The child becomes more aware of self-care self-regulation signals
- The child carefully investigates the emotions of others

Section VI- Specialized Interception Programming Opportunities



The proposed framework in section IV of this manual can be used as a foundational framework for children to develop interoception skills, not only for self-regulation and emotional regulation, but also for other areas of occupation. Additionally, there are opportunities for interoception-based interventions throughout many different areas of service delivery and populations. The following table represents some potential areas of current occupational therapy practice that can be enhanced by interoception.

Area of Opportunity	Description
Interoception Toileting Program for Children and Adults	-In this type of program, the occupational therapist would address the task of toileting using a holistic lens. Common concerns with toileting include underresponsivity and overresponsivity to interoception cues, which can cause issues such as constipation, frequent accidents, and fear associated with the task of toileting. The occupational therapist might analyze the how the sensorimotor, cognitive, and psychosocial skills of the person, interact with contextual factors associated with toileting (physical, social, temporal, and cultural). Current evidence shows the benefit of using interoception-based supports and interventions to enhance toileting concerns (Hample & Mahler, 2021).
Adult Physical Dysfunction	While there is currently little research on interoception-based interventions in acute care settings, evidence suggests that interoception is a critical component to many occupations. Some examples of further exploration regarding interoception and acute care or inpatient rehabilitation include: <ul style="list-style-type: none"> -Interoception & cardiac concerns (Self-identifying zones of intensity of various activities/exercises to enhance safety) -Interoception & pacing strategies (Self-identifying endurance levels and tasks that fall into or out of the daily performance range using interoceptive cues) -Self-insight and safety awareness programs -Breathing awareness programs
Mental Health Service Delivery for All Ages	Because interoception skills are so closely tied with self-regulation, emotional regulation, and social skills, interoception-based interventions have great potential for use in mental health service delivery. In fact, much of the research regarding interoception is derived from the field of psychology, and associated sub-disciplines. Specific examples of ways that interoception is currently used

	includes mindfulness programs, somatic-based insight programs, and sensory programs.
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Table 9- Potential opportunities for specialized interoception programming

As a new area of practice, interoception-based frameworks are starting to gather attention in many different specialized areas. The current state of the evidence suggests a strong connection between interoception and many different performance skills, including self-regulation, emotional regulation, social skills, and self-care skills. Mental health frameworks are shifting away from being behaviorally-focused, towards a focus on an underlying need or difference in the child's neurology that influences behavioral outcomes (Williams & Shellenberger, 1996). Thus, health professions have only recently tapped the surface of the potential of interoception-based supports. Despite the limited amount of specific evidence, the evidence towards use of interoception in pediatric and mental health service delivery settings is strong, and demonstrates great potential.

References

- American Occupational Therapy Association (2020). Occupational therapy practice framework: Domain and process (4th ed.). *American Journal of Occupational Therapy*, 74(Suppl. 2), 7412410010. doi: <https://doi.org/10.5014/ajot.2020.74S2001>
- Ardizzi, M., Ambrosecchia, M., Buratta, L., Ferri, F., Peciccia, M., Donnari, S., Mazzeschi, C., & Gallese, V. (2016). Interoception and positive symptoms in schizophrenia. *Frontiers in Human Neuroscience*, 10(379). pp. 1-10. doi: 10.3389/fnhum.2016.00379
- Arnold, A. J., Winkielman, P., & Dobkins, K. (2019). Interoception and social connection. *Frontiers in Psychology*, 10(2589). doi: 10.3389/fpsyg.2019.02589
- Bagby, R. M., Parker, J. D., & Taylor, G. J. (1994). The twenty-item Toronto Alexithymia Scale I. Item selection and cross-validation of the factor structure. *Journal of Psychosomatic Research*, 38(1), 23-32.
- Barrett, L. F., Quigley, K. S., Bliss-Moreau, E., & Aronson, K. R. (2004). Interoceptive sensitivity and self-reports of emotional experience. *J Pers Soc Psycho.*, 87(5). pp. 684-697.
- Bastable, S. B., Myers, G. M., & Arnaud, L. M. (2020). Developmental stages of the learner. In Bastable, S. B., Gramet, P. R., Sopxzyk, D. L., Jacobs, K., & Braungart, M. M. (Eds.), *Health Professional As Educator: Principles of Teaching and Learning*. pp. 185-237. Burlington, MA: Jones & Bartlett Learning, LLC.
- Bastable, S. B., & Rabbia, J. (2020). Behavioral objectives and teaching plans. In Bastable, S. B., Gramet, P. R., Sopxzyk, D. L., Jacobs, K., & Braungart, M. M. (Eds.), *Health Professional As Educator: Principles of Teaching and Learning*. pp. 467-505. Burlington, MA: Jones & Bartlett Learning, LLC.
- Beaudry-Bellefeuille, I., Lane, S. J., & Lane, A. E. (2019). Sensory integration concerns in children with function. *The American Journal of Occupational Therapy*, 73(3). pp. 1-13. <https://doi.org/10.5014/ajot.2019.030387>
- Connell, L., Lynott, D., & Banks, B. (2018). Interoception: The forgotten modality in perceptual grounding of abstract and concrete concepts. *Philosophical Transactions B: Royal Society Publishing*, 373(20170143). doi: <http://dx.doi.org/10.1098/rstb.2017.0143>
- Craig, A. D. (2002). How do you feel? Interoception: The sense of the physiological condition of the body. *Nature Reviews Neuroscience*, 3(8). pp. 655-666.
- Critchley, H. D., & Garfinkel, S. N. (2017). Interoception and emotion. *Current Opinion in Psychology*, 17. pp. 7-14. doi: <https://dx.doi.org/10.1016/j.copsyc.2017.04.020>
- Critchley, H. D., Wiens, S., Rotshtein, P., Öhman, A., & Dolan, R. J. (2004). Neural systems supporting interoceptive awareness. *Nature Neuroscience*, 7(2), 189-195
- Dean, E. E., Little, L. M., Wallisch, A., & Dunn, W. (2019). Sensory processing in everyday life. *In Willard and Spackman's Occupational Therapy (13th ed.)*. pp. 942-964. Baltimore, MD: Wolters Kluwer
- Dunn, B. D., Galton, H. C., Morgan, R., Evans, D., Oliver, C., Meyer, M., Cusack, R., Lawrence, A. D., & Dalgleish, T. (2010). Listening to your heart: How interoception shapes emotion experience and intuitive decision making. *Psychological Science*, 21(12), 1835-1844. doi: 10.1177/0956797610389191
- Dunn, W. (1997). The impact of sensory processing abilities on the daily lives of young children and their families: A conceptual model. *Infants and Young Children*, 9

- Dunn, W. (2017). The ecological model of occupation. In Hinojosa, J., Kramer, P., & Brasic Royeen, C. (Eds.), *Perspectives on Human Occupation: Theories Underlying Practice* (pp. 207-235). Philadelphia, PA: F. A. Davis Company
- Dunn, W., Brown, C., & McGuigan, A. (1994). The ecology of human performance: A framework for considering the effect of context. *American Journal of Occupational Therapy, 48*, 595-607. <https://doi.org/10.5014/ajot.48.7.595>
- Dunn, W., Smith Myles, B., & Orr, S. (2002). Sensory processing issues associated with Asperger syndrome: A preliminary investigation. *American Journal of Occupational Therapy, 56*, 97-102.
- Erickson, E. H. (1963). *Childhood and Society* (2nd ed.). New York: NY: Norton
- Füstös, J., Gramann, K., Herbert, B. M., & Pollatos, O. (2012). On the embodiment of emotion regulation: Interoceptive awareness facilitates reappraisal. *Social Cognitive and Affective Neuroscience*. doi: 10.1093/scan/nss089
- Gibson, J. (2019). Mindfulness, interoception, and the body: A contemporary perspective. *Frontier Psychology 10*. doi: 10.3389/fpsyg.2019.02012
- Grynberg, D., & Pollatos, O. (2014). Perceiving one's body shapes empathy. *Psychology and Behavior, 140*. pp. 54-60. doi: <https://dx.doi.org/10.1016/j.physbeh.2014.12026>
- Hample, K., & Mahler, K. (2021). Toileting, interoception & nutrition: An evidence-based approach for promoting toileting success and independence. [Online course]. <https://www.kelly-mahler.com/product/course-replay-toileting-interoception-nutrition/>
- Herbert, B. M., Herbert, C., & Pollatos, O. (2011). On the relationship between interoceptive awareness and alexithymia: Is interoceptive awareness related to emotional awareness? *Journal of Personality, 79*(5). pp. 1149-1175.
- Jackson, S. R., Parkinson, A., Kim, S. Y., Schürmann, M., & Eickhoff, S., B. (2011). On the functional anatomy of the urge-for-action. *Cognitive Neuroscience, 2*(3-4). pp. 227-257. doi: <http://dx.doi.org/10.1080/17588928.2011.604717>
- Jung, W., Ryu, Y., Lee, Y., Wallraven, C., & Chae, Y. (2017). Role of interoceptive accuracy in topographical changes in emotion-induced bodily sensations. *PLoS ONE 12*(9). doi: <https://doi.org/10.1371/journal.pone.0183211>
- Kandasamy, N., Garfinkel, S. N., Page, L., Hardy, B., Critchley, H. D., Gurnell, M., & Coates, J. M. (2016). Interoceptive ability predicts survival on a London trading floor. *Scientific Reports, 6*(32986). pp. 1-7. doi: 10.1038/srep32986
- Keiver, A., Pollatos, O., Vermeulen, N., & Grynberg, D. (2015). Interoceptive sensitivity facilitates both antecedent- and response-focused emotion regulation strategies. *Personality and Individual Differences, 87*. pp. 20-23. doi: <http://dx.doi.org/10.1016/j.paid.2015.07.014>
- Khoury, N. M., Lutz, J., & Schuman- Olivier, Z. (2018). Interoception in psychiatric disorders: A review of randomized controlled trials with interoception-based interventions. *Harv Rev Psychiatry, 26*(5). pp. 250-263. doi: 10.1097/HRP .00000 00000000170
- Kinnaird, E., Stewart, C., & Tchanturia, D. (2019). Investigating alexithymia in autism: A systematic review and meta-analysis. *Journal of European Psychology, 55*. pp. 80-89. doi: 10.1016/j.eurpsy.2018.09.004
- Kuypers, L. M. (2011). *The zones of regulation: A curriculum designed to foster self-regulation and emotional control*. Santa Clara, CA: Think Social Publishing.
- Laughter, S., Mitchell, V., Nguyen, N., & Kim, C. (2020). Interrelationship between sensory modulation, altered interoceptive awareness, and anxiety and impacts on quality of life.

- Occupational Therapy: Graduate Capstone Projects, 18.* doi: <https://doi.org/10.33015/dominican.edu/2020.OT.08>
- Lefranc, B., Martin- Krumm, C., Aufauvre-Poupon, C., Berthail, B., & Trousselard, M. (2020). Mindfulness, interoception, and olfaction: A network approach. *Brain Sciences, 10*(921). doi: 10.3390/brainsci1012 0921
- Little, L. M., Benton, K., Manuel-Rubio, M., Saps, M., & Fishbein, M. (2019). Contribution of sensory processing to chronic constipation in preschool children. *The Journal of Pediatrics, 210*. pp. 141-145. doi: <https://doi.org/10.1016/j.jpeds.2019.03.020>
- Ma-Kellams, C. (2014). Cross-cultural differences in somatic awareness and interoceptive accuracy: A review of the literature and directions for future research. *Frontiers in Psychology, 5*(1379). pp. 1-9. doi: 10.3389/fpsyg.2014.01379
- Mahler, K. (2016). *The comprehensive assessment for interoceptive awareness (2nd ed.) [assessment]*. Shawnee, KS: AAPC Publishing.
- Mahler, K. J. (2017). *Interoception: The eighth sensory system: Practical solutions for improving self-regulation, self-awareness and social understanding / Kelly Mahler ; foreword by A. D. "Bud" Craig*. Shawnee Mission, Kansas: AAPC Publishing
- Mahler, K. (2019). *The interoception curriculum: A step-by-step framework for developing mindful self-regulation*. United States of America.
- Mahler, K. J. (2021). An interoception-based approach for supporting traumatized learners [online course]. <https://www.kelly-mahler.com/product/on-demand-course-an-interoception-based-approach-for-supporting-traumatized-learners/>
- Mahler, K., Rothschild, C., & Alma, J. (2019). *My interoception workbook: A guide for adolescents, teens and adults*. United States of America.
- Mehling, W. E., Price, C., Daubenmier, J. J., Acree, M., Bartmess, E., & Steward, A. (2012). The multidimensional assessment of interoceptive awareness (MAIA). *PLoS One, 7*(11), e48230. Doi: 10.1371/journal.pone.0048230
- Noel, J., Lytle, M., Cascio, C., & Wallace, M. T. (2018). Disrupted integration of exteroceptive and interoceptive signaling in autism spectrum disorder. *Autism Res., 11*(1). pp. 194-205. doi: 10.1002/aur.1880
- Nummenmaa, L., Glerean, E., Hari, R., & Hietanen, J. K. (2014). Bodily maps of emotions. *PNAS, 111*(2). pp. 646-651. doi: www.pnas.org/cgi/doi/10.1073/pnas.1321664111
- Parham, L. D. & Mailloux, Z. (2020). Sensory integration. In Clifford O'Brien, J. & Kuhaneck, H. (Eds.), *Case-Smith's Occupational Therapy for Children and Adolescents* (pp. 516-549). St. Louis, Missouri: Elsevier, Inc.
- Perry-Parrish, C., Copeland-Linder, N., Webb, L., & Sibinga, E. M. S. (2016). Mindfulness-based approaches for children and youth. *Current Problems Pediatric Adolescent Health Care, 46*, pp. 172-178. doi: <http://dx.doi.org/10.1016/j.cppeds.2015.12.006>
- Price, C., Wells, E. A., Donovan, D. M., & Rue, T. (2012). Mindful awareness in body-oriented therapy as an adjunct to women's substance use disorder treatment: A pilot feasibility study. *Journal of Substance Abuse Treatment 43*(1). pp. 94-107. doi: 10.1016/j.jsat.2011.09.016
- Quadt, L., Critchley, H. D., & Garfinkel, S., N. (2018). The neurobiology of interoception in health and disease. *Ann. N. Y. Acad. Sci., 1428*. pp. 112-128. doi: 10.1111/nyas.13915
- Reiffe, C., Oosterveld, P., & Meerum Terwogt, M. (2006). An alexithymia questionnaire for children: Factorial and concurrent validation results. *Personality and Individual Differences, 40*, 123-133.

- Romano, L., Buonomo, I., Callea, A., & Fiorilli, C. (2019). Alexithymia in young people's academic career: The mediating role of anxiety and resilience. *The Journal of Genetic Psychology, 180*(4-5). pp. 157-169. doi: <https://doi.org/10.1080/00221325.2019.1620675>
- Salter Ainsworth, M. D., Blehar, M. C., Waters, E., and Wall, S. N. (2015). *Patterns of attachment: A psychological study of the strange situation*. New York, NY: Psychology Press.
- Scheffers, M., Hoek, J., Bosscher, R. J., Van Duijin, M. A. J., Schoevers, R. A., and van Busschback, J. T. (2017). Negative body experience in women with early childhood trauma: associations with trauma severity and dissociation. *European Journal of Psychotraumatology, 8*(1322892). pp. 1-9. doi: <https://doi.org/10.1080/20008198.2017.1322892>
- Schulz, A. & Vögele, C. (2015). Interoception and stress. *Frontiers in Psychology 6*(993). doi: 10.3389/fpsyg.2015.00993
- Sifneos, P. E. (1973). The prevalence of alexithymic characteristics in psychosomatic patients. *Psychother. Psychosom., 22*. pp. 255-262. doi: 10.1159/000286529
- Stern, E. R., Grimaldi, S. J., Muratore, A., Murrough, J., Leibu, E., Fleysher, L., Goodman, W. K., & Burdick, K. E. (2017). Neural correlates of interoception: Effects of interoceptive focus and relationship to dimensional measures of body awareness. *Human Brain Mapping 38*. Wiley Periodicals, Inc. doi: 10.1002/hbm.23811
- Suedel, S. (2021). Understanding my self-regulation signals. [Home Programming Educational Materials]. Copy in possession of author.
- Tang, W., Hu, T., Yang, L., & Xu, J. (2020). The role of alexithymia in the mental health problems of home-quarantine university students during the COVID-19 pandemic in China. *Personality and Individual Differences, 165*(110131). pp. 1-7. doi: <https://doi.org/10.1016/j.paid.2020.110131>
- Tsakiris, M., & Critchley, H. (2016). Interoception beyond homeostasis: Affect, cognition and mental health. *Philosophical Transactions B: The Royal Society Publishing, 371*(20160002). doi: <https://dx.doi.org/10.1098/rstb.2016.0002>
- Tsakiris, M., Tajadura-Jiménez, and Costantini, M. (2011). Just a heartbeat away from one's body: interoceptive sensitivity predicts malleability of body-representations. *Royal Society, 278*. pp. 2470-2476. doi: 10.1098/rspb.2010.2547
- Uljarevic, M. & Hamilton, A. (2012). Recognition of emotions in autism: A formal meta-analysis. *Journal of Autism and Developmental Disorders, 43*(7), 1517-1526. doi: 10.1007/s10803-012-1695-5
- Wang, X., Wu, Q., Egan, L., Gu, X., Liu, P., Gu, H., Yang, Y., Luo, J., Wu, Y., Gao, Z., & Fan, J. (2019). Anterior insular cortex plays a critical role in interoceptive attention. *eLife, 8*(42265). doi: <https://doi.org/10.7554/eLife.42265>
- Williams, M. S., & Shellenberger, S. (1996). "How Does Your Engine Run?" A leader's guide to the alert program for self-regulation. Albuquerque, NM: Therapy Works, Inc.
- Zhou, P., Critchley, H., Garfinkel, S., & Gao, Y. (2021). The conceptualization of emotions across cultures: A model based on interoceptive neuroscience. *Neuroscience and Biobehavioral Reviews, 125*. pp. 314-327. doi: <https://doi.org/10.1016/j.neubiorev.2021.02.023>

