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# The influence of interoception on engagement in occupation: a scoping review

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# THE INFLUENCE OF INTEROCEPTION ON ENGAGEMENT IN OCCUPATION: A SCOPING REVIEW

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree

of

Master of Science in Occupational Therapy

Johannesburg, 2022

# PLAGIARISM DECLARATION

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# ABSTRACT

Interoception provides information on internal sensations facilitating awareness of the physiological condition of the body. Interoception is an emergent concept within occupational therapy research and practice due to its impact on occupational performance. Poor interoceptive awareness (IA) may affect occupational engagement through individuals under or over responding to interoceptive cues. Considered a key component in emotional experience, interoception contributes to performance in various occupational areas. This scoping review explored the relationship between interoception and occupational engagement. The Joanna Briggs Institute (JBI) guidelines informed the methodology and involved a three-step search strategy using major scientific and grey literature databases. The search resulted in the extraction of thirteen articles (n=13) that met the inclusion criteria. Data analysis identified a relationship between IA and occupational engagement. Poor IA affects engagement in various occupational areas including activities of daily living, sleep, social participation, and education. The evidence related to interoception within occupational therapy is small but growing and IA appears to play a role in many conditions addressed by the occupational therapy profession. This research study could inform occupational therapy practice and future research related to interoception.



Keywords: Interoception; interoceptive awareness, occupation; occupational engagement

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## Abbreviations

| | |
|---|---|
| ADL | Activities of Daily Living |
| ANS | Autonomic Nervous System |
| ASD | Autism Spectrum Disorder |
| CNS | Central Nervous System |
| IA | Interoceptive Awareness |
| IADL | Instrumental Activities of Daily Living |
| IS | Interoceptive Sensitivity |
| JBI | Joanna Briggs Institute |
| OTPF-4 | Occupational Therapy Practice Framework (4th Edition) |
| SI | Sensory Integration |
| SPD | Sensory Processing Disorder |
| WFOT | World Federation of Occupational Therapists |

## Nomenclature

| | |
|---|---|
| Boolean operators | Words used during a search to combine or exclude keywords such as “AND” or “OR”. This increases or reduces the returned results leading to a more focused or comprehensive search (Thompson Rivers University Library , 2019; Northcentral University Library, 2021). |
| Categories of occupation | Occupations grouped as activities of daily living, instrumental activities of daily living, health management, rest and sleep, education, work, play, leisure, and social participation (American Occupational Therapy Association, 2020). |
| Emotional regulation | The ability to control one’s emotions and emotional responses (Thompson, 1994). |
| Interoception | Sensing the internal state or condition of the body (Mahler, 2017). |
| Interoceptive awareness | An individual’s awareness of internal body signals (Mahler, 2017). |
| Occupational engagement | Occupations performed due to choice, motivation, and significance in a supportive environment. This includes both objective and subjective aspects of an individual’s experience and involves mind, body, and spirit (American Occupational Therapy Association, 2020). |
| Occupational participation | This arises when individuals are actively involved and engaging in occupations or activities, which are meaning and purposeful (American Occupational Therapy Association, 2020). |
| Occupational performance | The ability to choose, organise and perform occupations that are meaningful and appropriate (American Occupational Therapy Association, 2020). |
| Occupations | The “everyday activities that people do” (World Federation of Occupational Therapists, 2021). |
| Overresponsivity | An individual who is overly responsive to sensory stimuli and experience an exaggerated, intense, or prolonged response (Bundy & Lane, 2020). |

| | |
|---|---|
| Self-regulation | The ability to control the way one feels and acts (Mahler, 2017). |
| Sensory discrimination | The interpretation of sensory stimuli and making use of this to enable interaction with the environment (Lane & Reynolds, 2020). |
| Sensory integration | Neural process that allows sensory input to be organised and integrated for use (Ayres & Robbins, 2005). |
| Sensory modulation | The ability to filter out or attend to relevant sensations to maintain an optimal arousal level and maintain attention to task (Lane, 2020a). |
| Sleep hygiene | Healthy habits or behaviours aimed at improving the ability to initiate sleep and maintain a sleep state (Irish, et al., 2015; Solet, 2013). |
| Truncation | The use of a specified symbol during a search to find alternative spellings or endings to words (Thompson Rivers University Library , 2019; Northcentral University Library, 2021). |
| Underresponsivity | An individual who is under responsive to sensory stimuli and experiences a reduced, slow, or delayed response (Bundy & Lane, 2020). |

# CHAPTER 1 INTRODUCTION

## 1.1 Introduction

The basis of occupational therapy practice is on the belief that humans are occupational beings and through engagement in occupation, across the lifespan, they can influence their development and wellbeing (American Occupational Therapy Association, 2020; Kielhofner, 2007). Engagement in occupation is therefore a fundamental concept and considered a means and an end goal in occupational therapy practice (Kielhofner, 2007; Larsson-Lund & Nyman, 2016). Occupations are defined in the occupational therapy practice framework as “various kinds of life activities which individuals, groups, or populations engage, including activities of daily living, instrumental activities of daily living, rest and sleep, education, work, play, leisure, and social participation” (American Occupational Therapy Association, 2020, p. 19). Interoception appears to have a significant influence on occupational performance and participation supporting or hindering engagement in occupations (Koscinski, 2018; Mahler, 2017).

Recently, interest in interoception research and practice has increased across fields including neuroscience, internal medicine, psychology, psychiatry, and occupational therapy (Craig, 2002; Khalsa, et al., 2018; Mahler, 2017; Zamariola, et al., 2019). This concept appears to be particularly relevant to the occupational therapy field due to its apparent relationship to occupational performance (Koscinski, 2018; Mahler, 2017). Understanding the influence of interoception on performance, participation, and engagement in occupation will provide an evidence base for clinical practice while informing future research. This study focuses on understanding the evidence base and the influence of interoception on occupational engagement, which has direct implications for practice.

The concept of interoception on occupational engagement is an emerging field within sensory integration theory and evidence-based research (Critchley & Garfinkel, 2017; Khalsa, et al., 2018; Mahler, 2017; Zamariola, et al., 2019). Sensory integration includes the registration, organisation, and integration of sensory information from the body and the environment, which support successful engagement in occupation

(Bundy & Lane, 2020). Sensory integration disorder is therefore a recognized area of concern in occupational therapy practice due to its impact on function and occupational performance (Bundy & Lane, 2020; Spitzer & Roley, 2001). Sensory integration difficulties can affect an individual's ability to engage in necessary occupations such as social participation, self-care, restorative activities, play, or work (Engel-Yeger & Shochat, 2012; Lombard, 2011; Miller, et al., 2001). Occupational therapists need to have a thorough understanding of the components that influence sensory integration and the effect of this on behaviour to support optimal engagement in occupations (American Occupational Therapy Association, 2020).

Interoception, as a component of sensory integration, refers to sensory information originating within the body related to physical states to ensure bodily integrity (Mahler, 2017). This includes conscious and subconscious awareness of sensations such as temperature, heart rate, hunger, or thirst (Mahler, 2017; Murphy, et al., 2017). Interoception plays a key role in emotional experience and regulation especially those directed at social integration and physical survival (Mahler, 2017; Price & Hooven, 2018). If we consider the neuroanatomical components that are involved in interoception; the insular cortex, cingulate cortex, and limbic cortical components are significant (Strigo & Craig, 2016). The insular cortex is an area of the brain not well studied or understood (Mahler, 2017). Recent research has highlighted that the insular cortex is involved in interoception and detecting the internal state of the body (Mahler, 2017; Strigo & Craig, 2016). Evidence suggests that the insular cortex, in addition to processing interoceptive activity, is also responsible for integration and modulation of cardiovascular, respiratory, and emotional inputs resulting in an integrated emotional experience (Strigo & Craig, 2016). Research to advance understanding of the insular cortex; its subdivisions and connections is developing (Mahler, 2017; Strigo & Craig, 2016).

There is a suggestion that a well-developed interoceptive system, like other sensory systems, can support engagement in occupations (Mahler, 2017). This is related to interoceptive awareness (IA), which has been defined as noticing and effectively interpreting internal sensations and responding to these appropriately to regulate physical needs and emotions making on-going adjustments (Craig, 2003; Mahler, 2017). Thus, cognitive functioning, social participation, and emotional regulation have been found to be facilitated by adequate IA (Critchley & Garfinkel, 2017; Mahler, 2017)

while poor IA has been associated with a variety of diagnoses such as depression, anxiety, eating disorders, schizophrenia, and substance use disorders (Khalsa, et al., 2018; Mahler, 2017; Merwin, et al., 2010; Smith, et al., 2018; Zamariola, et al., 2019).

Within occupational therapy research, terminology used by researchers related to SI and interoception varies. There have been concerns raised regarding the differing terminology within SI theory, as it can create confusion and lack of clarity among occupational therapists and between fields of study (Smith Roley, et al., 2007). It is however difficult for researchers to reach a consensus on which terminology is the best descriptor of the concepts (Smith Roley, et al., 2007).

This study will use the term sensory integration and when referring to sensory modulation, there will be the adoption of overresponsivity or underresponsivity. In terms of interoception, this study will apply the term interoception when considering the sensory system and IA when considering differing modulation or discrimination functions within this system.

## 1.2 Statement of the problem

There is limited evidence on the extent to which adequate or poor IA influences occupational participation and performance in occupations, and which components of occupation are impacted. Other disciplines, with an interest in interoception, have considered the effect on body functions and client factors but not the effects of adequate or poor IA on participation and engagement in occupations (Critchley & Garfinkel, 2017; Khalsa, et al., 2018).

Literature indicates there is an adequate link between IA and the ability to engage in occupations, while poor IA may relate to activity limitations and participation restrictions (Craig, 2002; Garfinkel & Critchley, 2013; Koscinski, 2018; Mahler, 2017). Furthermore, many health conditions such as eating disorders, anxiety disorders, depression, substance use disorder or autism spectrum disorder (ASD), which are addressed in occupational therapy practice, have been associated with the interoceptive system and poor IA (Khalsa, et al., 2018; Mahler, 2017; Merwin, et al., 2010; Smith, et al., 2018; Zamariola, et al., 2019).

## 1.3 Purpose of the study

Based on the understanding of sensory integration, regulation of behaviour and emotions and the effect that this has on engagement in occupations in occupational therapy, there is an extension into considering the influence of interoception on engagement in occupations.

The purpose of this study is therefore to determine if there is any evidence on the influence that interoception has on engagement in occupations and the implications for occupational therapy practice. Sensory integration theory has had a significant impact on occupational therapy practice through an improved understanding of behaviour and emotional regulation and the effect this has on engagement in occupation (Bundy & Lane, 2020). An improved understanding of interoception as an emergent sensory system with links to emotion and behaviour would be advantageous for practice and further research. This research therefore seeks to examine the current evidence to understand the influence of IA on engagement in occupation and its relevance to occupational therapy practice.

## 1.4 Research question

What is the relationship between interoception and engagement in occupation?

## 1.5 Research aim

To determine the influence of interoception on engagement in occupation and categories of occupation.

## 1.6 Objectives

1. To examine the extent to which interoceptive responsivity influences occupational performance.
2. To identify which components of occupation interoceptive awareness affects.

## 1.7 Justification for the study

The findings of this study will inform occupational therapy practice and are necessary to ensure that practice remains evidence based. This study will explore the nature and

extent of available research that pertains to the occupational therapy field and will thus identify future research needs.

This research report will introduce occupational science, occupational therapy, sensory integration and interoception through a literature review, and provide an outline of the methodology of a scoping review and its application in this study. The extracted data will be analysed in the results chapter and considered, in relation to the literature, in the discussion chapter. The report will conclude with a restatement of core developments of the study and recommendations in the conclusion chapter.

## 1.8 Structure of the research report

Chapter 1: Introduction to the study including a statement of the problem, the purpose of the study, research question, aims and objectives and justification

Chapter 2: Review of the literature related to the study

Chapter 3: Explanation of the methodology used to reach the research aim and objectives

Chapter 4: Collation of the extracted data and statistical analysis of results

Chapter 5: Discussion and interpretation of the data including limitations and strengths of the study

Chapter 6: Conclusion and recommendations for future research and practice

# CHAPTER 2 LITERATURE REVIEW

## 2.1 Introduction

This literature review examines the concept of occupation within occupational therapy practice and occupational science. It examines sensory integration with specific concern for the interoceptive system, and the way this system relates to emotional regulation and occupational areas. The primary source of literature was various databases, using search terms based on the study title: interoception, interoceptive awareness, occupational engagement, occupations, and occupational therapy. As the study progressed, there was an expanding of the search terms based on additional keywords identified in titles or abstracts of sourced literature. Literature was sourced from various disciplines, including neuroscience, psychology, and occupational therapy.

## 2.2 Occupational therapy and occupation

Occupational therapy focuses on the occupational nature of humans and the belief that participation in occupations influences health and wellbeing (American Occupational Therapy Association, 2020). The World Federation of Occupational Therapists (WFOT) defines occupations as “the everyday activities that people do as individuals, in families, and with communities to occupy time and bring meaning and purpose to life. Occupations include things people need to want to and are expected to do” (World Federation of Occupational Therapists, 2021). The belief that individuals seek to be occupied, and that what an individual does has a direct impact on their health and wellbeing forms the foundation of practice (Hocking, 2013; Wilcock, 2005). The concept of occupation is thus central to occupational therapy theory and practice (Dickie, 2013). Occupations are a means and an end goal in practice to enhance individuals and communities’ participation in the activities of everyday life, which construct occupation (Dickie, 2013; Hocking, 2013).

Occupational therapy, in line with its beliefs and philosophy, should remain occupation focused highlighting a need to consider how emergent concepts within the field such as interoception, relate to performance and participation in occupations and what influences occupational engagement (Kielhofner, 2007).

### 2.2.1 Categories of occupations

In occupational therapy, various models guiding theory and practice divide occupations into several domains. The Model of Human Occupation (MOHO) groups occupations into three categories, work, play or activities of daily living (ADL) (Kielhofner, 2002), the Canadian Model of Occupational Performance and Engagement (CMOP-E) categorises occupations into self-care, productivity, and leisure with a more recent focus on occupational engagement (Townsend & Polatajko, 2007) and the Vona du Toit Model of Creative Ability (VdTMoCA) considers four occupational areas, personal management, social ability, work ability and constructive use of time (Van der Reyden & Sherwood, 2019).

The Occupational Therapy Practice Framework 4th edition (OTPF-4) aims at creating a clear and coherent document stating the specific views and processes in occupational therapy (American Occupational Therapy Association, 2020). The OTPF-4 divides occupations into nine core categories: activities of daily living (ADLs), instrumental activities of daily living (IADLs), health management, rest and sleep, education, work, play, leisure, and social participation (American Occupational Therapy Association, 2020). Following this, these categories are divided into more specific occupational activities such as ADLs, which includes hygiene and eating occupations (American Occupational Therapy Association, 2020).

The category termed ADLs refers to occupations such as washing, bathing, feeding, and eating, whereas IADLs include meal preparation, shopping, and home management (American Occupational Therapy Association, 2020). These occupations are necessary and often need to be performed daily (American Occupational Therapy Association, 2020).

Health management involves occupations related to developing and maintaining health and wellness, including self-management such as exercise, nutrition management or meditation (American Occupational Therapy Association, 2020). Health management also includes the ability to identify or practice coping strategies to manage a condition or symptoms such as those related to trauma, pain, emotions, or behaviours (American Occupational Therapy Association, 2020).

Rest and sleep includes activities related to restoration during the day, routines performed in preparation to sleep as well as being able to sustain a sleep state to meet one's needs (American Occupational Therapy Association, 2020; Solet, 2013).

Education includes occupations such as academic, extramural, vocational, or other training activities (American Occupational Therapy Association, 2020; Swinth, 2013), while work, remunerative or volunteer based involves identifying pursuits, seeking employment, work performance and maintenance (American Occupational Therapy Association, 2020).

Play is a complex occupational area frequently referenced in literature (Knox, 2010; Parham, 2008; Primeau, 2013). Play is intrinsically motivated with an emphasis on the process rather than the end goal (Parham, 2008; Primeau, 2013). Play can include various types of play, such as exploratory play, practice play, pretend play, competitive play, constructive play, and symbolic play (American Occupational Therapy Association, 2020; Primeau, 2013). Play also includes an organisational component in requiring one to participate while maintaining toys and equipment (American Occupational Therapy Association, 2020). Play evolves into leisure with age, which too is intrinsically motivated and involves identifying interests, planning and participation (American Occupational Therapy Association, 2020; Primeau, 2013).

Social participation is another crucial occupational area that contributes to a sense of belonging and feeling connected (Hammel, 2017). Its significant contributions to health and wellbeing have been highlighted by the recent Covid-19 pandemic (Abel & McQueen, 2020; Vieira, et al., 2020; Zhao, et al., 2020). The view of humans is as social beings, and social participation as an occupation involving social interaction with others such as family, friends, peers, partners, or within the community (American Occupational Therapy Association, 2020; Hammel, 2017).

A core aspect of occupational therapy practice is to enable and support individuals or groups to engage in the above occupational areas actively to foster wellbeing (World Federation of Occupational Therapists, 2021).

### 2.2.2 Occupational engagement

The World Federation of Occupational Therapy (WFOT) highlights the role of occupational therapy as promoting health and wellness through occupation with a

primary goal of enabling people to participate in occupation (World Federation of Occupational Therapists, 2021). Thus, occupational engagement is a core concept for the occupational therapy profession.

The definition of occupational engagement is the performance of varied and meaningful occupations, within a supportive environment, enabled by personal factors and motivation (American Occupational Therapy Association, 2020). Literature recognises occupational engagement as being an important contributor to wellbeing (Hammell, 2004; Wilcock, 2005). In occupational therapy practice, successful engagement in occupations is associated with a sense of identity, agency, meaning, value, and satisfaction (Forsyth, et al., 2013). Thus, engagement in occupation is an important contributor to a life worth living (Hammell, 2004; Wilcock, 2005).

If we consider engagement in the categories of occupation in relation to wellbeing, categories concerned with taking care of oneself, such as those concerned with hygiene, eating or restoration, facilitate basic wellbeing needs (Hammell, 2004). Occupations involving social activities that facilitate a sense of belonging are associated with experiencing a sense of self-worth, feeling valued and appreciated (Hammel, 2017). Literature has also explored that doing occupations with others, termed co-occupation, strengthens relationships, enhances wellbeing, and can reduce the impact of stressful experiences (Hammell, 2004; Pickens & Pizur-Barnekow, 2009; Price & Stephenson, 2009). Other occupations related to productivity or leisure promote wellbeing through allowing one to experience pleasure, purpose and feel empowered through contributing to society (Dickie, 2013; Hammell, 2004).

Challenges to engagement in varied, meaningful and health-promoting occupations can result in occupational injustice (Wilcock & Townsend, 2013). Thus, understanding and addressing factors that may lead to engagement challenges is important. It is also important to note the potential negative outcomes related to occupational engagement in that an individual may experience an occupation as damaging to their health, uncomfortable, frustrating, or humiliating (Hammell, 2004; Hocking, 2013; Wilcock, 2005). This may be because of the engagement or the choice of occupation, such as self-harm or substance use (Dickie, 2013; Hocking, 2013).

There has been the suggestion of a transactional perspective on occupation to understand the complex nature of occupational engagement (Fogelberg & Frauwirth,

2010). This transactional lens suggests there is a relationship between the individual or group, occupation, and environment, which facilitates occupational engagement (Aldrich, 2008; Bunting, 2016; Fogelberg & Frauwirth, 2010; Kuo, 2011). This also implies these aspects, individual, environment and occupation, should not be independently considered (Bunting, 2016).

Occupational therapists need to have a thorough understanding of the functions within this transactional model to support optimal engagement in occupations (Bunting, 2016). This involves understanding the individual in terms of their underlying personal factors, functions and skills that affect occupational engagement, such as mental, physical, sensory, body and movement-related functions (American Occupational Therapy Association, 2020), and the occupation or the categories of occupation, as well as the relevant environment (American Occupational Therapy Association, 2020). The environment would also include incoming sensory information such as visual, auditory, and tactile stimuli (Lane, 2020b). To engage in an occupation effectively, an individual would need to register, interpret, and respond to sensory input, which involves sensory integration (Bundy & Lane, 2020).

## 2.3 Sensory integration

### 2.3.1 Introduction to sensory integration theory

Sensory integration has a long-standing history as one of the most distinct and researched frames of reference to originate from the occupational therapy field (Mailloux, et al., 2011). Sensory integration was established by Jean Ayres who devoted her career to understanding the importance of sensory integration (the processing of sensory information from the environment), for development and participation in occupations (Bundy & Lane, 2020; Parham & Cosbey, 2020). Since establishment, sensory integration theory and practice has continuously expanded and continues to develop with leading researchers across the world (Bundy & Lane, 2020). Despite the development of sensory integration theory, there is frequent reference to Ayres' original work in the literature and defines the philosophy of this area of practice (Spitzer & Roley, 2001). There has also been a move to trademark the term Ayres Sensory Integration® (ASI®) to protect Ayres' original theoretical framework so that it can continue to develop in the way that Ayres intended (Smith

Roley, et al., 2007). The intention of the trademark is to distinguish Ayres' work from other sensory-based theories and ensure it adheres to the core principles of Ayres' original work (Smith Roley, et al., 2007).

Ayres defined sensory integration as "the neurological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment" (Ayres, 1972, p. 11). Sensory integration, therefore, refers to the ability to register, modulate and integrate sensory input from internal and external environments (Miller, et al., 2001). This would include sensory information received by sensory systems originating from inside or outside the body, such as interoceptive, proprioceptive, vestibular, visual, tactile, or auditory input; the sensory information is then processed within the central nervous system (Bundy & Lane, 2020).

The central nervous system (CNS) plays a vital role in receiving and organising sensory and motor information (Gilman & Newman, 2003; Reeves, 2001). Regulation within the CNS is critical and provides the foundation for adaptation, behaviour, and emotional responses (Gilman & Newman, 2003; Reeves, 2001). Interactions between multiple neuroanatomical systems are involved in the process of regulation (Reeves, 2001). These systems allow synaptic transmission, habituation, and sensitisation to occur, and support arousal and attention (Gilman & Newman, 2003; Reeves, 2001). This involves continual coordination between neuroanatomical structures including the brainstem (reticular system, hypothalamus), the limbic system as well as the cerebrum (Mtui, et al., 2016). The intensity of the sensory input further plays a role in the coordination between these neuroanatomical structures (Gilman & Newman, 2003; Reeves, 2001).

The sensory integration process provides a means to generate adaptive responses to challenges arising from participation, learning and the external environment enabling occupational engagement (Spitzer & Roley, 2001). Adequate sensory integration, therefore, supports engagement in necessary and meaningful occupations (Bundy & Lane, 2020). While sensory integration difficulties can lead to occupational engagement challenges (Bundy & Lane, 2020).

### 2.3.2 Integrated sensation in occupational engagement and performance

Ayres' definition of sensory integration also corresponds with the transactional nature of occupation, in which the individual, occupation and environment act or interact to facilitate successful occupational engagement (Ayres, 1972; Spitzer & Roley, 2001). Sensory integration difficulties can be a significant barrier to occupational engagement for children and adults (Bundy & Lane, 2020). Figure 2.1 highlights this relationship between sensory difficulties and occupational engagement challenges. Sensory difficulties are divided into two categories: difficulties with modulation, which can be further divided into overresponsivity or underresponsivity, and difficulties with perception, which includes discrimination difficulties (Bundy & Lane, 2020).

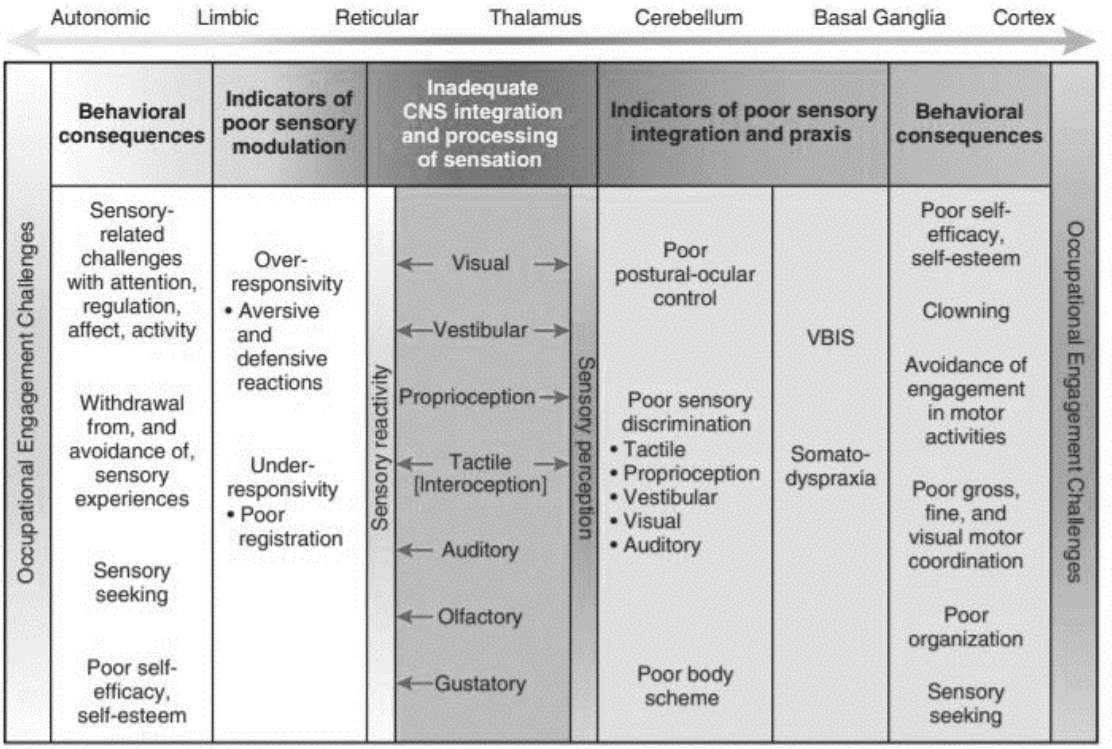



***Figure 2.1 Complex schematic representation of sensory integrative dysfunction (Bundy & Lane, 2020).***

Individuals who have difficulty with adequately receiving or interpreting sensations may restrict their engagement in occupations, which can contribute to occupational injustice (Bundy & Lane, 2020; Wilcock & Townsend, 2013). The goal of sensory integration practice is therefore to assist individuals, with a focus on their sensory

functions and environment, to engage in purposeful and valued occupations (Bundy & Lane, 2020).

### 2.3.3 Sensory integration and daily occupations

Social participation, self-care, leisure, play, and sleep occupational areas have been a focus in the literature when considering the impact of sensory functions on occupational engagement and participation (Bellefeuille, et al., 2013; Cosbey, et al., 2010; Engel-Yeger & Shochat, 2012; Lombard, 2011; Watts, et al., 2014). Participation in occupations is complex and sensory integration is only one factor that can influence successful engagement, but current literature suggests that sensory functions can have a significant impact on occupational areas (Bundy & Lane, 2020; Lombard, 2011; Mahler, 2017; Parham & Cosbey, 2020).

Most of the literature related to sensory integration has focused on well-known sensory systems including tactile, visual, auditory, proprioceptive, and vestibular functions (Bundy & Lane, 2020; Lane, 2020b; Lombard, 2011). Recent research across disciplines has considered an additional sensation, that received by the interoceptive system (Craig, 2003; Critchley & Garfinkel, 2017; Garfinkel & Critchley, 2013; Khalsa, et al., 2018; Mahler, 2017). To date, sensory integration research and application has primarily focused on paediatric populations, with a recent shift into considering sensory integration in adults (Anderson & Rieke, 2009; Engel-Yeger & Dunn, 2011; Engel-Yeger & Shochat, 2012; Lombard, 2011).

While neuroscience supports the importance of interaction and integration of sensory information from various systems (Reeves, 2001). It is valuable to consider the sensory modalities independently to fully understand the complexity of each system (Lane, 2020b). This literature review will focus on examining the emergent interoceptive system. In sensory integration theory and practice, research concerned with interoception has not been a focus, but there is developing interest in this area in recent years (Lane, 2020b). Also of note, the most recent OTPF-4 includes a change to the sensory functions category to include the addition of interoception (American Occupational Therapy Association, 2020).

## 2.4 Interoception

### 2.4.1 Introduction to interoception

Interoception involves sensing and integration related to the internal state of the body (Mahler, 2017). This allows us to perceive and respond to internal sensations such as muscle tension, pain, hunger, satiety and thirst, heart rate and visceral sensations (Craig, 2002). Interoception involves awareness of general and localised sensations, such as temperature, shivering, itch, or changes in muscles i.e., relaxation and contraction (Craig, 2002; Fuchs & Koch, 2014). The degree to which one is able to notice or effectively interpret these internal sensations, as well as the ability to respond adequately to regulate body or emotional needs is termed interoceptive awareness (IA) (Mahler, 2017).

The neurophysiological concept of interoception has been relatively unstudied until recent years. Sherrington first documented interoception in 1906, and used the term to describe information from the internal organs of the body (Ceunen, et al., 2016). Craig (2002) has shown an interest in interoception and has focused on tracking and tracing the sensory components of the autonomic nervous system (ANS) (Craig, 2002). Craig (2002) more recently expanded the interoceptive definition to include all sensory input relayed to the CNS related to how the body feels (Craig, 2002). This includes sensory information related to sensing the internal and external body (Craig, 2002). This broadening of the term was due to advances in functional neuroscience, which identified that receptors within the viscera, as well as the skin and fascia, are involved in interoception (Craig, 2002).

### 2.4.2 Neuroanatomy of interoception

Receptors for interoceptive input are found in internal organs, blood vessels, skin and fascia and include mechanoreceptors (i.e., muscle spindles, Golgi tendon organs, Pacinian corpuscles, Ruffini's Endings), nociceptors, chemoreceptors, and thermoreceptors (Craig, 2002; Lane, 2020b). Lane (2020) defines two rationales for the inclusion of skin receptors as interoceptors: skin receptors provide the CNS with information about the state of the body and consideration of how the receptors are activated, and how the information travels (Lane, 2020b). Internal mechanisms as well as external or mechanical input can stimulate sensations such as pain and

temperature (Lane, 2020b). In addition, the continuous activation of these sensations is to provide a constant flow of information related to the condition of the body (Lane, 2020b). Interoceptive stimuli received by these receptors, including pain, temperature, itch, as well as chemical and hormonal signals, are projected to the spinal cord over relatively small fibres (Lane, 2020b).

Research investigating the relationship between interoception and other senses is limited (Lane, 2020b). One consideration is that the neuroanatomical structures and pathways for interoception and other systems overlap, indicating a direct relationship (Frick, 2021). Mechanoreceptors travel in the dorsal column-medial lemniscal pathway discrimination and lateral spinothalamic pathways indicative of a relationship between pain, pleasure, proprioception and interoception (Frick, 2021).

Projections related to interoceptive input enter the spinal cord at lamina 1 (Craig, 2002; Lane, 2020b). In lamina 1 there are modality-specific cells that respond to changes in blood chemistry, i.e., oxygen or glucose levels, hormone levels and by-products from muscle activation (Craig, 2002; Lane, 2020b). Fibres project from lamina 1 to autonomic cell columns and homeostatic centres in the brainstem (Craig, 2002; Lane, 2020b). In the brainstem, tactile information from the body and sensory information from the internal organs and tissues (e.g., heart, lungs) meet and project to the solitary nucleus of the medulla (Craig, 2002; Lane, 2020b). The combination of interoceptive input from the body and internal organs forms the afferent aspect of the ANS (Craig, 2002; Lane, 2020b). This input allows for the mapping of internal awareness of self and supports the integration of sensation related to the functions of the ANS and homeostasis (Lane, 2020b).

These integrated sensations, following connections in the brainstem, then project to the hypothalamus, amygdala, and thalamus (Lane, 2020b). The hypothalamus is important for autonomic regulation, and stimulation of this area leads to hormonal, visceral and somatic motor responses to maintain homeostasis (Lane, 2020b). Hypothalamic hormones are involved in changes related to temperature, satiety, thirst, sleep, stress, mood, and sexual arousal (Lane, 2020b). The amygdala plays a role in the regulation of autonomic and emotional regulation or responses to environmental threats (Lane, 2020b).

Interoceptive information then projects to the insular cortex where research has identified sensory maps of the body (Craig, 2002; Lane, 2020b). This area of the cortex is associated with the actual and perceived stimulus of intensity and monitoring of the body's physiological state (Craig, 2002). The insula is also involved in attaching emotional context or significance to the physiological experience (i.e., muscle tension associated with stress) and plays a role in awareness of the environment, self, and others (Craig, 2002). These functions are therefore essential for homeostasis, interactions with the environment and understanding emotions. Furthermore, interoceptive information projects to the anterior cingulate cortex (limbic motor cortex), which guides action in homeostasis and provides a "felt sense of me" (Frick, 2021; Lane, 2020b).

The research showed there was a direct link between IA to the activity and structure of the insula cortex (Critchley, et al., 2004). Critchley et al. (2004) studied perceived heart rate and found increased insula activity correlated with increased accuracy of heart rate detection; indicative of improved IA. Of note was that the increased volume of grey matter in the insula cortex had a link to improved IA (Critchley, et al., 2004).

### 2.4.3 Homeostasis

To understand interoception, it is important to recognise the importance of homeostasis. Homeostasis refers to the maintenance of an optimal and relatively stable internal environment within the body (Sherwood, 2012). Homeostasis is essential for survival, and an ongoing process involving all body systems, such as the endocrine system, nervous system, and respiratory system (Sherwood, 2012). The reproductive system is the only system that does not rely on homeostasis for the survival of the individual, but it would have an impact on the preservation of the species (Sherwood, 2012). The homeostatic process involves the ability to detect deviations from the optimal range needed for body function, integration of this information with other relevant information and, in response, making appropriate adjustments to restore the optimal balance (Sherwood, 2012). These adjustments therefore may involve unconscious adjustments, such as chemical or hormonal processes within the body, or may rely on interoceptive signals to cue conscious purposeful actions (Mahler, 2017). Mahler (2017) outlines the role of interoception in supporting homeostasis: (1) feel a sensation, e.g. increased heart rate, tight muscles, (2) body state or emotion,

e.g. nervousness, (3) urge to act, (4) action, e.g. deep breathing or stretching, which then results in an (5) outcome, e.g. reduced uncomfortable feelings, e.g. reduced heart rate and less muscle tightness (Mahler, 2017).

### 2.4.4 Difficulties in interoceptive awareness

Mahler (2017) divides challenges related to IA into three categories based on modulation and discrimination difficulties (Mahler, 2017). Interoceptive overresponsivity refers to increased sensitivity to internal physiology resulting in an individual feeling internal body states quicker or more intensely (Mahler, 2017). In turn, interoceptive underresponsivity refers to reduced sensitivity resulting in less awareness of internal bodily sensations or not acknowledging a stimulus unless it is intense (Mahler, 2017). Mahler (2021) describes IA using a sliding scale with differing responsivity, underresponsivity (too small) and overresponsivity (too big) at either end (Mahler, 2021).

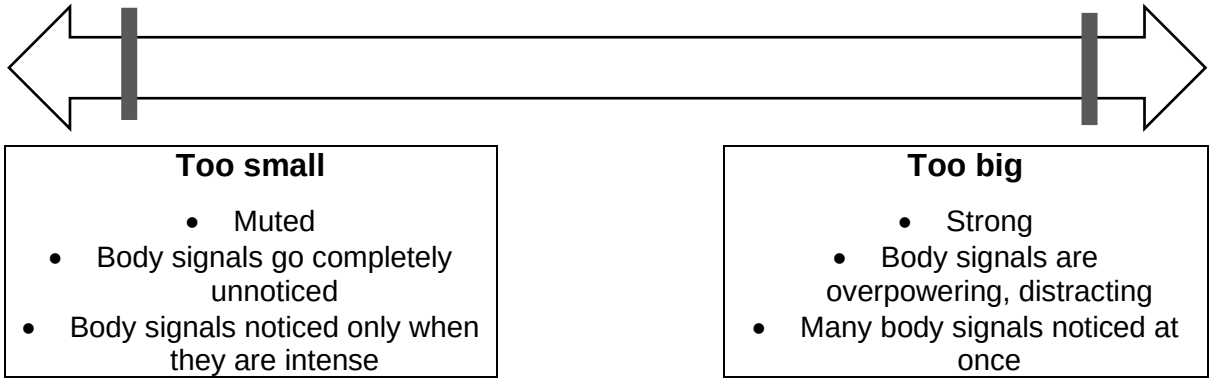



***Figure 2.2 IA: A Sliding Scale; adapted from course notes (Mahler, 2021)***

The final category, interoceptive discrimination difficulty, describes individuals who are unable to identify internal sensations, which impacts on the ability to pinpoint a sensation or understand the experience of the sensation such as not being able to discriminate between signals related to hunger or bladder discomfort (Mahler, 2017). This poor IA would also transfer into more complex skills, such as being able to detect a basic emotion but not being able to identify the intensity, or recognising a general feeling of excitement but not being able to identify other emotions intertwined with excitement, such as anxiety (Mahler, 2017).

### 2.4.5 Interoception and emotional regulation

Interoceptive awareness is essential to our emotional experience and contributes to the ability to observe, experience, and regulate emotions (Mahler, 2017). Research related to interoception has indicated that emotions and interoception are connected and not separable (Craig, 2003). The experience of emotions can be through localised or general sensations and each emotion relates to different sensations of varying intensities (Fuchs & Koch, 2014). The ability to discriminate between different body sensations allows one to experience different emotions (Fustos, et al., 2012). The interoceptive system, which allows one to feel subtle differences in sensations, thus contributes to the ability to understand our emotional experience (Fuchs & Koch, 2014). Adaptive IA has been linked to improved awareness and understanding of emotions (Critchley, et al., 2004; Fustos, et al., 2012; Herbert & Pollatos, 2012) .

While IA plays a key role in emotional experience, it is also essential for emotional regulation (Mahler, 2017). Adequate IA has been associated with improved affective regulation (Critchley & Garfinkel, 2017). Emotional regulation refers to internal and external processes, which allow an individual to monitor, evaluate and adjust emotional responses to function optimally (Thompson, 1994). Emotional regulation is a survival mechanism and the skills required for emotional regulation change and develop across the lifespan (Thompson, 1994). Co-regulation plays an important role in infancy, with caregivers serving as important external regulators (Thompson, 1994; Evans & Porter, 2009; Pauen, 2016). This co-regulation then develops into the ability to self-regulate emotions and behaviours (Mahler, 2017). The literature highlights the importance of adequate emotional regulation for successful occupational engagement (Mahler, 2017).

### 2.4.6 Self-regulation

The actions or behaviours associated with the maintenance of homeostasis are a means of self-regulation (Mahler, 2017). Self-regulation refers to “the ability to control the way we feel and act” (Mahler, 2017, p. 13). Self-regulation plays an important role in supporting occupational function, and known to contribute to factors such as attention, emotional regulation, the ability to handle change as well as health promoting behaviours, such as responding to satiety signals (Mahler, 2017). IA, which is involved in homeostasis, thus supports the ability to self-regulate and is critical for

the development of self-regulation skills (Mahler, 2017). In developing self-regulation skills, infants rely on caregivers to assist with regulation through co-regulation, and this slowly transitions into self-regulation (Mahler, 2017). The facilitation of this process is through more detailed interoceptive signals and the ability to link these sensations to body states or emotions (Mahler, 2017). Thus, without clear refined information related to our internal sense through IA, it is not possible to develop appropriate self-regulation skills (Mahler, 2017).

In occupational therapy research, IA, the ability to accurately detect and give meaning to interoceptive stimuli and develop appropriate self-regulation, appears to play an important role in supporting occupational engagement and performance (Koscinski, 2018; Mahler, 2017).

### 2.4.7 Influence of interoception awareness on function

Difficulties in integration and control of interoceptive signals, originating in the brain or periphery can disturb the whole system (Khalsa, et al., 2018; Mahler, 2017). Thus, interoceptive difficulties are associated with the pathophysiology of mental health conditions and in symptomatic expression of developmental, neurodegenerative, and neurological disorders (Khalsa, et al., 2018). Literature has identified a strong relationship between ASD and poor IA (Koscinski, 2018; Mahler, 2017; Palser, et al., 2018). Other diagnoses associated with interoceptive difficulties include depression (Dunn, et al., 2010; Khalsa, et al., 2018), anxiety (Dunn, et al., 2010; Khalsa, et al., 2018), eating disorders (Martin, et al., 2019; Merwin, et al., 2010; Smith, et al., 2018), schizophrenia (Ardizzi, et al., 2016), and substance use disorders (Jakubczyk, et al., 2020). Clients diagnosed with these mental health conditions may present with interoceptive difficulties, such as over- or underresponsivity, poor regulation of appetite and eating, pain and poor sleep-wake cycles that have a negative impact on their engagement in occupations (Craig, 2002; Mahler, 2017; Tsakiris & Critchley, 2016).

Poor IA, in terms of responsivity, may result in a heightened or reduced response to hunger or thirst cues, body aches or symptoms, or sensitivity to an increase in heart rate or breathing due to physical activity (Elwin, et al., 2012; Mahler, 2017), while difficulties with discrimination may result in feeling sensations less clearly resulting in poor or misidentification of body signals related to hunger or toileting (Mahler, 2017).

Furthermore, the emotional experience of disgust is directly related to the insula cortex, which may be particularly relevant to eating and feeding occupations where an individual with difficulty may experience aversion or disgust towards the food stimuli (Chapman & Anderson, 2012). With regards to sleep, poor IA has been correlated to not adequately identifying or acting on body signals, such as hunger or bladder signals, which support preparation for sleep and thus support sleep participation (Arora, et al., 2021; Wei & Van Someren, 2020).

Interoception, as explored earlier in this review of the literature, is a key component in emotional experiences, responses, and the ability to self-regulate (Critchley & Garfinkel, 2017; Mahler, 2017). Interoceptive overresponsivity may lead to emotions experienced as overwhelming, and difficulty identifying or understanding the emotion (Mahler, 2017). This would influence the ability to act in accordance with this emotion or practice appropriate self-regulation strategies (Glovinsky, 2021; Mahler, 2017). In turn, underresponsivity would also affect the ability to successfully implement self-regulation strategies due to the sensation only being noticed when it is intense, i.e., not being able to detect the build-up ahead of an anger outburst (Glovinsky, 2021; Mahler, 2017).

This emotional component has an influence on social participation, specifically social responses; allowing one to understand their own emotions and to understand others (Mahler, 2017; Uddin & Menon, 2009). This reduced understanding of emotions may result in difficulty controlling emotions or behaviours, such as having an anger outburst while at work or within a social context (Glovinsky, 2021; Mahler, 2017). Poor IA has also been associated with social awareness and responses (Mahler, 2017). This includes components that support engagement in social settings, such as loss of perspective, which affects the ability to understand how others may be feeling (Mahler, 2017). Poor social judgement reduces understanding and awareness of social norms or expectations (Mahler, 2017).

Poor IA also has a major impact on cognition affecting attention and perception, decision-making and memory (Tsakiris & Critchley, 2016). These executive functions are likely to have a direct impact on engagement in all occupational areas (American Occupational Therapy Association, 2020). If we consider decision-making, adequate IA would facilitate the ability to make quick intuitive decisions in response to contextual

cues, whereas poor IA would hinder this ability resulting in increased time and resorting to a logical process to guide decisions (De Martino, et al., 2008). Thus, poor IA in relation to decision-making may make routine decisions difficult, such as deciding what to eat, as well as more challenging decisions reflected in coping with a life stage change or navigating dynamic environments, such as social contexts (De Martino, et al., 2008).

Poor IA may also have an impact on aspects of self, with difficulty understanding emotions and the ability to regulate emotions linked to reduced self-awareness (Koscinski, 2018; Mahler, 2017; Tsakiris & Critchley, 2016). Poor IA has also been associated with reduced self-control and reduced ability to interpret risk due to lessened understanding of the internal environment (Koscinski, 2018; Mahler, 2017).

Inability to respond in accordance with one's internal body state can also have an impact on self-worth and self-esteem (Koscinski, 2018; Mahler, 2017; Tsakiris & Critchley, 2016). If someone is unable to control their emotions in social or work settings, they may choose to avoid engagement in these areas (Koscinski, 2018). Over-eating behaviours related to reduced self-control or due to interoceptive overresponsivity to hunger signals can be due to anxiety or depressive symptoms (Mahler, 2017). In exploring the apparent relationship between poor IA and underlying factors linked to occupational areas, it is evident that it may have a significant impact on occupational engagement.

## 2.5 Conclusion

Interoception is a sensory system that provides information related to the condition of the body. This information, related to the internal state of the body, assists in knowing how the body is feeling and therefore can drive action to meet body or emotional needs.

Interoception is a developing interest within the occupational therapy field due to the impact on occupational performance and participation. Poor IA appears to relate to occupational dysfunction, hindering an individual's ability to engage in occupations successfully (Koscinski, 2018; Mahler, 2017). This review highlighted the need to understand the concept of interoception and its impact on occupational engagement fully to inform occupational therapy practice; facilitation of this would be through

exploration of the nature and extent of available research concerned with interoception relevant to the occupational therapy field.

# CHAPTER 3 METHODOLOGY

## 3.1 Introduction

The aim of this study was to determine the influence of interoception on engagement in occupation and categories of occupation. This chapter describes the scoping review process and includes the research design, search strategy, extraction of results, data analysis and ethical considerations.

## 3.2 Research design

A scoping review provides a means to clarify complex concepts that could be understudied while guiding future research needs (Levac, et al., 2010). Thus, a scoping review was identified as a suitable study design for the emergent concept of interoception in occupational therapy research and practice.

While scoping reviews can be effective in examining the range and nature of evidence available on a particular topic, the critique is that they do not have consistent and rigorous methodological and reporting quality (Tricco, et al., 2018). To promote a transparent and comprehensive review and reporting process; guidelines for scoping review studies have been published (Peters, et al., 2015; Tricco, et al., 2018). The Joanna Briggs Institute (JBI) published a manual to guide the protocol development, methodology and reporting of scoping reviews (The Joanna Briggs Institute, 2015). This publication was informed by earlier work conducted by Arksey and O'Malley (2010) and Levac and Colleagues (Levac, et al., 2010; The Joanna Briggs Institute, 2015).

In addition, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) was adapted from the original Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement to guide reporting of scoping reviews and provide a checklist and explanation (Tricco, et al., 2018). The checklist, developed by an expert panel, contains 20 essential and two optional reporting items (Tricco, et al., 2018). It is possible to use the JBI manual in conjunction with the PRISMA-ScR to support best practice when conducting and preparing scoping review studies for publication.

The JBI scoping review methodology (The Joanna Briggs Institute, 2015) guided this study, in line with current recommendations. The aim of this study was to determine the influence of interoception on engagement in occupation and categories of occupation. A scoping review methodology was selected as it provided descriptive evidence of the effect that interoception has on occupational engagement.

Following the described guidelines for scoping reviews, there was a preliminary search conducted at the protocol development stage. The search, conducted on PubMed, CINAHL Complete [EBSCO] and Scopus databases, found occupational therapy-related publications concerned with interoception and emotional regulation as well as interoception and ASD. A search for existing scoping reviews on the topic of interoception and occupations yielded no results (The Joanna Briggs Institute, 2015). This confirmed the need to conduct such a study.

### 3.2.1 Inclusion and exclusion criteria

The researcher selected the inclusion and exclusion criteria in line with the research aim and objectives, as outlined in Table 3.1.

#### 3.2.1.1 Participants:

All studies from 1900 (the year in which the term “interoception” was coined) until 2021 were included. Open-source scientific articles, as well as those available through the University of the Witwatersrand library subscriptions, were included. Published and unpublished literature, including primary research studies, systematic reviews, and meta-analyses, were included. Excluded were non-scientific sources, such as opinion papers, blogs and narratives, due to the scientific nature of the research question. Studies in English, including those translated, were included, with the exclusion of non-English language studies. Also excluded were studies in which the full text was not available through the University of the Witwatersrand’s library.

#### 3.2.1.2 Concept:

All studies related to the concept of interoception, interoceptive awareness and occupation were included and those that did not focus directly on these concepts were excluded. Excluded were studies focusing on specific diagnoses, unless they specifically included affected occupational areas, and those concerned with underlying

factors likely to influence engagement in occupations, such as attention, self-esteem or endurance.

#### 3.2.1.3 Context:

The context of the scoping review was broad and included studies conducted in all geographical locations and settings. The aim of the study was to understand evidence related to interoception in relation to occupations as a whole and therefore all contexts were deemed relevant to include.

#### 3.2.1.4 Population:

All studies that met the inclusion criteria, related to interoception, engagement in occupations and occupational therapy were included. Studies concerning all age groups, fields of practice and contexts were included.

The inclusion and exclusion criteria were applied to the title, abstract, and full text during the screening of search results. Excluded from the data extraction process were publications that failed to meet the relevant criteria.

***Table 3.1 Inclusion and exclusion criteria***

| Inclusion Criteria | Exclusion Criteria |
|---|---|
| · Published from 1900 to 2021<br>· Open-source scientific articles as well as those available from the University of the Witwatersrand library subscriptions.<br>· Published and unpublished (grey) literature including primary research studies, systematic reviews, and meta-analyses<br>· English language studies: including publications that have been translated<br>· Studies conducted in all geographical locations<br>· Studies concerning all age groups and fields of occupational therapy practice | · Published before 1900<br>· Non-scientific sources, such as opinion papers, blogs, and narratives<br>· Studies that do not focus directly on interoception and occupation or an area of occupation<br>· Studies that focus on specific diagnoses or underlying factors that may influence occupational engagement e.g., attention, self-esteem or endurance will be excluded<br>· Non-English language studies<br>· Studies for which the full text cannot be sourced through the University's library |

| | |
|---|---|
| · All literature related to the concept of interoception and occupation<br>Studies that use a term related to interoception and a category of occupation or related term in the title or abstract will be included. Categories of occupation include, but are not limited to, those described in the occupational therapy practice framework such as social participation, play, work, or rest and sleep [1] | · |

## 3.3 Search strategy

The use of a three-step search strategy, as recommended by the JBI guideline, was to ensure a comprehensive search (The Joanna Briggs Institute, 2015). The researcher consulted with an experienced librarian at the University of the Witwatersrand to inform protocol development as well as during the study to review the search strategy. The search strategy aimed to be comprehensive to identify all potential sources of information, published and unpublished literature. The researcher searched for all sources of evidence simultaneously, which should have resulted in greater sensitivity (The Joanna Briggs Institute, 2015).

Step (1): This included a limited search of four identified databases, PubMed, CINAHL Complete [EBSCO], OT Seeker and Scopus (The Joanna Briggs Institute, 2015). This initial search used key concepts extracted from the research title, research question, aims and objectives. Terms used in the initial search included “interoception,” AND/OR “interoceptive,” AND/OR “interoceptive awareness,” AND/OR “occupational therapy,” AND/OR “occupational therapist,” AND/OR “occupation,” AND/OR “occupational engagement,” AND/OR “engagement,” AND/OR “occupational dysfunction.” Search techniques, including Boolean Operators[1] and Truncation,[2] were used during the initial

[1] Boolean Operators are words used during a search to combine or exclude keywords such as “AND” or “OR”. This increases or reduces the returned results leading to a more focused or comprehensive search (Thompson Rivers University Library , 2019; Northcentral University Library, 2021).

[2] Truncation is the use of a specified symbol during a search to find alternative spellings or endings to words (Thompson Rivers University Library , 2019; Northcentral University Library, 2021).

and later searches to increase the complexity and comprehensiveness of the search results (Thompson Rivers University Library , 2019; Northcentral University Library, 2021).

Step (2): Following the initial search, there was an expansive list of search terms compiled. The researcher examined text words present in the title and abstract of the retrieved studies (The Joanna Briggs Institute, 2015). This included reviewing the index terms used to label the articles (The Joanna Briggs Institute, 2015). The researcher also considered synonyms, antonyms, homonyms, alternative spellings, different terminology, abbreviations, and different word endings.

The identified text words and index terms were linked with key concepts as presented in Table 3.2: concept 1 related to interoception, concept 2 related to occupational engagement and concept 3 related to occupation and the categories of occupation.

***Table 3.2 Keywords and search terms used in the search strategy***

| **Terms connected by "OR"** | | **Terms connected by "OR"** | | **Terms connected by "OR"** |
|---|---|---|---|---|
| interoception<br>interoceptive<br>"interoceptive awareness" | "AND" | "occupational engagement"<br>engage*<br>function*<br>participat*<br>dysfunction<br>disability | "AND" | occupation*<br>"occupational areas"<br>"occupational therapy"<br>"occupational therapist"<br>ADL<br>hygiene<br>self-care<br>eating<br>feeding<br>toileting<br>education<br>vocation*<br>work<br>leisure<br>restorative<br>play<br>social<br>sexual activity<br>sleep |

* End-truncation applied to these terms.

As the search progressed, and the researcher became more familiar with the evidence base related to interoception and occupational engagement, additional keywords, terms and sources were included in the search strategy (The Joanna Briggs Institute, 2015).

Once there was identification of search terms, a second search took place across all included research databases (The Joanna Briggs Institute, 2015). There were filters applied for English language and humans where possible. Databases included in the second search were PubMed, EBSCOHost Academic Search Ultimate, EBSCOHost CINAHL Complete, EBSCOHost MEDLINE Complete, EBSCOHost ERIC (Education Research Information Center), Scopus, ProQuest Health and Medical Complete, ProQuest Nursing and Allied Health Source, ProQuest Psychology Database, Psychiatry Online, Cochrane Library and OT Seeker. There was an extension of the search to grey literature resources, which included Grey Matters, Opengrey, Mednar, Google Scholar and Microsoft Academic. Appendix B outlines the search strategies for each database.

The researcher reviewed and recorded the search results. This was beneficial in allowing the researcher to become more familiar with the literature and terminology resulting in refinement of the search process. The researcher's supervisor assisted with the review process, in line with the JBI protocol, to reduce reviewer bias. This input was divided in that the researcher completed 80 percent of the review process and the researcher's supervisor completed 20 percent. The researcher made use of a reference manager, Mendeley, and a Microsoft Excel spreadsheet, during the data screening process, to ensure accurate documentation and maintenance of records. The citation data for all the records retrieved was exported into Mendeley reference manager, and the citations formatted and transferred into a Microsoft Excel spreadsheet, which assisted in managing the number of records as well as with the removal of duplicates. Following the removal of duplicates, the title and abstract of the retrieved records underwent screening to identify relevant articles. Relevance determination was according to the inclusion criteria for the study. The full text of relevant articles was retrieved and assessed for eligibility, further studies excluded with reasons, and articles identified as eligible included in the scoping review.

Step (3): The researcher then searched the reference list of all included publications to identify additional studies (The Joanna Briggs Institute, 2015). The researcher followed the same process by reviewing the full text of articles to decide on inclusion.

## 3.4 Study selection and inclusion

The records identified through database searching totalled n=1705. Additional records (n=4) were identified through other sources, including reference list searching. Duplicate records were removed (n=1051), which resulted in records 658 (n=658) for screening. Further screening of titles and abstracts resulted in 609 exclusions (n=609) based on inclusion criteria. Full-text review of n=49 papers for eligibility resulted in a final n=13 papers suitable for inclusion in this scoping review. Appendix D lists the full-text articles excluded with reasons. The study selection and inclusion process are presented in the PRISMA flow diagram (Figure 3.1) (Moher, et al., 2009).

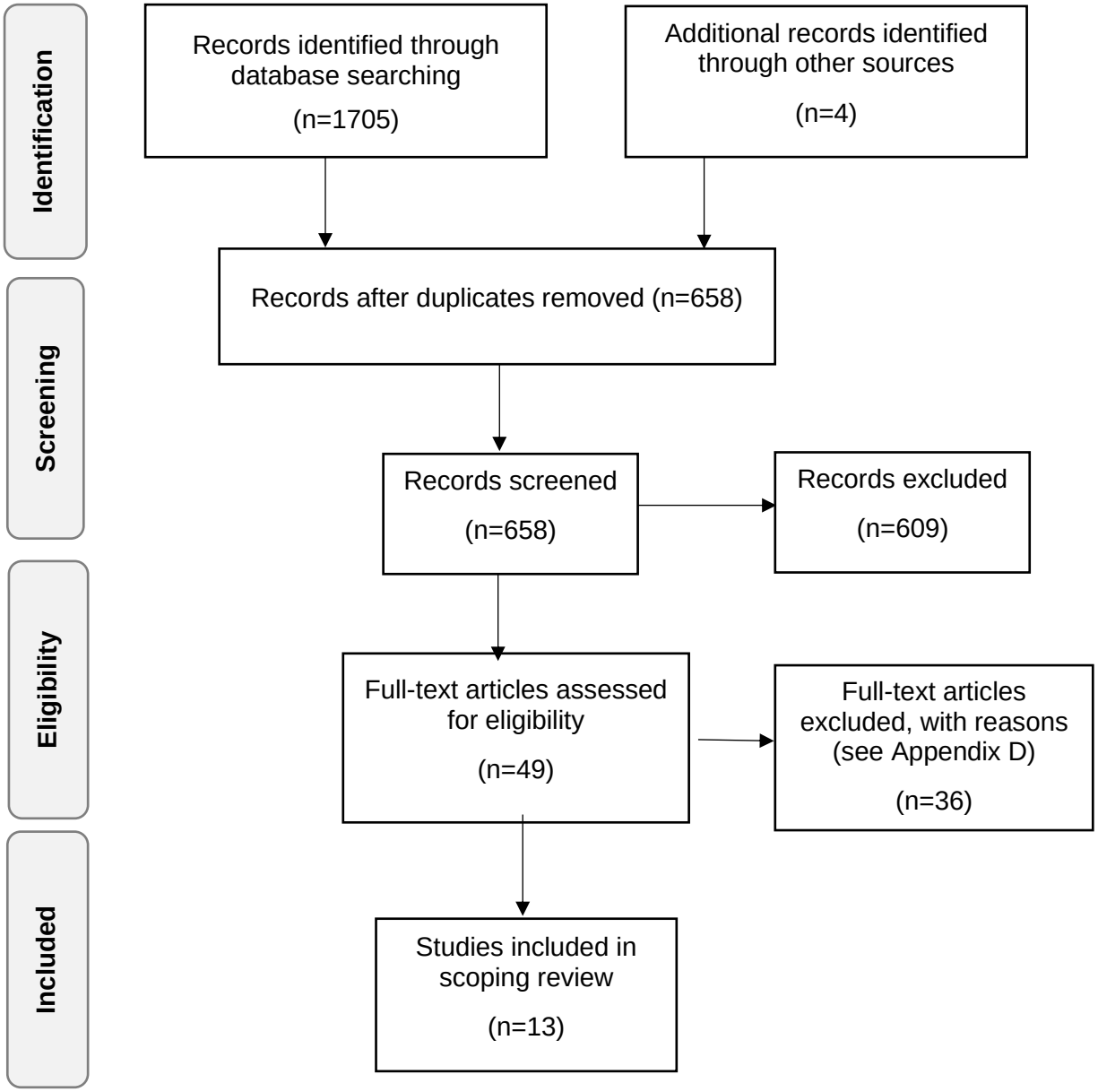



***Figure 3.1 Flow diagram of study selection and inclusion process (Moher, et al., 2009)***

## 3.5 Extraction of results

The data extraction process involved charting the information to provide a clear summary that related to the research question, aim and objectives [26].

A table guided the extraction of key data from each eligible research article. As recommended by JBI guidelines, this extraction table was created during the protocol development phase and updated and refined during the search process to ensure all relevant results were extracted (The Joanna Briggs Institute, 2015). The following information was collected: (1) bibliographical information including author, year of publication, geographical location, study design and methods, (2) study population including age group, sample size (3) area of occupation included in the study, and (4) scope of information on interoception and occupational engagement including terms used, outcomes and key findings of the study.

## 3.6 Ethical considerations

This research was a scoping review and therefore accessed publicly available documents to meet the research objectives. It did not involve human participants or collect sensitive or confidential information. The University of the Witwatersrand Human Research Ethics Committee (Medical) thus granted an ethical waiver - Ethical waiver number: W-CBP-210923-01 (Appendix D).

Furthermore, the use of the PRISMA-ScR checklist and explanation (Appendix F) during the protocol development and reporting phase was to ensure comprehensive and transparent reporting of the review process and results (Tricco, et al., 2018).

## 3.7 Conclusion

This chapter described the JBI methodology and justified the use of a scoping review research design to meet the research aims and objectives. It also outlined modifications to the search strategy and management of the data identified during the search process. This chapter used a PRISMA flow diagram to present the processing of search results subsequent to the selection of records for inclusion.

# CHAPTER 4 RESULTS

## 4.1 Introduction

This chapter provides a detailed analysis of the data extracted from the articles during the search process in relation to the objectives of the study. It describes the characteristics of the included studies, described and represented in a tabular format, the findings of the studies and the synthesis of results.

## 4.2 Characteristics of included studies

A Data Extraction Matrix (Appendix E) presents a summary of all the records included in the review. All 13 records were published between 2013 and 2021, with many (n=6, 46%) of the studies published between 2020 and 2021. Study designs included descriptive review studies (n=8), quantitative, experimental and longitudinal (n=2), qualitative (systematic review) (n=1) and mixed methods (n=2) studies.

Most of the studies occurred in Germany (n=4) and the United States of America (n=4); other countries included the United Kingdom (n=1), the Netherlands (n=1), Australia (n=1), Italy (n=1) and United Arab Emirates (n=1). Figure 4.1 presents the origin of included studies.

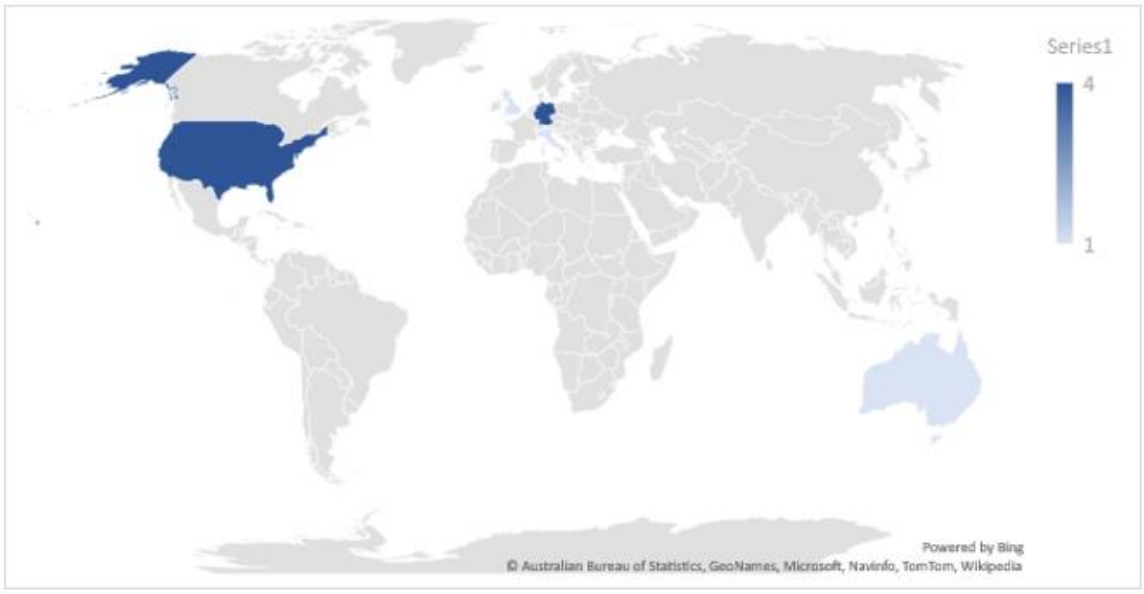



***Figure 4.1 Choropleth world map indicating origins of study***

Many of the studies indicated in Figure 4.2 were from the disciplinary basis of psychology (n=7); other disciplines included occupational therapy (n=3), neuroscience (n=2) and education (n=1). Peer-reviewed studies made up most of the included studies (n=11), with less grey literature studies that met the inclusion criteria (n=2).

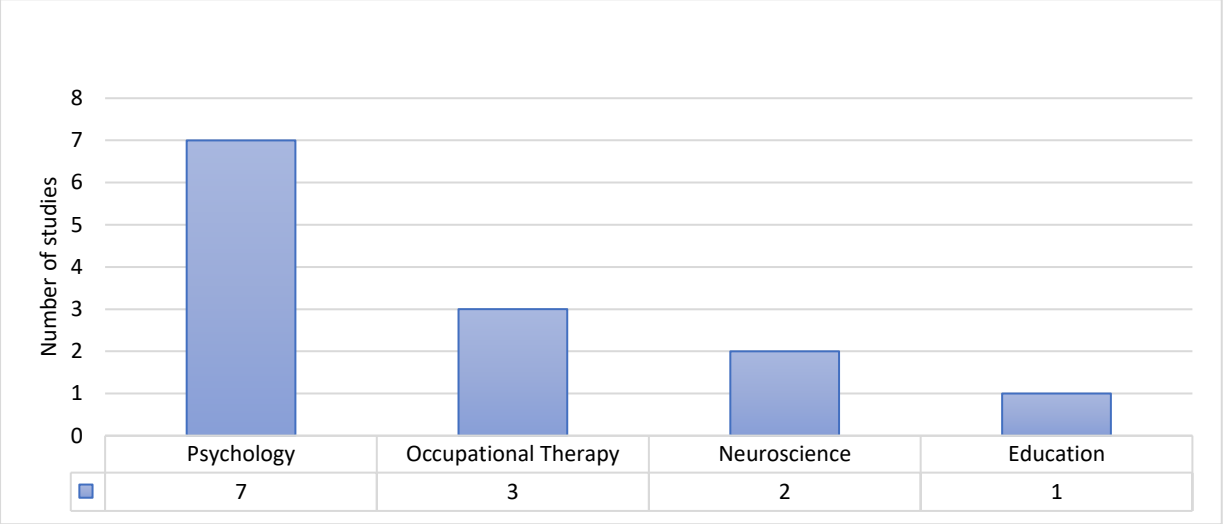



***Figure 4.2 Included studies originating from each discipline***

The terminology related to interoception differed between studies, often with multiple terms used. The majority of the studies used the term “interoception” (n=11) and “interoceptive awareness” (n=8); other less frequently utilised terms included “interoceptive sensitivity” (n=5), “interoceptive deficits” (n=3), “interoceptive” (n=3) and “interoceptive sensibility” (n=2). Figure 4.3 visually presents the number of studies and the term(s).

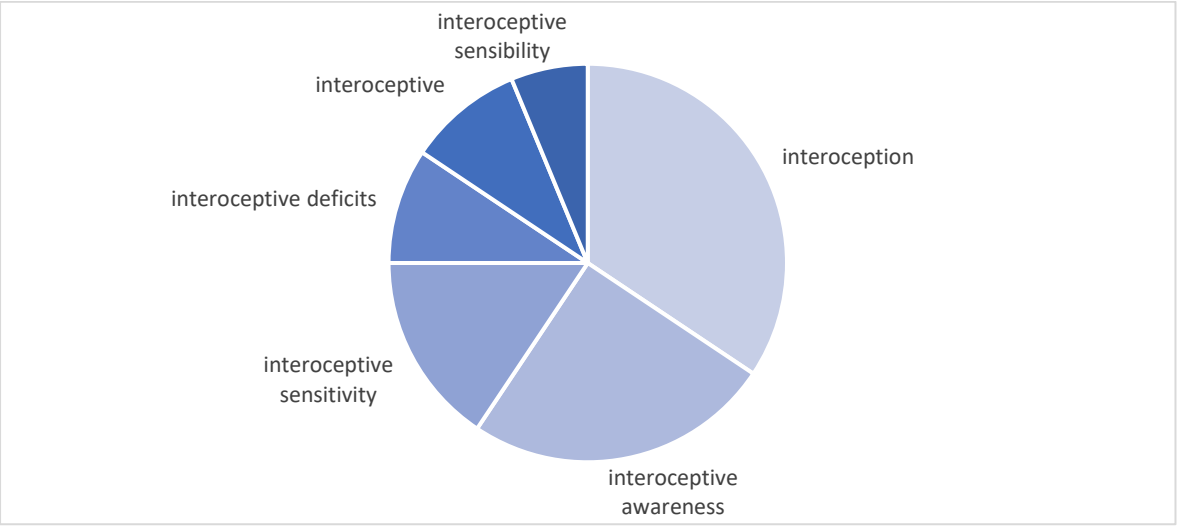



***Figure 4.3 Pie chart indicating use of various interoceptive terms used in studies***

The populations included in the studies varied, with most studies recruiting adult participants (n=4), and other populations including adolescents (n=1), children (n=1) and, both adolescents and children (n=1). It was not possible to specify the population studied in the review type studies (n=6) as they included and reviewed multiple other studies. Of the studies with defined populations (n=7), most studies included male and female participants (n=6), with one study (n=1) including only female participants. Of the studies that included male and female participants, most included a higher percentage of females (n=5), with select studies (n=2) reflecting as many as 90% female participants, and only one study (n=1) including a higher percentage of males. The systematic review study, which included 104 studies, revealed the majority of the studies (74%) recruited woman only.

The purpose of the studies varied, with most of the studies (n=8) aimed at investigating a relationship between a dimension of interoception in relation to an occupational area of category, e.g., sleep quality, eating behaviours, learning and education. The remaining, review studies or book publications, intended to outline and draw conclusions based on current research related to interoception and an occupational area(s) (n=5).

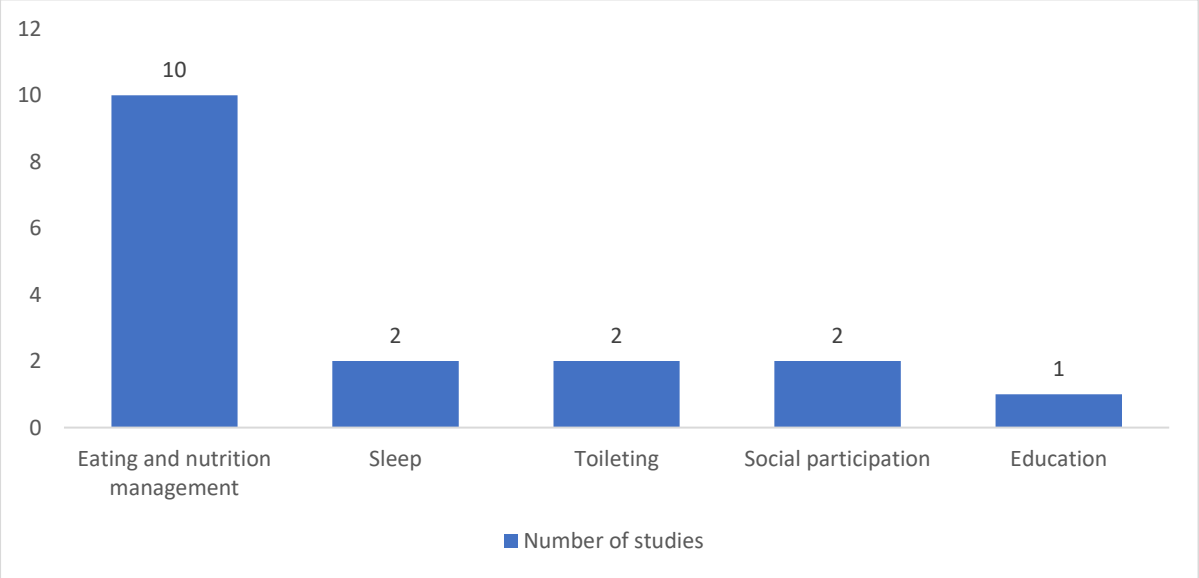



***Figure 4.4 Number of studies including occupational categories***

Of the occupational areas included in the articles, the majority included eating and nutrition management (n=10); other areas included were sleep (n=2), toileting (n=2),

social participation (n=2) and education (n=1). Figure 4.4 visually presents these in a column graph.

In analysing the assessment methods or tools used in applicable studies, most of the studies relied on self-reporting measures (n=5) with no studies making use of the same self-reporting measures; other methods used included heartbeat perception (n=2), heartbeat detection (n=1), behavioural analysis (n=1) and semi-structured interviews (n=1).

In line with the inclusion criteria, studies which only focused on diagnoses were excluded, however ASD and eating disorders were mentioned in some (n=3) of the included studies (Koscinski, 2018; Mahler, 2017; Martin, et al., 2019).

## 4.3 Review findings and synthesis of results

### 4.3.1 Eating and nutrition management

The studies considering eating behaviours and nutrition management (n=10) varied in terms of study design, which made correlation of the results difficult. Of note was that all the included studies found a relationship between poor IA and maladaptive eating behaviours.

***Table 4.1 Comparison of findings for eating and nutrition***

| | **Aim of study** | **Study design, population size** | **Key findings** |
|---|---|---|---|
| **Di Nardo et al. (2020)** | To investigate the relationship between interoceptive deficits and binge eating behaviours | Cross sectional, n=120 | Poor IA is involved in the development and maintenance of maladaptive eating behaviours<br>An association between binge eating symptoms and interoceptive deficits was identified<br>A causal relationship could not be identified due to the study design |
| **Herbert, et al. (2013)** | To clarify the relationships between IS, intuitive eating and body mass index (BMI) | Cross sectional, n=111 | IA and acknowledgement of body signals play a role in adaptive eating behaviours and weight regulation<br>IA and subjective evaluation of body signals significantly predict eating in accordance with physiological cues |

| | | | |
|---|---|---|---|
| **Koch & Pollatos (2014)** | To examine interoceptive sensitivity among overweight and obese participants | Experimental, n=1657 | No direct relation was found between IA and BMI<br>Significantly increased appetite responses in overweight and obese children when compared to normal weight children were found<br>In overweight children, external and emotional eating behaviours were noted as predictive of later interoceptive overresponsivity<br>Poor IA is secondary to maladaptive eating behaviours in overweight children |
| **Simmons et al. (2017)** | To review interoception and relationship to overeating and obesity | Narrative review, N/A | Obesity may be related to overresponsivity to interoceptive cues which undermine attempts to reduce food intake<br>Underresponsivity may have the same consequence affecting the ability to accurately detect satiety signals contributing to overeating behaviours |
| **Glaspey (2021)** | To identify if there is a correlation between IA and weight management success using internal vs. external tools | Mixed methods, n=10 | IA may be a necessary skill for intuitive eating.<br>Poor IA and underresponsivity to interoceptive cues were more likely to use external tools to manage nutrition for weight loss<br>Individuals who relied on external cues were less likely to sustain adapted eating habits and those who were able to rely on internal cues found it easier to sustain changes and experience success in changing eating habits |
| **Herbert (2020)** | To summarise empirical findings related to interoception and eating behaviour | Narrative review, N/A | Significant evidence that adequate IA is positively linked with eating adaptively; balancing food intake with energy needs, which is important for weight regulation<br>One's perception of their interoceptive cues may predict a higher BMI and an increase in emotional eating behaviours<br>Evidence for both underresponsivity and overresponsivity to interoceptive cues related to obesity<br>Poor IA appears important in the diagnosis of disordered eating and eating disorders |
| **Herbert & Pollatos (2014)** | To examine IA among overweight and obese populations | Experimental, n=75 | IA was higher in normal weight participants when compared to overweight or obese participants<br>Overweight, or obese individuals may experience more difficulties identifying body signals due to poor IA |

| | | | |
|---|---|---|---|
| **Martin et al. (2019)** | To examine role of interoception in the development of disordered eating and eating disorders | Systematic review, 104 studies including n=32883 participants | Poor IA is associated with disordered eating behaviours<br>This was seen across eating disorder types and interoceptive modalities (gastric, cardiac and pain)<br>There is limited evidence that interoception has a causal role in disordered eating |
| **Mahler (2017)** | Describe current literature related to interoception and occupational participation | Book (descriptive), N/A | Poor IA may affect hunger or thirst cues resulting in feeling hunger or thirst more frequently or alternatively missing hunger or thirst cues<br>Specific mention of an ASD population who are known to have poor IA |
| **Koscinski (2018)** | Describe current literature related to interoception and occupational participation | Book (descriptive), N/A | IA is likely to influence eating and feeding due to the ability to feel physiological cues<br>Specific mention of an ASD population who are known to have poor IA |

### 4.3.2 Sleep

Studies on sleep and interoception included a subjective review of interoception and quality of sleep as well as a summary of the present knowledge about the interaction of sleep quality and interoception. The studies were descriptive and included a cross-sectional survey completed on 609 adults.

***Table 4.2 Comparison of findings for sleep***

| | **Aim of study** | **Study design, population size** | **Key findings** |
|---|---|---|---|
| **Arora et al. (2021)** | To investigate the relationship between sleep quality and interoception | Cross sectional, n=609 | Identified small but significant relationship between subjective sleep quality and IA<br>Poor sleep quality may reduce interoceptive abilities or by reverse impairments to IA could result in poorer sleep habits, quality, or duration<br>A causal relationship could not be identified<br>Heightened awareness of body signals may be important in understanding relationship between sleep and obesity |

| | | | |
|---|---|---|---|
| **Wei & Van Someren (2020)** | To review current knowledge about interoception and sleep | Review, N/A | Noxious or stressful stimuli are known to increase arousal, having an impact on sleep<br>Certain types of interoceptive stimuli appear to promote sleep e.g., gastrointestinal stimulation and mild skin warming<br>Acute or chronic sleep deprivation results in altered IA |

### 4.3.3 Toileting

Toileting, which includes bowel and bladder management, appeared in two of the included studies. Both studies were descriptive book publications with occupational therapists as authors. The publications were applicable to all populations, focusing on children, with a specific mention of an ASD population found to have difficulties with IA (Koscinski, 2018; Mahler, 2017).

***Table 4.3 Comparison of findings for toileting***

| | **Aim of study** | **Study design, population size** | **Key findings** |
|---|---|---|---|
| **Mahler (2017)** | Describe current literature related to interoception and occupational participation | Book (descriptive), N/A | Interoceptive overresponsivity may cause discomfort and increase awareness of the need to eliminate bowels and bladder<br>Interoceptive underresponsivity may result in not sensing the need to eliminate bowels or bladder |
| **Koscinski (2018)** | Describe current literature related to interoception and occupational participation | Book (descriptive), N/A | Interoceptive difficulties related to responsivity are likely to influence self-care including bowel and bladder management<br>Children may experience the urge to urinate or have a bowel movement as intense or may not feel pressure in the bowels and rectum with differing responsivity levels<br>This may also affect the movement of stools due to reduced feedback<br>Difficulties with interoception and toileting may contribute to constipation or accidents in public settings |

### 4.3.4 Social participation

There was social participation included in two studies; these studies were descriptive book publications with occupational therapists as authors. The publications were

applicable to all populations with a specific mention of the ASD population identified in the research as having poor IA (Koscinski, 2018; Mahler, 2017).

***Table 4.4 Comparison of findings for social participation***

| | **Aim of study** | **Study design, population size** | **Key findings** |
|---|---|---|---|
| **Mahler (2017)** | Describe current literature related to interoception and occupational participation | Book (descriptive), N/A | Poor IA may affect social participation in terms of affecting three components: perspective taking and empathy, social touch, and awareness of self |
| **Koscinski (2018)** | Describe current literature related to interoception and occupational participation | Book (descriptive), N/A | Interoceptive difficulties related to responsivity are likely to influence social function<br>SPD may impact the ability to manage poor interoception impacting on behaviour at work, school and in relationships |

### 4.3.5 Education

There was only one article considering the occupational area of education identified, therefore a comparison was not possible. The findings of the study are summarised in Table 4.5.

***Table 4.5 Findings for education***

| | **Aim of study** | **Study design, population size** | **Key findings** |
|---|---|---|---|
| **Goodall (2021)** | To investigate if IA activities improve self-regulation skills, decrease challenging behaviours, and improve learning and education | Mixed methods: behavioural analysis and semi-structured interviews<br><br>Participants included 12 primary, high, and special schools | IA activities resulted in visible increases in engagement in learning and education These IA activities included feeling body parts and muscles, temperature, awareness of breath and emotions, feeling heart rate and awareness of satiety and thirst Teaching IA was also found to increase self-management and self-regulation in school context<br>All schools included in the study reported reduced behavioural consequences |

## 4.4 Summary: Key findings related to occupational performance areas

### 4.4.1 Eating and nutrition management

- There has been a relationship identified between IA and maladaptive eating behaviours.
- Poor IA has been divided into interoceptive overresponsivity, related to feeling hunger and thirst sensations more frequently and interoceptive underresponsivity, which may result in missing hunger cues.
- IA appears to play a vital role in the ability to eat intuitively through supporting the awareness of physiological cues related to hunger or satiety. Thus, individuals with poor IA are more likely to rely on external cues to manage weight.
- Poor IA has been associated with obesity or an increased risk of developing obesity. This is related to overresponsivity to hunger cues and in turn to underresponsivity to satiety signals.
- Obesity, or maladaptive eating behaviours, results in poor IA.
- Interoception appears to be related to emotional eating behaviours and in eating disorder populations dysfunctional self-regulation strategies related to eating or weight management behaviours.
- Findings highlight limited causal evidence on the relationship between IA and disordered eating.

### 4.4.2 Sleep

- There has been a small significant relationship identified between sleep quality and IA, but studies have not been able to identify a causal relationship.
- Poor sleep quality, acute or chronic sleep deprivation may all be associated with poor IA. While good sleep quality may support IA.
- Interoceptive overresponsivity may be important in understanding the relationship between sleep and obesity, as well as type 2 diabetes.
- Stimuli that target the interoceptive system may hinder or support sleep initiation and maintenance of a sleep state.

### 4.4.3 Toileting

- There has been a relationship between poor IA and bowel and bladder management identified.
- Interoceptive overresponsivity may lead to discomfort and an increased awareness of the need to eliminate bowels or bladder.
- Interoceptive underresponsivity may result in reduced awareness of the need to eliminate bowels or bladder.
- Poor IA in children, and the effects on toileting, can lead to constipation or accidents in public settings which can cause humiliation and contribute to anxiety related to toileting.

### 4.4.4 Social participation

- Poor IA would result in difficulty managing social situations, which are often dynamic and unpredictable.
- Poor IA may be seen in limited empathy or perspective taking, decreased awareness of social norms, difficulty regulating emotions and behaviours.
- IA plays a key role in self-awareness, which provides the foundation for effective social participation.

### 4.4.5 Education

- Activities aimed at improving IA had a positive effect on engagement in education and learning in a school context.
- Improved IA was related to increased engagement in learning.

## 4.5 Conclusion

This chapter presented the data extracted during the search process. The data extracted from the studies was summarised separately and then compared. A Data Extraction Matrix summarised the data and facilitated the comparison of included studies. Descriptive statistics described the year published, origin, study design and population, discipline of the first author, terminology as well as the occupational area considered. From the extracted data, poor IA influences occupational areas specifically eating and nutrition management, sleep, social participation, toileting, and

education. The following discussion chapter highlights the contributions made by each included publication to the research aim and objectives related to interoception and occupational engagement.

# CHAPTER 5 DISCUSSION

## 5.1 Introduction

This chapter will review and discuss the data extracted in the study, and reported in Chapter 4. It will consider the findings in relation to current literature and the extent to which the results answer the research question: What is the relationship between interoception and engagement in occupation? This chapter will discuss the characteristics of the included studies and the results according to the objectives of the study.

## 5.2 Background information

### 5.2.1 Terminology used in the literature

The inconsistent terminology used in the publications, such as “interoception,” “interoceptive awareness (IA),” “interoceptive sensitivity” and “interoceptive sensibility” is a concern as it creates confusion when accessing the evidence base. This was apparent between disciplines as well as within disciplines. Within the occupational therapy publications, Glaspey (2021) used the terms “interoceptive awareness” and “interoceptive sensitivity,” while Mahler (2017) and Koscinski (2018) used the terms “interoception” and “interoceptive awareness.” Mahler and Koscinski did however use incoherent terms when considering the categories of interoceptive difficulties. Mahler refers to “interoceptive overresponsivity” and “interoceptive underresponsivity,” while Koscinski uses the terms “hyper-responsive” and “hypo-responsive” (Koscinski, 2018; Mahler, 2017). The inconsistent terminology used within SI theory has been and is a concern, as well as criticism within SI literature due to its limitation in creating a clear and robust body of knowledge (Smith Roley, et al., 2007).

This study adopted the term “sensory integration” and when referring to sensory modulation, “overresponsivity” or “underresponsivity.” In terms of interoception, the use of the term “interoception” was when considering the sensory system and “interoceptive awareness (IA)” when considering differing modulation or discrimination functions within this system

### 5.2.2 Demographics of literature

The majority of included studies occurred in Germany and the United States of America, with no included studies originating from Africa. This may have resulted in an overrepresentation of these two countries and may have had an impact on the generalisability of findings.

The extent to which IA influences occupational performance was difficult to establish due to the heterogenous nature of the included studies. Studies differed in terms of study design, methodology, sample sizes and purpose, which made correlation of the results difficult. Furthermore, the majority of the selected population samples were not diverse in terms of gender or age, which again makes generalisability of results to a wider population challenging.

## 5.3 Objective 1: To examine the extent to which interoceptive responsivity influences occupational performance.

The findings of the included studies differ in terms of how IA influences engagement and performance in each occupational area, but interoceptive responsivity appears to be a major contributor in supporting or hindering engagement across studies (Di Nardo, et al., 2020; Glaspey, 2021; Herbert, 2020; Herbert, et al., 2013; Herbert & Pollatos, 2014; Mahler, 2017; Martin, et al., 2019; Simmons & DeVille, 2017). Difficulties with interoceptive responsivity, over or under responding to interoceptive signals was found to affect an individual's ability to adequately respond to and in accordance with their internal and external environment (Mahler, 2017). This aligns with sensory integration theory, which describes sensory integration difficulties as a significant barrier to occupational engagement for children and adults (Bundy & Lane, 2020).

### 5.3.1 Interoceptive responsivity in eating

Herbert et al. (2013) found that IA and subjective evaluation of body signals contribute to adaptive or maladaptive eating behaviours. Individuals who experience hunger as an unpleasant emotion may be more likely to act to relieve this discomfort (Herbert, et al., 2013). In turn, overresponsivity to hunger cues may be associated with increased pleasure in responding to hunger cues (Simmons & DeVille, 2017). Additional findings

suggest that subjective perception of interoceptive cues may also predict a higher body mass index (BMI) and an increase in emotional eating behaviours (Herbert, 2020). This corresponds with the literature, which indicates interoception plays a role in emotional regulation and associated behaviours (Critchley & Garfinkel, 2017; Herbert, 2020; Mahler, 2017).

Improved IA is associated with improved emotional awareness, which supports the ability to regulate emotions (Mahler, 2017). Adequate emotional regulation would thus support adaptive eating behaviours in facilitating the ability to eat in response to hunger rather than in response to external or emotional signals (Herbert, et al., 2013). Diagnostic symptoms of eating disorders (e.g., purging, binging, excessive exercise) may be understood as dysfunctional self-regulation strategies (Herbert, 2020). These strategies or eating behaviours may not correlate with body signals but are an attempt to avoid or relieve stressful emotions or affective states (Herbert, et al., 2013).

#### 5.3.1.1 Awareness of physiological signals related to eating and nutrition management

Adequate IA supports the acknowledgement of physiological signals, such as hunger or satiety cues, which support adaptive eating behaviours and weight regulation (Herbert, et al., 2013). This is related to interoceptive responsivity; underresponsivity or overresponsivity, which influences an individual's awareness of interoceptive cues such as hunger or satiety cues (Koscinski, 2018; Mahler, 2017).

Interoceptive underresponsivity would affect engagement in eating behaviours in that the individual may not be able to notice hunger, thirst or satiety cues resulting in them not adequately responding to signals, missing meals, delaying eating or undereating (Glaspey, 2021; Koscinski, 2018; Mahler, 2017). It may also contribute to reduced awareness of satiety cues where an individual may continue to eat despite being full resulting in overeating behaviours (Koscinski, 2018; Mahler, 2017). Glaspey (2021) also found that underresponsivity to hunger or satiety may have an impact on the ability to eat intuitively or adaptively. This resulted in individuals relying on external cues, such as reminders or scheduling to meet their nutritional needs or attempts to lose weight (Glaspey, 2021). In contrast, interoceptive overresponsivity would result in heightened awareness of hunger or thirst cues resulting in frequent eating or eating excess food to match this signal (Koscinski, 2018; Mahler, 2017).

#### 5.3.1.2 Interoceptive responsivity and obesity

Findings suggest evidence for both underresponsivity and overresponsivity to interoceptive signals as contributors to obesity (Herbert, 2020; Simmons & DeVille, 2017). Underresponsivity to interoceptive signals related to satiety and fullness have a link to obesity (Herbert, 2020; Herbert & Pollatos, 2014), while overresponsivity to interoceptive signals related to hunger or related bodily cues (insulin changes, body weakness) may increase food seeking and eating behaviours (Herbert, 2020).

Koch and Pollatos (2014) looked at eating behaviour in children and found significantly increased responses to hunger cues in overweight and obese children. Their findings supported the idea that those who are obese or at risk of developing obesity show heightened responses to external cues, ignoring interoceptive cues related to hunger or satiety (Koch A, 2014). These external and emotional eating behaviours were predictive of later interoceptive overresponsivity (Koch A, 2014). Herbert and Pollatos (2014) too identified poor IA in overweight and obese participants when compared to normal weight participants. These findings again highlighted the relevance of sensory integration theory, specifically related to sensory modulation in addressing behaviours that may present as maladaptive eating behaviours (Bundy & Lane, 2020).

Simmons et al.'s (2017) findings suggest that obesity may relate to overresponsivity to interoceptive cues, such as hunger, which undermine attempts to reduce food intake. Alternatively, underresponsivity to interoceptive signals may have the same consequence, affecting the ability to accurately detect signals related to satiety contributing to overeating behaviours (Simmons & DeVille, 2017). Interoceptive overresponsivity or underresponsivity may therefore undermine attempts to reduce unhealthy eating and there is evidence to support both relationships (Simmons & DeVille, 2017). Responsivity to interoceptive cues thus influences eating and feeding behaviours through the awareness and response to hunger and satiety cues (Herbert, et al., 2013).

### 5.3.2 Interoceptive responsivity in sleep

Findings from the studies related to sleep found that IA is related to sleep participation (Arora, et al., 2021; Wei & Van Someren, 2020). Arora et al. (2021) found a small but significant relationship between sleep quality and IA, although the study design meant there was no causal relationship identified. Their results suggest that poor sleep

quality may be associated with poor IA (Arora, et al., 2021); Wei and Van Someren (2020) also found that poor sleep quality may affect IA.

Arora et al. (2021) found that poor IA affecting the ability to recognise and adequately respond to interoceptive signals, such as hunger or bladder cues, was more likely to reduce sleep participation; this was specifically noted in terms of sleep habits, duration of sleep and quality of sleep (Arora, et al., 2021). These findings suggest that individuals able to recognise and adequately respond to interoceptive signals, such as hunger or bladder management signals, are more likely to have improved sleep habits, duration and quality of sleep (Arora, et al., 2021). Thus, poor IA was associated with poorer sleep quality or duration.

Both studies concerned with sleep found that acute and chronic sleep deprivation led to altered IA (Wei & Van Someren, 2020). Reduced sleep quality may lead to poor IA in terms of overresponsivity to interoceptive cues (Arora, et al., 2021). Wei and Van Someren (2020) also found that acute and chronic sleep deprivation led to altered IA (Wei & Van Someren, 2020). Their results indicated that sleep deprivation resulted in overresponsivity to stimuli specifically pain (Wei & Van Someren, 2020), while good sleep quality was shown to have a positive effect on pain (Wei & Van Someren, 2020). The relationship between sleep and pain may be valuable when considering occupational therapy assessment and intervention in populations who experience acute or chronic pain conditions.

Interoceptive overresponsivity in response to sleep deprivation may also be important in understanding the relationship between sleep and obesity as well as type 2 diabetes (Arora, et al., 2021). Interoceptive signals related to hunger may increase, contributing to maladaptive eating behaviours (Arora, et al., 2021).

### 5.3.3 Interoceptive responsivity in toileting

Interoceptive responsivity affected toileting habits and behaviours (Koscinski, 2018; Mahler, 2017). Poor IA contributed to increased or decreased awareness of the need to urinate or have a bowel movement, thus having an impact on toileting skills (Koscinski, 2018; Mahler, 2017).

Mahler (2017) described that interoceptive overresponsivity may cause discomfort and increase the awareness of the need to eliminate bowels or bladder. Koscinski (2018)

adds that some children may experience the urge to urinate or have a bowel movement as intense; they may describe the feeling of a full bladder or rectum as painful (Koscinski, 2018). Underresponsivity may result in not sensing the need to eliminate bowels or bladder (Mahler, 2017). These children may not detect the need to use the toilet as they may not feel the pressure in the bowels and rectum; this can often lead to discomfort and constipation and also result in urine or bowel related accidents in public settings, which can cause embarrassment and contribute to anxiety related to toileting (Koscinski, 2018).

Furthermore, the interoceptive feelings associated with the elimination of a stool or urine may be uncomfortable and lead to children feeling “empty” or out of control (Koscinski, 2018). Koscinski (2018) describes another possible explanation for toileting difficulties as difficulty with the pushing component when moving stools (Koscinski, 2018). Children with poor IA may have difficulty with this pushing component into a toilet as it provides limited touch or tactile feedback, whereas a pull-up nappy provides more tactile feedback when the stool is eliminated (Koscinski, 2018).

### 5.3.4 Interoceptive responsivity in social participation

Emotional awareness and regulation are factors outlined in the OTPF-4 and addressed within occupational therapy practice due to their influence on occupational engagement (American Occupational Therapy Association, 2020). It is therefore beneficial to consider IA as an underlying factor, which may address emotional regulation difficulties to support improved self-regulation abilities as opposed to a reliance on maladaptive behaviours (Herbert, 2020; Mahler, 2017).

Mahler (2017) found that poor IA related to reduced responsivity to interoceptive signals contributed to reduced performance in social participation. Poor IA has a negative impact on social awareness, which would result in an individual being unable to navigate social situations intuitively, contributing to inaccurate or delayed responses, i.e., not being able to act in accordance with social norms and expectations, poor emotional control, or reduced ability to assess risk (Mahler, 2017). In addition, poor IA responsivity was found to affect the ability to experience social touch, e.g., as pleasant, reassuring or motivating (Mahler, 2017). This can further

hinder engagement in social relationships with family, friends, or partners (Mahler, 2017).

### 5.3.5 Interoceptive responsivity in education

Goodall (2021) implemented activities, aimed at improving IA, related to body awareness (feeling body parts or muscle tension), body temperature, awareness of breath, emotional awareness, feeling heart rate and identifying satiety, hunger, or thirst (Goodall, 2021). Following implementation of the IA programme, there was an improvement in pro-social behaviours and engagement in learning noted (Goodall, 2021).

These findings show that engagement in activities focused on mindful body awareness resulted in improved regulation contributing to reduced maladaptive behaviours (Goodall, 2021). There was a successful application of implemented programme to a young population, which indicates the findings could be successful with paediatric populations commonly seen within occupational therapy SI practice (Goodall, 2021). It was also noted that the school staff were able to use the IA framework to guide decision making despite not having a thorough understanding on this concept; again, confirming that similar programmes may be successfully generalised to different contexts (Goodall, 2021).

Mahler (2021) further explains these findings in the sliding scale of IA, which looks at over- or underresponsivity. If interoceptive signals are muted or intense it would interfere with the ability to take action to maintain homeostasis and thus influence the bodies readiness to engage in learning activities (Mahler, 2017; Mahler, 2021).

## 5.4 Objective 2: To identify which components of occupation interoceptive awareness affects

The basis of occupational therapy practice is on the understanding that successful engagement and participation in occupations can have a positive impact on health and wellbeing (American Occupational Therapy Association, 2020; Hammell, 2004). It is therefore valuable that this study has identified a relationship between interoception and occupational engagement. Engagement in occupations is complex, but it is common knowledge that sensory functions can have a significant impact on occupational performance (Bundy & Lane, 2020; Parham & Cosbey, 2020). It is

therefore important that research and practice continue to consider interoception as a novel sensory system of concern.

Many of the studies published in this area were not designed to explore an association between IA and occupational engagement, thus, the number of included studies was limited (n=13). The limited number of studies that met the inclusion criteria is a concern, particularly due to the increased interest within this area in occupational therapy practice. There were only three occupational therapy specific publications identified that also considered occupational engagement.

The included studies were heterogenous and differed in terms of purpose, study design, methods of assessment and population, which made analysis and correlation of the results difficult. Findings indicate that IA has an influence on occupational performance, with poor IA having a negative effect on performance in areas related to eating and nutrition management, toileting, sleep, social participation, and education. Also noted was that poor participation in occupational areas, specifically eating and sleep, could contribute to poor IA.

This study found that IA influenced various categories of occupation. Poor IA had a negative effect on five of the nine core categories of occupation described in the OTPF-4 (American Occupational Therapy Association, 2020). The studies differed in terms of the category of occupation studied, which limited the amount of evidence pertaining to each occupational area. Included studies considered the following categories of occupation: eating and nutrition management (Di Nardo, et al., 2020; Glaspey, 2021; Herbert, 2020; Herbert, et al., 2013; Herbert & Pollatos, 2014; Mahler, 2017; Martin, et al., 2019; Simmons & DeVille, 2017), toileting (Koscinski, 2018; Mahler, 2017), sleep (Arora, et al., 2021; Wei & Van Someren, 2020), social participation (Koscinski, 2018; Mahler, 2017) and education (Goodall, 2021).

It can be hypothesised, based on the transactional nature of occupation, that the remaining four categories may be influenced by IA, but no research studies considering these areas were identified for inclusion in this study (Aldrich, 2008; Bunting, 2016; Fogelberg & Frauwirth, 2010; Kuo, 2011). It was noted that poor engagement or participation in the occupations of eating (Herbert & Pollatos, 2014; Koch A, 2014) and sleep (Arora, et al., 2021; Wei & Van Someren, 2020) may have a negative influence on IA.

### 5.4.1 Categories of occupation: Eating and nutrition management

Eating and nutrition management is a core area of occupational therapy practice (American Occupational Therapy Association, 2020). This study identified key areas related to IA and eating, adaptive eating, emotional regulation and eating behaviour, awareness of physiological signals, interoceptive responsivity and obesity as well as IA interventions to improve eating behaviours and nutrition management.

#### 5.4.1.1 IA and eating behaviours

Adequate IA has been associated with the ability to eat adaptively and maintain a healthy weight (Herbert, 2020). All included studies on eating and nutrition management (n=10) confirmed a relationship between poor IA and the development or maintenance of maladaptive eating behaviours (Di Nardo, et al., 2020; Glaspey, 2021; Herbert, 2020; Herbert, et al., 2013; Herbert & Pollatos, 2014; Koch A, 2014; Koscinski, 2018; Mahler, 2017; Martin, et al., 2019; Simmons & DeVille, 2017). A causal relationship was however difficult to establish. (Herbert, et al., 2013; Martin, et al., 2019). Poor IA may therefore be secondary to maladaptive eating behaviours, which was a finding in the study by Koch and Pollatos (2014).

Adaptive eating or intuitive eating is defined as being able to eat in accordance with one's nutritional needs, thus balancing intake with energy expenditure, to maintain a healthy weight (Herbert, 2020). Adequate IA would therefore enable behaviours that are responsive to an individual's metabolic needs, thus maintaining homeostasis and promoting health, while maladaptive eating would include behaviours such as binge eating (Di Nardo, et al., 2020), over- or under-eating behaviours (Mahler, 2017).

Adaptive eating or the ability to intuitively eat is often impacted on by the introduction of dieting behaviours, external food rules, weight gain and eating based on emotional responses or contextual factors rather than in response to food cues (Glaspey, 2021; Herbert, et al., 2013). Maladaptive eating behaviours may therefore contribute to the development of health conditions such as obesity (Herbert & Pollatos, 2012; Koch A, 2014; Simmons & DeVille, 2017) or eating disorders (Herbert, 2020; Martin, et al., 2019).

Herbert (2020) summarised empirical findings related to interoception and eating behaviours:

- Adaptive eating behaviours: Findings suggest that there is significant evidence that IA has a positive link with eating adaptively; balancing food intake with energy needs, which is important for weight regulation (Herbert, 2020). Furthermore, results indicate that one's perception of their interoceptive cues, e.g., a dislike for feeling hungry, may predict a higher BMI and an increase in emotional eating behaviours (Herbert, 2020). This also relates to the idea that interoception is related to emotional regulation behaviours (Herbert, 2020).
- Obesity: Findings suggest evidence for both underresponsivity and overresponsivity to interoceptive signals in obesity (Herbert, 2020). Underresponsivity to interoceptive signals related to satiety and fullness in obesity (Herbert, 2020), while overresponsivity to interoceptive signals related to hunger or related bodily cues (insulin changes, body weakness) may increase food seeking and eating behaviours (Herbert, 2020).
- Eating disorders: Poor IA appears to be important in the diagnosis of disordered eating and eating disorders (Herbert, 2020). Diagnostic symptoms of eating disorders (e.g., purging, binging, excessive exercise) may be dysfunctional self-regulation strategies (Herbert, 2020).

Di Nardo et al. (2020) identified an association between binge eating symptoms and poor IA. They used a cross sectional study design and therefore a causal relationship could not be identified (Di Nardo, et al., 2020). This study included 120 participants aged 17-21 years. Their findings indicate that poor IA is involved in the development and maintenance of maladaptive eating behaviours (Di Nardo, et al., 2020).

Herbert et al. (2013) also used a cross sectional study design, which limited the ability to draw causal relationships among the 111 adult participants. Their findings show that IA and acknowledgement of body signals, such as hunger and satiety cues, play a role in adaptive eating behaviours and weight regulation (Herbert, et al., 2013). Furthermore, their results show that IA and the subjective evaluation of body signals e.g., perceiving them as pleasant or negative are independent processes, both significantly predict eating according to physiological cues, i.e., hunger signals and satiety cues (Herbert, et al., 2013).

Koch and Pollatos (2014) studied the role of interoception measured with a heartbeat perception task and BMI as well as eating behaviour in children. The study included a large sample of 1657 children aged 6-11 years. They found no direct relation between IA and BMI (Koch A, 2014). Their findings indicated significantly increased appetite responses to food in overweight and obese children when compared to normal weight children (Koch A, 2014). This supports the idea that those who are obese or at risk of developing obesity show increased responses to external food cues disregarding hunger and satiety cues. In overweight children, there were external and emotional eating behaviours noted as predictive of later interoceptive overresponsivity (Koch A, 2014). Their findings show that eating behaviours and poor IA are prospectively related to each other in that poor IA is secondary to maladaptive eating behaviours in overweight children (Koch A, 2014).

Herbert and Pollatos (2014) examined interoceptive awareness among overweight and obese populations. They used an experimental design, which included a heartbeat detection task with 75 adult participants. Their findings showed that IA was higher in normal weight participants when compared to overweight or obese participants (Herbert & Pollatos, 2014). There was a negative correlation coefficient found between BMI and IA in overweight and obese participants (Herbert & Pollatos, 2014). Thus, overweight, or obese individuals may experience greater difficulties in noticing body signals due to poor IA (Herbert & Pollatos, 2014). IA is likely to interact with regulation of food intake in daily life, in allowing for the recognition of satiety signals or physiological changes (Herbert & Pollatos, 2014).

Glaspey (2021) investigated intuitive eating and the results of the study showed that IA may be a necessary skill for intuitive eating. This mixed methods study design included 10 participants between 18-25 years. The findings indicated that students who had poor IA and underresponsivity to interoceptive cues, such as hunger and satiety, were more likely to use external tools to manage nutrition to support weight loss (Glaspey, 2021). These external tools included dieting apps, measuring cups, low calorie foods, calorie counting or eliminating certain foods (Glaspey, 2021). Glaspey (2021) found that individuals who relied on external cues were less likely to sustain adapted eating habits, and that those who were able to rely on internal cues found it easier to sustain changes and were more likely to experience success in changing eating habits (Glaspey, 2021). Those with adequate IA did not need to rely on

reminders or schedules to eat and were able to understand when they needed to eat and when they were satisfied (Glaspey, 2021). Those with poor IA experienced nausea or headaches when they were hungry due to a potential delayed acknowledgement of hunger (Glaspey, 2021). Poor IA was also identified in those who felt extreme hunger and ate large quantities or quickly, in that their awareness of interoceptive cues may have been ignored or delayed (Glaspey, 2021).

Mahler (2017) showed that poor IA could affect hunger or thirst cues resulting in feeling hunger or thirst more frequently, or alternatively missing hunger or thirst cues. This was applicable to all populations, but specifically mentioned an ASD population known to have poor IA. Mahler further links this to overeating behaviours due to an inability to sense satiety cues (Mahler, 2017). Koscinski (2018) discusses that poor IA, related to an ASD population, suggests that IA is likely to influence eating and feeding due to the ability to feel physiological cues (Koscinski, 2018).

Martin et al. (2019), through a systematic review, evaluated the role of interoception as a predisposing factor in the development of disordered eating and eating disorders. Their findings indicated that poor IA is associated with disordered eating behaviours (Martin, et al., 2019). This was noted across eating disorder categories and interoceptive modalities (Martin, et al., 2019), which included gastric interoception, such as self-questionnaires related to hunger and satiety, cardiac interoception including studies using heartbeat detection and pain interoception, which considered pain threshold and time taken to withdraw from noxious stimuli (Martin, et al., 2019). Furthermore, their findings highlighted that there is limited evidence on the causal role of interoception and IA in disordered eating (Martin, et al., 2019).

### 5.4.2 Category of occupation: Sleep

Rest and sleep are not only critical for health but provide energy to support engagement in other occupations (American Occupational Therapy Association, 2020; Solet, 2013). Identified areas of sleep influenced by poor IA included sleep participation, sleep initiation and maintenance of a sleep state (Arora, et al., 2021; Wei & Van Someren, 2020).

#### 5.4.2.1 Interoceptive awareness and sleep participation

Studies on sleep and interoception identified a relationship between IA and sleep participation (Arora, et al., 2021; Wei & Van Someren, 2020). Poor IA may have an impact on sleep participation, while sleep participation may result in poor IA (Arora, et al., 2021; Wei & Van Someren, 2020). This relationship is significant in health promotion and prevention approaches within occupational therapy practice (American Occupational Therapy Association, 2020).

Sleep deprivation has also been associated with fatigue, a negative mood, and a perception of feeling unwell (Solet, 2013; Wei & Van Someren, 2020). There is also a link between sleep loss and substance use, increased likelihood of being involved in a road accident, behavioural and health conditions (Arora, et al., 2021). Poor IA may also cause psychological and neurological changes with consequent changes in mood and sleep behaviour (Arora, et al., 2021; Wei & Van Someren, 2020). Findings also suggested that sleep loss is likely to be involved in emotional dysregulation in anxiety and depression (Arora, et al., 2021). The relationship between poor sleep participation and health conditions is an important finding to inform occupational therapy practice and conditions associated with sleep deprivation (Engel-Yeger & Shochat, 2012; Solet, 2013).

#### 5.4.2.2 IA, sleep initiation and maintenance of a sleep state

Wei and Van Someren (2020) found that IA influenced sleep participation in terms of sleep initiation and maintenance of a sleep state (Wei & Van Someren, 2020). Interoceptive stimuli may hinder or support sleep initiation (Wei & Van Someren, 2020). This may be important to consider when looking at sleep hygiene within occupational therapy practice (Solet, 2013). Noxious, stressful, or intense temperature (hot or cold) stimuli can increase arousal hindering sleep initiation (Wei & Van Someren, 2020), while gastrointestinal stimulation and mild skin warming was found to reduce the time taken to fall asleep (Wei & Van Someren, 2020). IA is expected to reduce during stable sleep as a protective function, to protect sleep and prevent arousals (Wei & Van Someren, 2020). One could consider this when assessing an individual's sleep needs, e.g., those vulnerable to gastrointestinal reflex (Wei & Van Someren, 2020). Furthermore, subtle skin warming during wakefulness a few hours before bedtime may promote slow wave sleep and may again be valuable to consider with sleep hygiene intervention (Solet, 2013; Wei & Van Someren, 2020).

### 5.4.3 Categories of occupation: Toileting

Toileting falls into the occupational category of ADLs and deemed necessary for basic survival and health (American Occupational Therapy Association, 2020). Of the two studies that considered toileting, both studies found that poor IA could affect the engagement in bowel and bladder management with specific mention of an ASD population (Koscinski, 2018; Mahler, 2017).

#### 5.4.3.1 Improving and compensating for poor IA

Koscinski (2018) highlights how difficulties with toileting may also affect occupational engagement in other areas, such as social participation as children may have accidents in public settings and therefore leaving home may cause anxiety or distress.

Mahler (2017) and Koscinski (2018) suggest occupational therapy interventions related to mindfulness and body awareness, such as body scanning strategies to support improved IA and toileting. Body scanning with a specific focus on toileting may involve drawing attention and awareness to the feelings associated with a full bladder or the feeling when urine leaves the body (Koscinski, 2018; Mahler, 2017).

Other factors may include external cues to support poor IA, such as consistent environments and additional cues from other senses, e.g., food colouring in toilet, calming music or smells, managing transitions and a focus on building routine (Koscinski, 2018).

### 5.4.4 Categories of occupation: Social participation

Occupational engagement challenges affecting social participation may have significant implications for health and wellbeing (Abel & McQueen, 2020; Vieira, et al., 2020; Zhao, et al., 2020). Engagement in social activities contributes to a sense of belonging (Hammel, 2017). Adequate IA appears to be a key component in navigating social situations and guiding social behaviour (Koscinski, 2018; Mahler, 2017).

Despite the identified relationship between IA and social participation, there was a limited number of studies considering this domain identified for inclusion in this study. The two publications (n=2) that did consider social participation both had occupational therapists as authors, with specific mention of an ASD population (Koscinski, 2018; Mahler, 2017). One can hypothesise that the authors understanding of occupation and

the underlying client factors or performance skills, which would influence occupational engagement allowed them to report on social participation. Other professions, such as psychology or neuroscience, have looked at social aspects but have not linked their findings to function or the occupational domain of social participation and thus these studies did not meet the inclusion criteria for this study.

#### 5.4.4.1 Perspective taking, social touch and self-awareness

Poor IA affects underlying skills needed for adequate social participation (Mahler, 2017). Mahler (2017) describes the ability to 'know' what to do in social settings to align with the norms and expectations of the situation as being related to interoception. Thus, poor IA would result in difficulty managing social situations and making unintentional social errors or having difficulty complying with social norms.

Mahler (2017) describes underlying skills, namely perspective taking, self-awareness and social touch, which are likely to affect engagement in social participation.

Poor IA contributed to difficulties with perspective taking and empathy (Mahler, 2017). Mahler found that IA relates to social cognitive areas, which allow one to predict their response but also to predict how others may feel in a similar or the same situation (Mahler, 2017). The idea that we can infer what interoceptive signals others may be feeling based on our own experiences and what interoceptive signals we experienced in the past (Mahler, 2017). This requires one to think about and feel someone else's emotions and experiences (Mahler, 2017). This would affect the ability to understand how others may be feeling, which develops from our own interoceptive experiences (Mahler, 2017). Perspective taking is also important to allow one to develop a clear sense of others (Mahler, 2017).

Mahler (2017) also identified that poor IA affects self-awareness, an important contributor to developing awareness of others. Awareness of self may also support the ability to behave in accordance with the environment within a social context, e.g., the ability to manage one's emotions and inhibit an inappropriate action or response (Mahler, 2017). Koscinski (2018) expanded on this idea, describing those individuals who have difficulty managing their poor IA, such as those affected by sensory processing disorder (SPD), may have difficulty managing their behaviour in communal settings and within relationships (Koscinski, 2018). Self-awareness, if also linked to

emotional awareness and regulation, supports the development of more complex social skills such as conflict management or assertiveness skills (Mahler, 2017).

Mahler (2017) also describes the interoceptive system as playing a role in providing information about emotional and social touch (Mahler, 2017). It therefore facilitates the ability to experience social touch sensations as pleasant, reassuring or motivating (Mahler, 2017). This aspect is important for the development of social relationships between family, friends, or with a partner (Mahler, 2017).

#### 5.4.4.2 Considering IA when addressing social skills and participation

The OTPF-4 highlights various underlying client factors and performance skills that have an impact on social participation (American Occupational Therapy Association, 2020). The identified relationship between IA and social functions highlights a need to consider interoception as a contributing sensory function when addressing social challenges (Koscinski, 2018; Mahler, 2017). One can hypothesise that addressing IA prior to or adjunctively to other social functions may be beneficial within occupational therapy practice.

### 5.4.5 Categories of occupation: Education

In the study on education, improving IA had a positive effect on education and learning within a school context (Goodall, 2021). Occupational therapists are often involved in school contexts and with paediatric populations, thus this finding is significant (Swinth, 2013).

#### 5.4.5.1 Improving IA in school context

One mixed methods study looked at interoception and education through behavioural analysis and semi-structured interviews, which included 12 schools: primary schools, high schools, and special schools (Goodall, 2021). The purpose of the study was to investigate if engaging in IA activities would improve self-regulation skills, decrease challenging behaviours, and improve learning and education (Goodall, 2021).

Goodall (2021) found that interoceptive intervention activities, aimed at improving IA, had a positive effect on engagement in education and learning in a school context. These activities included feeling body parts or muscle tension, feeling and explaining body temperature, awareness of breath, emotional awareness, feeling heart rate and identifying satiety, hunger, or thirst (Goodall, 2021). In terms of muscle tension,

students become aware of the building of pain before their hand becomes extremely painful when writing, resulting in work avoidance and outbursts.

Findings showed a reduction in 80% of behavioural consequences across the 12 schools included in the study following the implementation of intervention activities (Goodall, 2021). Qualitative perceptions confirmed that increased IA improved many behaviours related to pro-social behaviour and engagement in learning (Goodall, 2021).

## 5.5 Conclusion

This chapter reviewed and discussed the findings in relation to the objectives of the study. It described the influence that IA has on engagement in the various categories of occupation. There was a relationship found between IA and several categories of occupation, highlighting the relevance of this concept to occupational therapy practice. More research related to interoception, and occupational engagement is necessary. The concluding chapter will discuss further recommendations for research and practice.

# CHAPTER 6 CONCLUSION

## 6.1 Introduction

This study focused on the influence that interoception has on occupational performance and how adequate or poor IA influences occupation. This chapter reviews the previous chapters emphasising the key methodology and findings of the study, the limitations of the study and outline the recommendations for practice and future research.

## 6.2 Conclusion

The purpose of this study was to determine the influence of interoception on engagement in occupation to inform occupational therapy practice. The use of a scoping review research design was to extract and analyse the available evidence related to the research aim and objectives. The JBI scoping review methodology ensured a comprehensive and transparent search process. A data extraction table was used to draw and relate the data to the research objectives.

The findings of this study highlight the need for more research related to interoception, which is occupation focused. In addition, the outcomes and findings of the studies emphasise the importance of interoception for occupational therapy practice, particularly for those working with children or in mental health settings.

Improved understanding of the concept of interoception and its influence on occupational engagement and participation would enable occupational therapists to provide enhanced intervention. It is evident that interoception has a significant impact on various areas of occupation, including sleep, eating, social participation and health management, and that poor IA can negatively affect occupational engagement. It is therefore critical that occupational therapists consider this domain during assessment and intervention to holistically support the individuals they serve.

While there is evidence of a relationship between interoception and occupation, there are no well-researched assessments or intervention methods to support evidence-based practice.

## 6.3 Limitations of the study

This study only included publications available in English; although this was a practical decision, it may have resulted in the missing of potentially relevant articles. Most of the records included in this review originated from the United States of America, which may be an overrepresentation of this country. This study only included full-text records available to the public or through the University of the Witwatersrand's library, therefore relevant articles may have been excluded. There are additional databases containing research articles related to sensory integration that were not included in the search strategy due to time and resource limitations and it is possible that other records could have been included in this study. Furthermore, there was no assessment of the quality of the included studies, as the purpose of this study was to map the evidence related to interoception and occupational engagement.

The concept of interoception is currently being recognised, and explored by various disciplines with studies included in this scoping review from psychology, occupational therapy, neuroscience, and education. Consequently, drawing conclusions was difficult due to differing theoretical bases and researchers limited recognition of how findings may link to other disciplines or practice. Many of the more science focused disciplines included anatomical, physiological, experimental, or clinical neuroscientific findings, which may directly influence occupation, but it is difficult as an occupational therapy researcher, with limited understanding of the experimental mechanisms, to draw conclusions related to function.

Another limitation across articles was the tools or assessment methods used. The majority of the articles (n=5) used self-report measures, which may have affected the accuracy of results due to interpretation of the questionnaire, response bias and social influences (Arora, et al., 2021). Other methods used to a lesser extent were heartbeat perception (n=2) and detection tools (n=1), which are standardised and well validated (Herbert, et al., 2013).

## 6.4 Recommendations

### 6.4.1 Recommendations for occupational therapy practice

This research provides insight into the current research related to interoception and occupational engagement. It also highlights major occupational areas, which are emerging within the literature related to interoception, such as social functioning, eating and sleep.

Occupational therapists should be aware of the important role that interoception plays in occupational therapy practice with regards to assessment and intervention. Occupational therapists working with clients with diagnoses or challenges that align with current research should consider interoception in their practice. However, interoception is one component, and research regarding its interaction with other relevant components, such as the proprioceptive or vestibular system, is developing (Lane, 2020b). Therefore, one needs to consider all aspects to promote optimal outcomes and occupational performance.

Occupational therapists are encouraged to involve themselves in current research, which aims to develop interoceptive assessments that will support intervention related to interoception (Brown & Dunn, 2020). Effective assessment is a critical step in effectively addressing interoceptive difficulties.

### 6.4.2 Recommendations for future studies

Of note during the review process was that many articles explored underlying skills or components that may influence occupation, i.e., body image or emotional regulation. While these components were not included in this review, they are valuable to consider and are likely to influence occupational areas and engagement. The recommendation is that future studies focus on a specific occupational area, as this will allow for the consideration of underlying skills related to that occupational area.

The recommendation is that occupational therapy researchers aim to use consistent terminology when investigating concepts such as interoception; this suggestion is for the broader term, sensory integration, in which there has been debate regarding the best descriptor (Smith Roley, et al., 2007). Inconsistent terminology can create confusion for the public, other professionals, and occupational therapists.

The potential relationship between interoception and trauma necessitates further investigation and may be particularly relevant to the South African context. Furthermore, based on sensory integration theory, it is valuable to consider sensory systems independently and their relationships to each other to understand each modality fully (Lane, 2020b). A better understanding of interoception in relation to other sensory systems is necessary.

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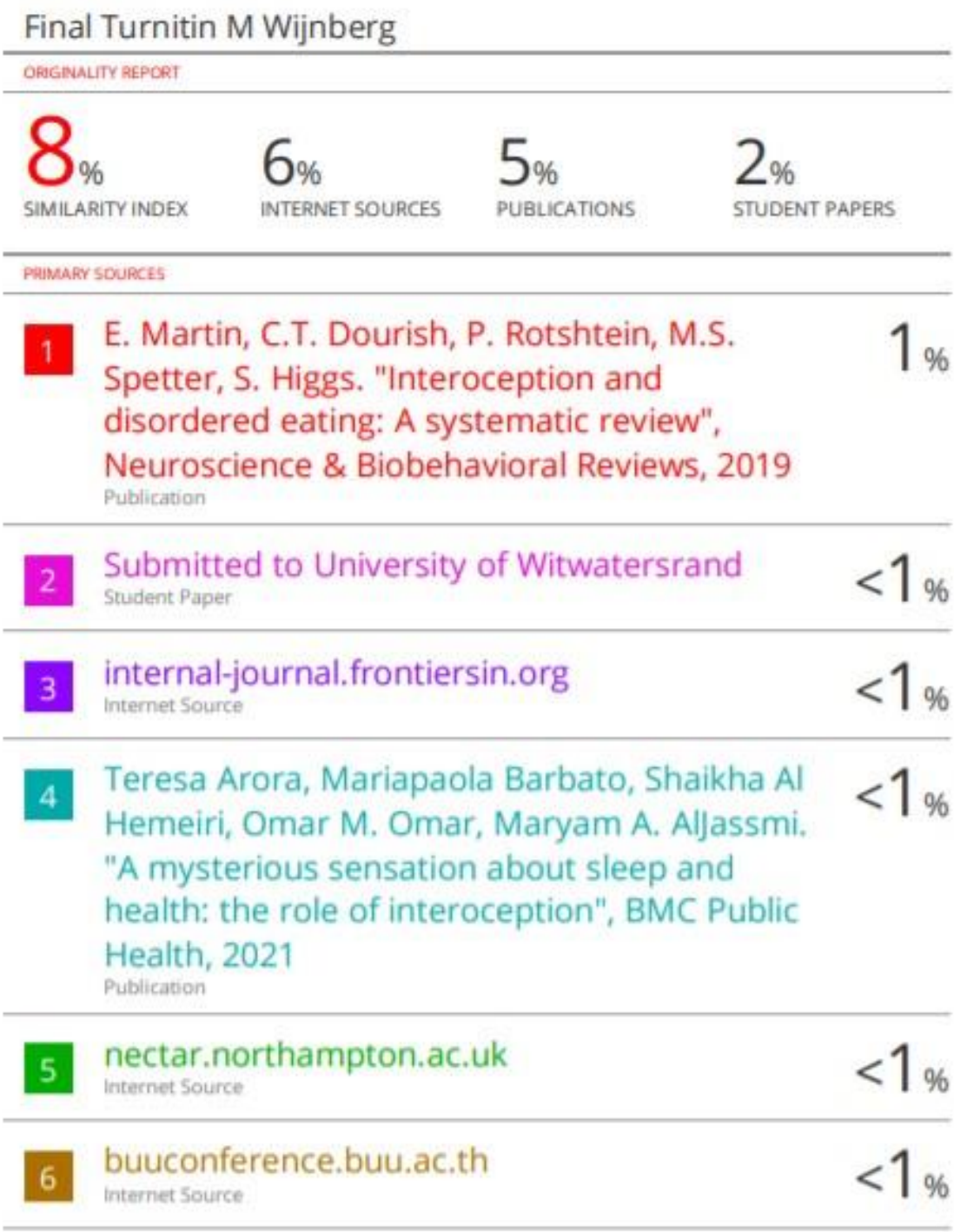
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# APPENDICES

## Appendix A – Turnitin report



Final Turnitin M Wijnberg

ORIGINALITY REPORT

| 8% | 6% | 5% | 2% |
|---|---|---|---|
| SIMILARITY INDEX | INTERNET SOURCES | PUBLICATIONS | STUDENT PAPERS |

PRIMARY SOURCES

| | | |
|---|---|---|
| 1 | E. Martin, C.T. Dourish, P. Rotshtein, M.S. Spetter, S. Higgs. "Interoception and disordered eating: A systematic review", Neuroscience & Biobehavioral Reviews, 2019<br>Publication | 1% |
| 2 | Submitted to University of Witwatersrand<br>Student Paper | <1% |
| 3 | internal-journal.frontiersin.org<br>Internet Source | <1% |
| 4 | Teresa Arora, Mariapaola Barbato, Shaikha Al Hemeiri, Omar M. Omar, Maryam A. AlJassmi. "A mysterious sensation about sleep and health: the role of interoception", BMC Public Health, 2021<br>Publication | <1% |
| 5 | nectar.northampton.ac.uk<br>Internet Source | <1% |
| 6 | buuconference.buu.ac.th<br>Internet Source | <1% |

## Appendix B – Ethical waiver

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

**Office of the Deputy Vice-Chancellor (Research & Innovation)**

23/09/2021

Ref: W-CBP-210923-01

**TO WHOM IT MAY CONCERN**

**Waiver:** This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical)

**Investigator:** Ms M Wijnberg
Student No. (if appropriate): 456172
Staff No. (if appropriate):

**Supervisor:** Dr J van der Linde

**School:** Therapeutic Sciences
**Department:** Occupational Therapy
Medical School
University

**Project title:** *The influence of interoception on engagement in occupation: a scoping review*

**Reason:** Review of information in the public domain
No human participants will be involved in the study

Dr CB Penny
Chairperson: Human Research Ethics Committee (Medical)

Research Office Secretariat:
Third Floor, Phillip Tobias Building, corner of St Andrews and York Roads, Parktown, Johannesburg 2193
Postal address: Private Bag 3, Wits 2050
Tel Nos: +27 (0)11 717 1234/1252/2656/2700
Office E-mail: HREC-Medical.ResearchOffice@wits.ac.za
Website:
https://www.wits.ac.za/research/researcher-support/research-ethics/ethics-committees/

## Appendix C – Search strategies

Searches conducted on 17 October 2021.

**PubMed**

The search for terms was in title and abstract

Filters applied: English language, January 1900 to October 2021 and humans

(("interoception"[Title/Abstract] OR "interoceptive"[Title/Abstract] OR "interoceptive awareness"[Title/Abstract]) AND ("occupational engagement"[Title/Abstract] OR "engage*"[Title/Abstract] OR "function*"[Title/Abstract] OR "participat*"[Title/Abstract] OR "dysfunction*"[Title/Abstract] OR "disabilit*"[Title/Abstract]) AND ("occupation"[Title/Abstract] OR "occupational areas"[Title/Abstract] OR "occupational therapy"[Title/Abstract] OR "occupational therapist"[Title/Abstract] OR "ADL"[Title/Abstract] OR "hygiene"[Title/Abstract] OR "self-care"[Title/Abstract] OR "eating"[Title/Abstract] OR "feeding"[Title/Abstract] OR "toileting"[Title/Abstract] OR "education"[Title/Abstract] OR "vocation*"[Title/Abstract] OR "work"[Title/Abstract] OR "leisure"[Title/Abstract] OR "restorative"[Title/Abstract] OR "play"[Title/Abstract] OR "social"[Title/Abstract] OR "sexual activity"[Title/Abstract] OR "sleep"[Title/Abstract])) AND ((humans[Filter]) AND (english[Filter]))

Records retrieved: 265

**EBSCOhost**

The following data bases affiliated with EBSCO were searched through one combined search: Academic Search Ultimate, CINAHL Complete, MEDLINE Complete, ERIC.

Terms were searched for in abstract

Filters applied: English language, humans, January 1900 to October 2021

AB ( interoception OR interoceptive OR “interoceptive awareness” ) AND AB ( “occupational engagement” OR engage*“occupational engagement” OR engage* OR function* OR participat* OR dysfunction* OR disabilit* ) AND AB ( occupation OR “occupational areas” OR “occupational therapy” OR “occupational therapist” OR ADL OR hygiene OR “self-care” OR eating OR feeding OR toileting OR education OR vocation* OR work OR leisure OR restorative OR play OR social OR “sexual activity” OR sleep )

Records retrieved: 558

| | |
|---|---|
| Academic Search Ultimate | 245 |
| CINAHL Complete | 52 |
| MEDLINE Complete | 257 |
| ERIC | 4 |

**Scopus**

Terms were searched for in title and abstract

Filters applied: English language, January 1900 to October 2021 and humans

TITLE-ABS ( interoception OR interoceptive OR "interoceptive awareness" ) AND TITLE-ABS ( "occupational engagement" OR engage* OR function* OR participat* OR dysfunction* OR disabilit* ) AND TITLE-ABS ( occupation OR "occupational areas" OR "occupational therapy" OR "occupational therapist" OR adl OR hygiene OR "self-care" OR eating OR feeding OR toileting OR education OR vocation* OR work OR leisure OR restorative OR play OR social OR "sexual activity" OR sleep ) AND ( LIMIT-TO ( LANGUAGE , "English" ) )

Records retrieved: 454

**ProQuest**

The following data bases affiliated with ProQuest were searched through one combined search: Health and Medical Collection, Nursing and Allied Health Database, Psychology Database.

Terms were searched for in abstract

Filters applied: English language, January 1900 to October 2021

ab(interoception OR interoceptive OR “interoceptive awareness” ) AND ab(“occupational engagement” OR engage* OR function* OR participat* OR dysfunction* OR disabilit*) AND ab(occupation OR “occupational areas” OR “occupational therapy” OR “occupational therapist” OR ADL OR hygiene OR “self-

care” OR eating OR feeding OR toileting OR education OR vocation* OR work OR leisure OR restorative OR play OR social OR “sexual activity” OR sleep)

Records retrieved: 181

**Cochrane Library**

Terms were searched for in title and abstract

Filters applied: January 1900 to October 2021

interoception OR interoceptive OR “interoceptive awareness” in Title Abstract Keyword AND “occupational engagement” OR engage* OR function* OR participat* OR dysfunction* OR disabilit* in Title Abstract Keyword AND occupation OR “occupational areas” OR “occupational therapy” OR “occupational therapist” OR ADL OR hygiene OR “self-care” OR eating OR feeding OR toileting OR education OR vocation* OR work OR leisure OR restorative OR play OR social OR “sexual activity” OR sleep in Title Abstract Keyword - with Publication Year from 1990 to 2021, in Trials

Records retrieved: 80

**Psychiatry Online**

Terms were searched for in title and abstract

Filters applied: January 1900 to October 2021

interoception OR interoceptive OR “interoceptive awareness” AND “occupational engagement” OR engage* OR function* OR participat* OR dysfunction* OR disabilit* AND occupation OR “occupational areas” OR “occupational therapy” OR “occupational therapist” OR ADL OR hygiene OR “self-care” OR eating OR feeding OR toileting OR education OR vocation* OR work OR leisure OR restorative OR play OR social OR “sexual activity” OR sleep

Records retrieved: 5

**OT Seeker**

In the initial search this database was found to have limited results retrieval but was included in the second search as it aggregates research specific to the occupational therapy profession. This led to an adapted search strategy; only search terms pertaining to interoception were applied in turn.

Terms were searched for in title and abstract

Filters applied: not applicable to database

Search term applied and records retrieved:

| | |
|---|---|
| interoception | 0 |
| interoceptive | 1 |
| “interoceptive awareness” | 0 |

**Google Scholar**

Filters applied: 1900 to 2021

The advanced search function on Google Scholar had limitations and therefore there were multiple searches conducted. When multiple search terms were used in the title of the article no results were retrieved, when multiple search terms were used “anywhere in the article” an unmanageable number of results were retrieved.

Search 1: “Anywhere in article” with differing term related to interoception.

| | | | | | | |
|---|---|---|---|---|---|---|
| With all the words | (1) interoception<br>(2) interoceptive<br>(3) “interoceptive awareness” | | | | | |
| With the exact phrase | “occupational engagement” | engage* | function* | participat* | dysfunction* | disabilit* |
| With at least one of the words | occupation “occupational areas” “occupational therapy” “occupational therapist” ADL hygiene “self-care” eating feeding toileting education vocation* work leisure restorative play social “sexual activity” sleep | | | | | |
| Total number of records retrieved | (1) 2870<br>(2) 13000<br>(3) 38 | (1) 164<br>(2) 157<br>(3) 137 | (1) 18400<br>(2) 25000<br>(3) 22000 | (1) 114<br>(2) 112<br>(3) 92 | (1) 16400<br>(2) 17000<br>(3) 11700 | (1) 4<br>(2) 4<br>(3) 3 |

Search 2: “Anywhere in article” with “occupational therapy” specific search

| | |
|---|---|
| With all the words | (1) interoception<br>(2) interoceptive<br>(3) “interoceptive awareness” |
| With the exact phrase | “occupational therapy” |
| With at least one of the words | - |
| Total number of records retrieved | (1) 1140<br>(2) 1110<br>(3) 1040 |

The results of the second search were exported to Mendeley reference manager for screening.

**Microsoft Academic**

It was only possible to complete a basic search on this database. Search results with one or more terms, i.e., interoception, interoception AND “occupational therapy” returned the same results. Thus, there was an adapted search using only terms pertaining to interception used.

Terms were searched for in default setting, unable to specify

Filters applied: interoception, humans

Search term applied and records retrieved:

| | |
|---|---|
| Interoception AND “occupational therapy” | 614 |
| interoception | 614 |
| interoceptive | 542 |
| “interoceptive awareness” | 165 |

**Grey Matters**

It was not possible to complete an advanced search and there were limited records retrieved. An adapted search strategy was used; only search terms pertaining to interoception were applied in turn.

Terms were searched for in “contain any words”

Filters applied: not applicable to database.

Search term applied and records retrieved:

| | |
|---|---|
| Interoception | 0 |
| interoceptive | 0 |
| “interoceptive awareness” | 0 |

**Open Grey**

It was not possible to complete an advanced search. There was an adapted search strategy used; only search terms pertaining to interoception were applied in turn.

Terms were searched for in abstract

Filters applied: not applicable to database

Search term applied and records retrieved:

| | |
|---|---|
| Interoception | 3 |
| interoceptive | 1 |
| “interoceptive awareness” | 5 |

**Mednar**

It was not possible to complete an advanced search and there were limited records retrieved. There was an adapted search strategy used; only search terms pertaining to interoception were applied in turn.

Terms were searched for in default setting, unable to specify

Filters applied: not applicable to database

No results were retrieved for the search terms; interoception, interoceptive and “interoceptive awareness”

Records retrieved: 0

## Appendix D – Studies ineligible following full-text review

Balconi, M. & Balconi, M. & Angioletti, L., 2021. One's Interoception Affects the Representation of Seeing Others' Pain: A Randomized Controlled qEEG Study. *Pain Research and Management*, Volume 2021, pp. 1-15.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Benau, E., 2018. The blink and the body: The role of interoception in the perception of emotionally salient words in an attentional blink paradigm. *Doctoral dissertation, University of Kansas*, pp. 1-77.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Berntson, G. & Khalsa, S., 2021. Neural circuits of interoception. *Trends in Neurosciences*, 44(1), pp. 17-28.

*Reason for exclusion: Unable to access full text.*

Brown, C. & Dunn, W., 2020. Development of a Participation-Focused Measure of Interoception. *American Journal of Occupational Therapy*, 74(S1), p. 1.

*Reason for exclusion: Study did not specifically include interoception in relation to areas of occupation.*

Craig, A., 2002. How do you feel? Interoception: the sense of the physiological condition of the body. *Nature Reviews Neuroscience*, 3(8), pp. 655-666.

*Reason for exclusion: Study investigated interoception in relation to mental health conditions but did not consider specific occupational areas.*

Di Lernia, D. et al., 2018. Feel the time. Time perception as a function of interoceptive processing. *Frontiers in Human Neuroscience*, Volume 12, p. 74.

*Reason for exclusion: Study did not specifically include interoception in relation to areas of occupation.*

Dirupo, G., Corradi-Dell'Acqua, C., Kashef, M. D. M. & Badoud, D., 2020. The role of interoception in understanding others' affect. Dissociation between superficial and detailed appraisal of facial expressions. *Cortex*, Volume 130, pp. 16-31.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Durlik, C. & Tsakiris, M., 2015. Decreased interoceptive accuracy following social exclusion. *International Journal of Psychophysiology*, 96(1), pp. 57-63.

*Reason for exclusion: Study investigated influence of social exclusion on interoception rather than interoception on social engagement.*

Esménio, S. et al., 2019. Brain circuits involved in understanding our own and other's internal states in the context of romantic relationships. *Social Neuroscience*, 14(6), pp. 729-773.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Ewing, D. et al., 2017. Sleep and the heart: Interoceptive differences linked to poor experiential sleep quality in anxiety and depression. *Biological Psychology*, Volume 127, p. 16.

*Reason for exclusion: Study investigated influence of sleep quality on interoceptive components rather than the influence of interoception on sleep as the occupation.*

Feldman, M., 2021. Interoceptive ability moderates the effect of physiological reactivity on social judgment. *Doctoral dissertation, The University of North Carolina at Chapel Hill*.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category*

Ferraro, I. & Taylor, A., 2021. Adult attachment styles and emotional regulation: The role of interoceptive awareness and alexithymia. *Personality and Individual Differences*, Volume 173.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Ferri, F., Ardizzi, M., Ambrosecchia, M. & Gallese, V., 2013. Closing the gap between the inside and the outside: interoceptive sensitivity and social distances. *PloS One*, 8(10), pp. 1-11.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Gao, Q., Ping, X. & Chen, W., 2019. Body influences on social cognition through interoception. *Frontiers in Psychology*, 10(2066), pp. 1-5.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Garfinkel, S. & Critchley, H., 2014. Neural correlates of fear: insights from neuroimaging. *Neuroscience and Neuroeconomics*, Volume 3, pp. 111-125.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Goodall, E., 2020. Interoception as a proactive tool to decrease challenging behaviour. *The Journal for Educators*, 39(1), pp. 20-24.

*Reason for exclusion: Handout for a presentation.*

Hample, K., Mahler, K. & Amspacher, A., 2020. An Interoception-Based Intervention for Children with Autism Spectrum Disorder: A Pilot Study. *Journal of Occupational Therapy, Schools, & Early Intervention*, 13(4), pp. 339-352.

*Reason for exclusion: Study investigated interoception intervention and did not include occupation or occupational areas.*

Herbert, B. & Pollatos, O., 2012. The body in the mind: on the relationship between interoception and embodiment. *Topics in Cognitive Science*, 4(4), pp. 692-704.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Khalsa, S. et al., 2018. Interoception and mental health: a roadmap. *Biological psychiatry: cognitive neuroscience and neuroimaging*, 3(6), pp. 501-513.

*Reason for exclusion: Study investigated interoception in relation to mental health conditions but did not consider specific occupational areas.*

Koch, A. & Pollatos, O., 2014. On the Relevance of Interoceptive Sensitivity for Overweight and Eating Behavior in Middle Childhood. *European Health Psychologist*, 16(S), p. 323.

*Reason for exclusion: Unable to access full text.*

Lamm, C. & Singer, T., 2010. The role of anterior insular cortex in social emotions. *Brain Structure and Function*, 214(5-6), pp. 579-591.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Lovan, P. & Coccia, C., 2021. The Correlation Between Internal Bodily Signals, Eating Behaviors, and Self-Regulation of Food Intake in College Students. *Journal of Nutrition Education and Behavior*, 53(7), pp. S39-40.

*Reason for exclusion: Abstract for poster*

Mahler, K., McLaughlin, E. & Anson, D., 2020. Interoception Across Varying Degrees of Mental Wellness. *American Journal of Occupational Therapy*, 74(S1).

*Reason for exclusion: Study focused on interoception and mental wellness and not specifically occupation or occupational areas.*

Merwin, R., Zucker, N., Lacy, J. & Elliott, C., 2010. Interoceptive awareness in eating disorders: Distinguishing lack of clarity from non-acceptance of internal experience. *Cognition and Emotion*, 24(5), pp. 892-902.

*Reason for exclusion: Study focused on interoception and eating disorders and not specifically occupation or occupational areas.*

Mitchell, V., Kim, C., Nguyen, N. & Laughter, S., 2020. Sensory Modulation, Anxiety, and Interoception in Typical Adults. *American Journal of Occupational Therapy*, 74(S1).

*Reason for exclusion: Study focused on interoceptive awareness and quality of life and did not focus on specific quality of life categories which would correlate with occupational areas.*

Nisticò, V. et al., 2021. The effect of eight yoga sessions on interoceptive accuracy, confidence and awareness in a sample of patients with eating disorder: A preliminary study. *European Psychiatry*, 64(1), pp. S353-S353.

*Reason for exclusion: Unable to access full text.*

Poole, P., 2021. Illuminate Academy Interoception Curriculum & Resources. *OTD Capstone Projects Belmont University*, Volume 79.

*Reason for exclusion: Abstract for project poster presentation.*

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*Reason for exclusion: Unable to access full text.*

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*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Schwerdtfeger, A., Heene, S. & Messner, E., 2019. Interoceptive awareness and perceived control moderate the relationship between cognitive reappraisal, self-esteem, and cardiac activity in daily life. *International Journal of Psychophysiology*, Volume 141, pp. 84-92.

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*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

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*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

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*Reason for exclusion: Unable to access full text.*

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*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

Yang, H. et al., 2021. A network analysis of interoception, self-awareness, empathy, alexithymia, and autistic traits. *European Archives of Psychiatry and Clinical Neuroscience*, pp. 1-11.

*Reason for exclusion: Study investigated interoception in relation to an underlying factor that may influence occupational engagement rather than a specific occupational category.*

## Appendix E – Data Extraction Matrix

| (Author(s), year of publication) and origin | Discipline of first author | Research design | Population and sample size | Term(s) related to interoception used | Occupational area included in study *Sub-category* | Purpose of study | Key findings and outcomes reported by author(s) |
|---|---|---|---|---|---|---|---|
| **(Arora, et al., 2021)** United Arab Emirates . | Psychology | Cross-sectional: included survey and 2 self-report measures (MAIA-2, PSQI) (Descriptive) | Adults; 10% males, and 90% females 18-25 years n=609 | Interoception, interoceptive awareness (IA), interoceptive sensibility | Sleep *Sleep participation* | To investigate the relationship between subjective sleep quality and interoception | Study identified small but significant relationship between sleep quality and interoceptive abilities<br>Poorer sleep quality may be associated with interoceptive sensibility<br>Poor sleep quality could impair interoceptive skills or by reverse impairments to interoceptive skills could result in poorer sleep habits, quality, or duration<br>Due to study design causal relationship could not be identified<br>Heightened awareness of body signals, i.e., hunger, due to sleep loss, may be important to understand relationship between sleep and obesity |
| **(Di Nardo, et al., 2020)**. Italy | Psychology | Cross-sectional: included self-report questionnaire (BES, EDI-3, BUT, PANAS) (Descriptive) | Adolescents; 56.6% males and 43.3% females 17-21 years n=120 | Interoceptive deficits (ID) | ADLs *Eating/ feeding*<br><br>Health management *Nutrition management* | To investigate the relationship between interoceptive deficits and binge eating behaviours. | Study identified association between binge eating symptoms and interoceptive deficits, body uneasiness and negative affectivity<br>Due to study design, causal relationship could not be identified<br>Interoceptive deficits are involved in the development and |

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| | | | | | | | maintenance of maladaptive eating behaviours |
| **(Glaspey, 2021)**. United States of America | Occupational therapy | Case study to compare results of self-report surveys. (Int vs. ext. tools survey, Interoceptive Awareness Interview) (Mixed methods) | Adults; 10% male and 90% female 18-25 years n=10 | Interoception awareness (IA), Interoceptive sensitivity (IS) | ADLs *Eating/ feeding*<br><br>Health management *Nutrition management* | To identify if there is a correlation between IA and weight management success using internal vs. external tools | Study results showed that IA could be a necessary skill for intuitive eating Students who had poor IA skills and hyporesponsivity to hunger and fullness cues were more likely to use external tools to lose weight<br>External tools included measuring cups, dieting applications, calorie counting, eliminating certain goods<br>Those with adequate IA did not need to use reminders or schedules to eat<br>Those with poor IA experienced headaches or nausea due to delayed acknowledgement hunger<br>Extreme hunger or eating quickly was also linked to reduced IA<br>Findings support need for IA interventions, which may enhance intuitive eating<br>Limitations of the study highlight the small sample and lack of diversity in sample. |
| **(Goodall, 2021)**. Australia | Education | Mixed methods: behavioural analysis and semi-structured interviews (Mixed methods) | Participants included 12 primary, high, and special schools. | Interoception, interoceptive awareness (IA) | Education *Formal educational participation* | To study if engaging in IA activities will improve self-regulation skills, decrease challenging behaviours, and | Study findings indicate that IA activities resulted in visible increases in engagement in learning and education<br>A reduction in reported behavioural consequences was reported at all the schools<br>IA activities included feeling body parts/muscles, feeling |

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| | | | | | | improve learning and education. | temperature, awareness of breath and emotions, feeling heartrate, satiety, and thirst<br>Teaching IA increased engagement in learning, education, self-management, and self-regulation in a school context<br>Limitation was schools' application and consistency in application of IA tools. |
| **(Herbert, 2020)**. Germany | Psychology | Narrative review (Descriptive) | N/A | Interoception, Interoceptive accuracy (IAcc), Interoceptive Sensibility (IS), Interoceptive awareness (IA), Interoceptive deficits | ADLs<br>*Eating/feeding*<br><br>Health management<br>*Nutrition management* | To summarise empirical findings and draw conclusions on the role of interoception in eating behaviour, body weight and eating disorders | The review summarised findings related to interoception, adaptive eating and eating disorders<br>Dysfunctional interoception appears to be important with diagnosis of eating disorders as well as in disordered eating<br>Adaptive eating is described as eating in accordance with interoceptive signals undisturbed by emotional or external influences i.e., intuitive eating<br>IS may influence eating behaviours and body weight. |
| **(Herbert, et al., 2013)**. Germany | Psychology | Cross-sectional study including survey, heartbeat perception task and self-report measures (IES, STAI) (Descriptive) | Adults, females only n=111 | Interoceptive sensitivity (IS), interoception, interoceptive abilities | ADLs<br>*Eating/feeding*<br><br>Health management<br>*Nutrition management* | To clarify the relationships between IS, intuitive eating and body mass index (BMI) | Findings show the role of IS and acknowledgement of bodily signals (such as hunger, satiety) for adaptive eating behaviour and body weight regulation<br>IS and subjective awareness of body signals are independent processes, and both significantly predict eating according to hunger signals and satiety cues.<br>IS influences eating and feeding behaviours through the awareness and response to hunger and satiety signals. |

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| **(Herbert & Pollatos, 2014)**, Germany | Psychology | Experimental design including a heartbeat detection task (Quantitative) | Adults; 26.6% male and 73.3% female n=75 | Interoceptive sensitivity (IS), interoception | ADLs *Eating/feeding*<br><br>Health management *Nutrition management* | To examine interoceptive sensitivity among overweight and obese participants | IS was higher in normal weight participants compared to overweight or obese participants<br>Thus, overweight, and obese individuals may experience greater difficulties in detecting body signals due to reduced IS<br>Negative correlation coefficient was found between BMI and IS in overweight and obese participants<br>IS is likely to interact with regulation of food intake in everyday life, in allowing for the detection of satiety signals or changes |
| **(Koch A, 2014)**. Germany | Psychology | Longitudinal study including heartbeat perception task, self-report questionnaire (CEBQ) (Quantitative) | Children; 47.9% male and 52.1% female 6-11 years n=1657 | Interoceptive sensitivity (IS), interoception, interoceptive awareness (IA) | ADLs *Eating/feeding*<br><br>Health management *Nutrition management* | To examine the possible relations between IS, body weight and different eating disorders in children | No direct relation between IS and BMI were found<br>Only in overweight children external and emotional eating behaviour was predictive for later IS<br>Altered interoceptive processes followed rather than proceeded non-adaptive eating behaviour patterns in overweight children<br>Eating behaviour and IS are prospectively related to each other |
| **(Koscinski, 2018)**. United States of America | Occupational therapy | Book (Descriptive) | N/A | Interoception, interoceptive awareness (IA) | Social functioning<br><br>ADLs *Toileting Eating/feeding* | Outlines key themes in current literature related to interoception and occupational participation. Assessment and intervention for interoception. | Types of SPD defined as hyper-responsive, hypo-responsive, and mixed responsiveness |

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| | | | | | | | Interoceptive difficulties, related to responsivity, is likely to influence:<br>· Self-care including bowel and bladder management<br>· Eating and feeding; poor IA may impact on the ability to feel physiological cues<br>· Social function<br>Relationship exists between interoception and emotion. Interoception difficulties influence the ability to ask self how we feel which can impact on self-care<br>SPD may influence the ability to manage poor interoception, impacting on behaviour at work, school, in relationships |
| **(Mahler, 2017)**. United States of America | Occupational therapy | Book (Descriptive) | Not specific but does focus on ASD population. | Interoception, Interoceptive awareness (IA)n | Social participation<br><br>ADLs<br>*Toileting*<br>*Eating/feeding*<br><br>Health management<br>*Nutrition management* | Outlines key themes in current literature related to interoception and occupational participation.<br>Assessment and intervention for interoception. | Poor IA divided into three main categories: interoceptive overresponsivity – feeling internal states more readily, unresponsively – not noticing states/signals unless intense and interoception discrimination difficulty – not being able to pinpoint signals<br>Poor IA may affect:<br>· Emotional awareness and regulation<br>· Decision making, thought flexibility, awareness of self<br>· Toileting: either increased sensitivity to the need to eliminate bowels and |

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| | | | | | | | discomfort or not sensing the need to eliminate waste<br>· Hunger or thirst cues leading to feeling hunger or thirst frequently or missing cues<br>· Social participation; which was discussed in terms of three components; perspective taking and empathy, social touch, awareness of self |
| **(Martin, et al., 2019)**. United Kingdom | Psychology | Systematic review (Qualitative) | 104 studies included total of 32883 participants male and female<br><br>Majority of studies recruited females only (74%) | Interoception, interoceptive deficits | ADLs<br>*Eating/feeding*<br><br>Health management<br>*Nutrition management* | To evaluate the possible role of poor interoception as a predisposing factor in the development of disordered eating and eating disorders. | Majority of studies assessed interoception using questionnaires and some with heartbeat perception tasks<br>Deficits in interoception are associated with disordered eating behaviours<br>This was observed across eating disorder types and interoceptive modalities; gastric interoception, cardiac interoception and pain threshold; this included subclinical populations n=24)<br>There is limited evidence on the causal role of interoception in disordered eating. Interoceptive deficits are associated with disordered eating behaviours |
| **(Simmons & DeVille, 2017)**. United States of America | Neuroscience | Narrative review (Descriptive) | N/A | Interoception, Interoceptive, Interoceptive awareness (IA) | ADLs<br>*Eating/feeding*<br><br>Health management<br>*Nutrition management* | Review focuses on obesity may be related to hypersensitivity to interoceptive signals and overeating or obesity may arise | Obesity may be related to overresponsivity to interoceptive signals of hunger<br>Obesity may arise from an underresponsivity to interoceptive signals affecting the ability to accurately detect interoceptive signals of satiety |

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| | | | | | | from an inability to accurately detect interoceptive signals. | Altered interoception of satiety signals may contribute to obesity Interoceptive overresponsivity may undermine attempts to reduce unhealthy eating Findings support continued development of new interventions, focused on mindfulness or vagal nerve stimulation, for obesity aimed at promoting IA. |
| **(Wei & Van Someren, 2020)**. Netherlands | Neuroscience | Review (Descriptive) | N/A | Interoception, Interoceptive sensitivity (IS) | Sleep *Sleep participation* | Outline current knowledge about interactions between interoception and sleep. | Most represented themes discussed; impact of interoception on sleep initiation, roles of interoception during sleep, impacts of sleep deprivation on interoception, associations between interoception and habitual sleep and altered interoception in sleep disorders Interoception may hinder or support initiation of sleep or maintenance of sleep state Interoception relates to sleep participation while sleep deprivation may increase sensitivity to interoceptive signals such as pain |

## Appendix F – PRISMA-ScR Checklist (Tricco, et al., 2018)

| SECTION | ITEM | PRISMA-ScR CHECKLIST ITEM | REPORTED ON PAGE # |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a scoping review. | 0 |
| **ABSTRACT** | | | |
| Structured summary | 2 | Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives. | ii |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach. | 2 |
| Objectives | 4 | Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives. | 3 |
| **METHODS** | | | |
| Protocol and registration | 5 | Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number. | N/A |
| Eligibility criteria | 6 | Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale. | 22 |
| Information sources* | 7 | Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed. | 25 |
| Search | 8 | Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated. | 31 |
| Selection of sources of evidence† | 9 | State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review. | 25 |
| Data charting process‡ | 10 | Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators. | 26 |
| Data items | 11 | List and define all variables for which data were sought and any assumptions and simplifications made. | 27 |
| Critical appraisal of individual sources of evidence§ | 12 | If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate). | N/A |
| Synthesis of results | 13 | Describe the methods of handling and summarizing the data that were charted. | 27 |
| **RESULTS** | | | |

| SECTION | ITEM | PRISMA-ScR CHECKLIST ITEM | REPORTED ON PAGE # |
|---|---|---|---|
| Selection of sources of evidence | 14 | Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram. | 27 |
| Characteristics of sources of evidence | 15 | For each source of evidence, present characteristics for which data were charted and provide the citations. | 27 |
| Critical appraisal within sources of evidence | 16 | If done, present data on critical appraisal of included sources of evidence (see item 12). | N/A |
| Results of individual sources of evidence | 17 | For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives. | 28 |
| Synthesis of results | 18 | Summarize and/or present the charting results as they relate to the review questions and objectives. | 28 |
| **DISCUSSION** | | | |
| Summary of evidence | 19 | Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups. | 24 |
| Limitations | 20 | Discuss the limitations of the scoping review process. | 25 |
| Conclusions | 21 | Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps. | 26 |
| **FUNDING** | | | |
| Funding | 22 | Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review. | N/A |

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

## Appendix G – Proofreading and language work certificate


Gill Smithies

Proofreading & Language Editing Services

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Work Certificate

| | |
|---|---|
| To | Ms. M. L. Wijnberg |
| Address | Faculty of Health Sciences, University of the Witwatersrand, Johannesburg |
| Date | 21/02/2022 |
| Subject | THE INFLUENCE OF INTEROCEPTION ON ENGAGEMENT IN OCCUPATION: A SCOPING REVIEW |
| Ref | MLW/GS/01 |

I, Gill Smithies, certify that I have proofed the following for grammar, language and style,

Scoping Review: The influence of interoception on engagement in occupation,

to the standard as required by the University of the Witwatersrand.

Gill Smithies

Work Certificate