Thriving at School: how interoception is helping children and young people engage in learning everyday

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Abstract Children thrive at school when they are supported to attend, take in and process information, and interact positively with their peers and educators. Children who are neurodiverse, disenfranchised or traumatised can have difficulties with emotional self-regulation, and experience higher rates of disengagement and suspensions as well as poorer learning outcomes relative to their peers. In response to teacher requests for more effective supports for dysregulated students, a programme grounded in universal design, is indicating that teaching interoception skills to all students can positively influence their engagement and achievement in the classroom, and shift a school's culture to being more pro-social, in South Australia.

This paper provides an overview of interoception and its role in emotional cognition, expression and regulation. Interoception, the conscious perception of internal body signals, tends to be atypical in people with developmental disabilities, mental health disorders, trauma, intergenerational trauma, and chronic stress. Using the activities developed in South Australia, and effectively implemented across over 250 preschools and schools across the state, this paper will explain how educators, families and other professionals can implement a range of interoception activities to support well-being and engagement in the home, schools, and other contexts, such as justice, mental health, and aged care.

Two practical tools to use with children and adults to support the development of self-awareness and connectedness in a positive and non-judgemental manner will be presented. These tools are being used in schools and preschools across South Australia as well as schools in New Zealand as a universal design for learning strategy. Children and young people and their educators have shown improvements in interoceptive awareness over time, and demonstrated more effective self-regulation and pro-social behaviour. Results from the South Australian and New Zealand implementation have demonstrated that through using these tools, professionals improve their understanding of the children and young people whom they are working with, increasing effective support for well-being and engagement in learning. The activities and practical skills learned in this workshop are equally applicable in the home, and can be used by families.

Keywords: interoception, self-regulate, emotional cognition, engagement, learning, pro-social, universal design

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Schools and preschools can be challenged to effectively manage dysregulated children and young people, with research indicating educators are still locating difficulties as 'within the students' (Sullivan, Johnson, Owens & Conway, 2014). These difficulties may be due to developmental disabilities, disenfranchisement, or trauma, including intergenerational trauma. Dysregulation has a major impact on educational outcomes, resulting in higher rates of disengagement, suspensions, poorer learning outcomes and difficulties engaging in pro-social behaviours, (Füstös et al., 2012; Slutske, Moffitt, Poulton, & Caspi, 2012; Moffitt,

Poulton, & Caspi, 2013; Nigg, 2017). Self-regulation is a concept referring to an individual's ability to manage and helpfully express their own social-emotional behaviours, emotions, wants, and needs (Heatherton & Tice, 1994). Self-regulation can be triggered by the need to self-manage to achieve bodily homeostasis. Dysregulation, following self-management needs are implicated in increased physical and mental health difficulties and lower life outcomes for children impacting social and academic outcomes (Nigg, 2017).

Self-regulation can be thought of holistically or divided into three separate facets; cognitive, emotional, and behavioural (Murray, Rosanbalm, Christopoulos, & Hamoudi, 2015). Cognitive self-regulation involves focused attention, decision making and executive functioning, emotional self-regulation refers to the ability to recognise and respond helpfully to one's emotions and behavioural self-regulation can be demonstrated through behaviours such as following rules, impulse control, working towards goals, and conflict resolution (Murray et al., 2015). Self-regulation has been found to be positively correlated with psychological wellbeing including aspects of personal growth and relatedness, life purpose, and self-acceptance (Singh & Sharma, 2018). In line with the research finding that self-fulfilling prophecies have a significant impact on educational and wellbeing outcomes for children and students, using a proactive model should impact positively on both schools and preschools as well as children and students (Zyngier, 2007). The South Australian trial was multi-dimensional universal design response to the Disability Standards in Education Act 2005 (DSE), aiming to proactively increase self-regulation skills and pro-social behaviour through an attitude to include all students. This response was conceptualized using the model in Figure 1 below:

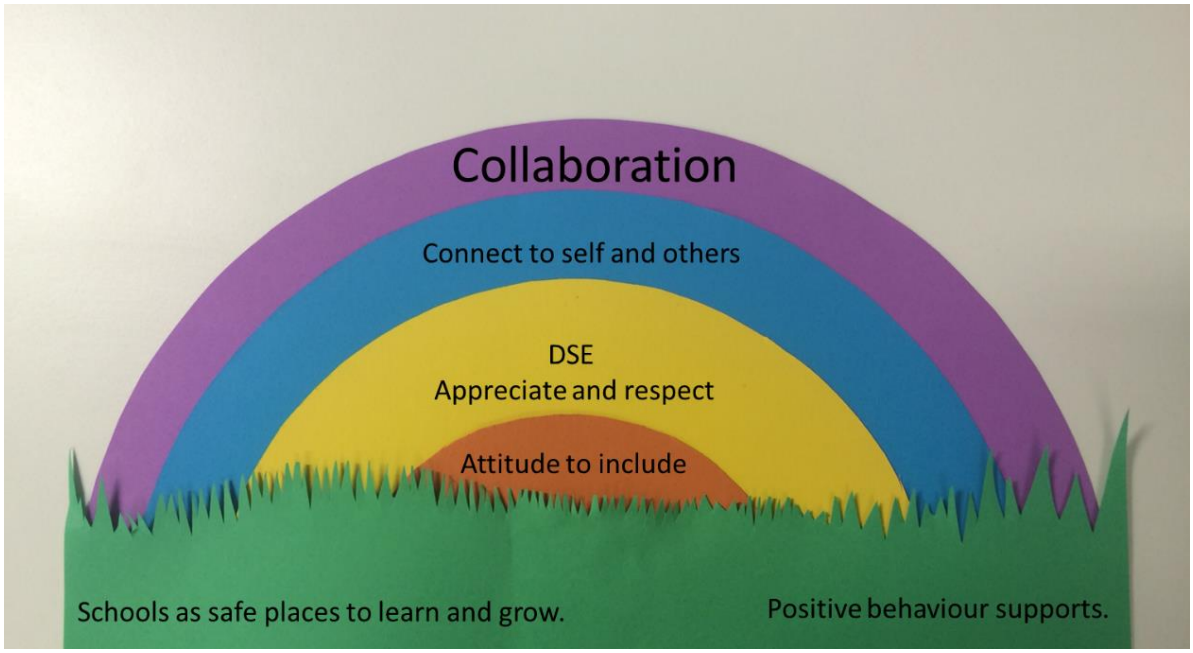

Figure 1: Rationale for the interoception trial

The explicit links to universal design principles as conceived and developed by The Center for Universal Design at North Carolina State University, were reviewed prior to designing the interoception intervention trialled over a two year period, as recorded in table 1.

Principles of Universal Design (UD)[1]	**Principles behind the interoception trial**
1 Equitable use – useful and accessible to all	1 Equitable access to education
2 Flexibility in use – accommodates a wide range of abilities and preferences	2 Flexibility in curriculum design and implementation
3 Simple and intuitive – easy to implement for all ages/stages	3 All sites/staff know how to respond inclusively to all students
4 Perceptible information – user information is clear and accessible for all	4 Teaching creates accessible learning for ALL students
5 Tolerance for error – minimizes unintended adverse consequences	5 Attitude to include minimizes risks of unlawful barriers
6 Low physical effort – not tiring to implement	6 Effective and efficient way to meet DSE for schools and staff
7 Size and space for approach and use – able to be implemented in spaces small and large and for children/adults of all sizes and physical abilities	7 Appropriate supports provided as needed to ALL, in class or outside and/or in a dedicated space

Table 1: Review of interoception trial to ensure it met principles of UD

The interoception trial was based on an attitude to include all students, including those traditionally suspended or excluded. This came out of a collaboration between education services, support services, schools and preschools and the communities they serve. A key part of the whole site (school or preschool) interoception approach, through true collaboration, was to provide a flexible and individualised response to ensure all students could access education, both in class and in outdoor and off site activities. Appreciation and respect for the individuality of students, with their personal profiles of strengths and support needs was central to the interoception trial which aimed to upskill schools to enable students to connect to themselves and to others using a proactive positive behaviour support. Underpinning the interoception trial was the belief that schools should be safe places to learn and grow for all.

When contemplating the reactions of educators to children and young people presenting with dysregulated behaviours, it is important to note that Sorhagen (2013) found that the expectations of teachers in the first few years of education disproportionately affect student outcomes in high school. The relationship was compounded where students came from low socio-economic backgrounds. Other researchers have found that low expectations are often present for students with behavioural challenges and/or disabilities, particularly those identified as having an intellectual disability and these low expectations are known to lead to fewer educational opportunities and poor outcomes (Shifrer, 2013).

Although self-regulation skills usually develop in early childhood, the neuroplasticity of human brains allows it to be taught and learnt throughout the life span (Aikens, Klein, Tarullo & West, 2013). Interventions teaching adolescents self-regulation strategies have been found to improve self-esteem and internalising behaviour (van Genugten, Dusseldorp, Massey & van Empelen, 2017), whilst emotional dysregulation was found to be linked to suicidal behaviour and ideation (Davey, Halberstad, Bell, Collings, 2018).

Many children enter preschool without effective self-regulation (Montroy, Bowles, Skibbe, McClelland, & Morrison, 2016), especially those with neurodevelopmental disabilities and those who have experienced trauma. The theoretical influence of parenting and attachment style on a child's later development of interoception and self-regulation provides a logical

explanation for the atypical development of interoception in individuals without neurodevelopmental disabilities. Infants associate interoceptive feelings of warmth and safety with visual cues of their parents' face, which helps develop a secure attachment to them, thus helping predict more successful emotional regulation later in life (Murphy, Geary, Millgate, Catmur, & Bird, 2017).

Children who receive unresponsive or non-interactive parenting can develop deficits and struggle to develop their ability to recognise bodily sensations, show lower levels of emotional recognition and awareness, increased alexithymia, decreased academic and social function and develop fewer self-regulation strategies (Abraham, Hendler, Zagoory-Sharon & Feldman, 2019). Due to this decreased interoceptive sensitivity, they often show a disconnect between their external environment and internal body state, which can lead to social problems and a poor sense of self (Murphy et al., 2017).

Furthermore, a meta-analysis of several studies found that Parent-Child positive synchrony is positively correlated with self-regulation by the child (Davis, Bilms, & Suveg, 2017). The emotional regulation of a child is also influenced by their parents' emotional regulation. Parents/caregivers who exhibit poor emotional regulation often have children with the same emotional deficit (Gallagher, 2017). Whether this is due to modelling and observational learning, or due to genetic and biological factors is unclear. However, this is likely caused by an interaction of multiple factors. Taken together research indicates that parenting styles which promote secure attachment and high parent-child synchrony aid in the development of socially, emotionally, and interoceptively aware and regulated children.

Research has indicated that attachment style may be a predictor of future Post Traumatic Stress Disorder (PTSD) development. Secure attachment is correlated with a decreased risk of developing PTSD following trauma which suggests it could be a protective factor in the face of trauma. Decreased attachment security is linked to poor emotional regulation strategies which may contribute to the development of PTSD as a trauma response (Benoit, Bouthillier, Moss, Rousseau, & Brunet, 2010). Furthermore, maternal PTSD is associated with insecure and disorganised attachment styles, which may then lead to subsequent PTSD development in the child (Enlow, Egeland, Carlson, Blood & Wright, 2014). People with trauma, including that which has been transmitted intergenerationally, are known to experience significant negative impacts on wellbeing and lower individual's interoceptive abilities and self-regulation. Intergenerational trauma, which is the transmission of trauma from one generation to the next, has been identified in multiple populations around the world. One population that experiences intergenerational trauma includes the descendants of the Stolen Generations of Australia. Descendants of refugees, first people populations subject to colonisation, and those who lived through war all experience the lasting effects of trauma through their families (Sangalang & Vang, 2017), with some experiencing PTSD.

The negative impacts of dysregulation can be mitigated if families, professionals, and the education system can effectively improve children's self-regulation. Without self-regulation children are unable to engage in learning activities (Blair & Raver, 2015) and with dysregulation comes higher rates of internalising and externalising (disruptive) behaviours and less engagement in learning. Both families and educators can struggle to manage highly dysregulated children and young-people. Facilitating the development of self-regulation in early childhood, offers the potential to ensure early education is accessible to and effective for all children (Blair & Raver, 2015).

Both behaviour and emotions have a contextual element, whereby individuals carry out actions or express emotions in response to their thoughts and/or their experiences of the context around them (Wilutzky, 2015). Grecucci, Koch, and Rumiati (2011) reported that emotions can also impact imitative actions (for example if someone screams, people around are more likely to scream). Mayer, Salovey, and Caruso's (2008) suggest that emotional intelligence relies on individuals processing complex information about their own and others' emotions, to guide resultant behaviour. Thus, you need to be aware of what emotions you are experiencing, in order to process your own emotions.

This awareness is a key aspect of interoception, which is sometimes referred to as somatic awareness, and colloquially known as the eighth sense with the other seven being; proprioception, vestibular, sight, hearing, taste, smell, and touch (Lynch & Simpson, 2004). While most people are familiar with sight, hearing, taste, smell, and touch, the vestibular and proprioception senses are less well known and are focussed on the awareness of the whole body. Vestibular refers to our sense of balance, which is governed by the inner ear and proprioception refers to the sense of where our body is placed in space, for example where our head ends and space starts, which is useful to prevent us banging our heads on overhanging objects. Theoretically interoception can be described as mindful body awareness, as it is the conscious perception (mindful) of internal body signals (body awareness).

Much like the other senses, interoception has at least two components; interoceptive awareness and interoceptive accuracy (Calì, Ambrosini, Picconi, & Mehling, 2015). Interoception is implicated in both maintaining homeostasis and regulating emotions (Badoud & Tsakiris, 2017). Interoceptive awareness refers to metacognitive abilities relating to an individual's own bodily performance (Garfinkel, Tiley, O'Keeffe, Harrison, Seth, & Critchley, 2016), that is to say the individual is aware of their internal body signals in relation to the body's needs (for homeostasis) and wants (emotions). Researchers have currently referenced interoceptive accuracy as reflecting accurate interpretations of the of heartbeat detection, with little research currently on more general accurate perception of internal body signals (Garfinkel, Seth, Barrett, Suzuki & Critchley, 2015).

Interoception atypicality is implicated in many psychological and developmental disorders such as Alexithymia, Anxiety, Autism Spectrum Disorder, Depression, Eating Disorders and Schizophrenia. Due to the involvement of poor interoception in so many mental health conditions, it has been proposed that it could be the underlying factor of these conditions (Murphy et al., 2017). Targeting interoceptive abilities early in development may be an effective way to decrease the risk of developing psychological disorders later in life, by increasing the ability of individuals to self-regulate through facilitating their awareness of their internal body states, feelings, and emotions. This is in line with Mayer et al.'s (2008) four branches of their model of emotional intelligence, for which interoception underlies each branch, indicating that improving interoception will increase emotional intelligence overall, as well increasing the ability to self-regulate.

High interoceptive accuracy has been found to be positively correlated with self-reported levels of body satisfaction, positive thoughts about one's body and perceived control over their body, and lower levels of hypochondriac symptoms (Duschek, Werner, del Paso & Shandry, 2015). In contrast, children with lower interoception, such as those on the autism spectrum with decreased self-regulation struggle to behave in prosocial ways and are less well emotionally and behaviourally engaged (Jahromi, Bryce & Swanson, 2013), and have high levels of eating disorders (Huke, Turk, Saeidi, Kent, & Morgan, 2013). Emotional

regulation has also been linked to prosocial peer engagement, which can be problematic for autistics as social communication difficulties are a core diagnostic characteristic for autism (Jahromi, Bryce & Swanson, 2013).

A neuroimaging study found that those with PTSD show decreased anterior insular cortex activation during affective set shifting, suggesting a difficulty in activation of neural networks involved in shifting emotional states and interoceptive adaptation (Simmons, Strigo, Matthews, Paulus & Stein, 2009). Trauma may also affect self-regulation as evidenced in PTSD patients and adolescents with additional early life stress (Lackner, 2018). In both cases, we propose that the effects of trauma are correlated with both decreased or abnormal self-regulation (Lackner, 2018) and atypical interoception (Mehling et al., 2017).

At a neuroanatomical level, interoception has mostly been linked to; the insular cortex (IC) and the anterior cingulate cortex (ACC) (Badoud & Tsakiris, 2017). The IC is thought to be the "centre" of interoception, integrating physiological and emotional perception whilst the ACC has been implicated in the perception of interoceptive signals (Couto et al., 2015). However, there is evidence that the medial temporal lobe (MTL) is also critical to develop interoception. Berriman, Stevenson, Thayer, Thompson, Mohamed, Watson, and Miller's (2016) animal lesion study supported this theory when it discovered that removal of the hippocampus was followed by dysregulation of hunger and satiety.

Craig (2009) found that activation of the Anterior Insular Cortex (AIC) was involved in mechanisms requiring human awareness. These mechanisms include; attention and goal directed attention, cognition, music, time perception, and awareness of sensation, movement, visual information, and auditory information. Craig proposed that the neural basis of awareness relies on the awareness of the physiological state of one's body (Craig, 2009). Neuroanatomical evidence suggests that interoception and emotions may be neurologically linked. For example, emotional feelings, which trigger joint activation of the AIC and ACC, which are both involved in interoception, and thus interoception and emotions may be based in similar neural networks, or indeed relate directly (Craig, 2009).

In addition, emotional knowledge, emotional regulation, and empathy are all positively correlated with cognitive regulation, knowledge, and processing, which suggests a link between emotional intelligence and metacognition (Mahasneh, 2014). Cognition and emotion can also be linked through the functional connectivity of neural networks, with the "Salience" network including the AIC, ACC, amygdala, and hypothalamus. The Salience network is known to be involved in emotions, whilst the "Executive control" network includes the dorsolateral prefrontal cortex and parietal areas. Areas of the AIC and MPFC near the ACC are seen to be activated in both networks, suggesting a connectivity between cognition and emotion (Seeley et al., 2007).

Social Cognitive Theory of Self-regulation states three processes are required to self-regulate; consistent self-monitoring of the causes and effects of one's own behaviour, judgment of behaviour in relation to personal values and context, and affective self-reaction (Bandura, 1991). Self-monitoring is the noticing of self, both internal and external body signals, which by definition includes interoceptive awareness; the conscious perception of internal body signals. Bandura posited that self-regulation depends on a negative feedback mechanism of self-monitoring (Bandura, 1991). Negative feedback mechanisms are homeostatic in nature as they detect deviations from the optimal state in order to initiate behaviour that drives allostasis. Therefore, self-regulation can be viewed a critical part of maintaining homeostasis. Self-control can be defined through different measures such as willpower, delay of

gratification, self-discipline, and self-regulation. Thus, those with optimal self-control are able to regulate their behaviour, emotions and attention in order to achieve their long-term goals (Duckworth & Kern, 2011).

Moffit et al. (2011) found that children with poor self-control, defined as a difficulty delaying gratification, went on to be more likely to have poorer health, less wealth, and higher rates of substance abuse and criminal offenses in adulthood. This effect was found to be separate from intelligence and social status, which were correlated with life outcomes (Moffitt et al., 2011). Children who were highly dysregulated at age three have been found to be more likely in adulthood to develop and experience; gambling problems, substance dependence, financial struggle, poorer parenting skills, poorer health, employment difficulty, interpersonal conflict and higher rates of criminal offending, (Slutske et al., 2012; Moffitt et al., 2013). As it may be easier to improve self-regulation in children than it is to improve their social-economic status or overall intelligence, targeting the improvement of self-regulation skills in young children would seem likely to effectively improve outcomes in adulthood.

Interoception has been found to be associated with emotional processing, emotional regulation, and self-compassion, suggesting that the ability to sense one's internal body states is fundamental to Emotional Intelligence (Gawande et al., 2019; Kanbara & Funkunaga, 2016). In addition, Garfinkel and Critchley (2013) found evidence to suggest that emotions are experienced as being more intense when there is increased interoceptive sensitivity to bodily sensations. In contrast, people have difficulty processing and expressing emotions, such as those with alexithymia, often show decreased interoception and tend to focus on exteroceptive over interoceptive signals (Davey et al., 2018; Kanbara & Funkunaga, 2016).

Together, these results suggest that interoception, metacognition and emotional intelligence are all linked and when combined, provide the basis of human self-awareness and self-regulation (Füstös et al., 2012). Without interoception, it is probable that children and young people will be unable to develop metacognitive emotional abilities (Goodall, 2016). In order to improve interoception and therefore self-regulation, the ability to notice internal body signals interoceptive awareness needs to be increased. This requires a level of neuroplasticity to ensure the brain circuits involved in interoceptive awareness are activated.

Researchers have shown that, neuroplasticity, the ability of the human brain to create new connections or neurons (neurogenesis) throughout life (Eriksson, Perfilieva, Björk-Eriksson, Alborn, Nordborg, Peterson, & Gage, 1998; Garland & Howard, 2009). The principal finding of neuroplasticity is that the human brain can create new connections and in effect learn new skills throughout the lifespan, and that even significant damage to the brain can, with effective therapies, rewire itself to compensate or mitigate the damage. For example, improved functional connectivity between the posterior and anterior insula have also been observed following interventions (Farb, Anderson & Segal, 2013).

Principles of neuroplasticity suggest that through feedback mechanisms within the brain, the representation of information selectively enables plastic changes that affect brain connections throughout the lifespan (Nahum, Lee, & Merzenich, 2013). For example, the events held in and attended to by working memory; selectively guide individuals to certain activities which sharpen and refine brain connections through learning (Ahissar, Nahum, Nelken, Hockstein, 2009). Neuroplasticity is "primarily expressed by a change in connectional strength at the synapse level, achieved both by increasing the powers and the numbers of synapses specifically supporting a progressively improving behaviour" (Nahum, Lee, & Merzenich, 2013, p.144). This idea is encapsulated in the iconic phrase "what fires together wires

together", coined by Hebb (1949). These principles of neuroplasticity have also been implicated in teaching individuals with diagnoses of post-traumatic stress disorder to self-regulate behaviour (Mehling et al.,, 2018).

Brain reorganisation linked to the physical body (somatotopic) was first demonstrated in primates (Jenkins et al., 1990), with the discovery that changes in cortical space in the motor cortex following directed physical training in primates. This was replicated in humans in 1995 when string players were found to have increased cortical areas dedicated to the movement of their left fingers. This increase varied as a function of the length of time they had been playing (Elbert et al., 1995). In contrast the van der Kolk's (1994) theorem was that the physical body contains markers indicating trauma experienced by people, so the body is changed by the brain. Dzubur Kulenovic (2017) tested this theorem and found that individuals with PTSD had significantly higher levels of all plasma lipid parameters (cholesterol, triglycerides, VLDLC, and LDLC) and a significantly higher risk for coronary disease and significantly lower HDLC concentration. Both sets of research indicate a link between body and brain.

Other studies looking at behaviour and brain changes have found that mindfulness interventions such as Mindfulness-Based Stress Reduction (MBSR) and Mindfulness Training (MT) using Interoceptive Awareness (IA) can alter the brain's structure including changing the grey matter density and improving functional connectivity of related areas. This improved functional connectivity of the areas related to interoceptive awareness, should increase the self-regulation skills and emotional intelligence of children and young people who are currently struggling to identify and/or express their emotions helpfully.

An 8-week Mindfulness-Based Stress Reduction (MBSR) intervention discovered that participants experienced decreased stress, which was directly correlated to decreased grey matter density in the right basolateral amygdala, a limbic structure involved in fear and anxiety (Hölzel et al., 2009). A neuroimaging study found that following MBSR training there was an increase in grey matter density in the posterior cingulate cortex (PCC), hippocampus, temporo-parietal junction (TPJ) and cerebellum (Hölzel et al., 2009). The hippocampus is implicated in memory and is thought to be involved in emotional regulation, with smaller hippocampi observed in patients with major depression and post-traumatic stress disorder (Hölzel et al., 2009).

The cerebellum also aides in emotional and cognitive regulation whilst the cingulate cortex as a whole is accepted in its involvement in interoception (Badoud & Tsakiris, 2017; Murphy, Brewer, Catmur, & Bird, 2017). The TPJ has been found to be important in embodiment and experiencing the body "as a whole" (embodied sense of self) and also is involved in social cognition (Hölzel et al., 2009). Improved functional connectivity between the posterior and anterior insula have also been reported following Mindfulness Training, implicated in improving interoception (Farb, Segal & Anderson, 2013). Given these potential adaptations, behaviour, the actions and expression of the body, including self-regulation of behaviours and emotions are assumed to a product of brain systems, and thus can potentially be changed through changing brain systems according to neuroplasticity (Nahum, Lee, & Merzenich, 2013).

There is a paucity of current research specifically examining the relationship between developing interoceptive awareness and improving self-regulation. An exception is Füstös et al.'s (2012) paper, which stated that "One prerequisite of successful emotion regulation is the awareness of emotional states, which in turn is associated with the awareness of bodily

signals [interoceptive awareness] (p.1). This paper demonstrated that interoceptive awareness is required to continually reappraise the body's states, in order to manage those states, including emotions. Concluding that "the perception of bodily states and their meta-representation as somatic markers are an essential prerequisite for adequate emotion regulation" (p.6). This clearly suggested that the awareness of emotional states is a prerequisite of successful emotion regulation, which in turn requires the awareness of bodily signals [(interoceptive awareness [(IA]).

Other researchers specifically linking the perception of bodily changes (interoception) with emotional and cognitive processes made no suggestions as to how to improve interoceptive awareness, nor if doing so actually increases emotional and behavioural self-regulation (James, 1884; Damasio, 1994; Craig, 2004). A more recent study from Zamariola, Frost, Oost, Corneille & Luminet, 2(019) examined the relationship between interoception and emotional regulation using a mixed methods approach. The results suggested that those with higher interoception were more positive when faced with challenges and had better awareness of the effectiveness of their regulation strategies. In comparison, those with low interoception reported feeling confused in the face of negative emotions.

One commonality shared by interoception and self-regulation is their required input into sustaining homeostasis. Driven by negative feedback mechanisms detecting deviations from the set point of factors such as temperature, pH, and oxygen levels, homeostasis drives activity to return the body to equilibrium (McEwen, 2016). One aspect of homeostatic balance is the interplay between the sympathetic and parasympathetic branches of the autonomic nervous system (ANS) (Nirmalan & Nirmalan, 2017). The ANS is responsible for regulating the internal environment and innervating the blood vessels, visceral organs, and glands. The sympathetic branch activates the body for activity, especially in response to a threat. This is commonly known as the "Fight or flight" response, or more accurately the survival response, which includes not just fight or flight, but also freeze, flop, or drop. The parasympathetic nervous system activates gastrointestinal and urinary functions and thus is coined to be responsible for "rest and digest" (Hans, Kachlík, & Tubbs, 2018). Both self-regulation and interoception interact with the parasympathetic and sympathetic nervous systems and thus appear to be linked in some way (Domasio & Dolan, 1999; Domasio, 2010).

Self-regulation strategies may be able to help students in maintaining autonomic homeostasis whilst under the stress of examinations or experiencing stressors in other contexts. The effect of self-regulation strategies including focusing on breathing, body relaxation with autogenic training, and mentally visualising themselves passing the exam were examined. These techniques were found to increase activity of the parasympathetic nervous system, thus helping balance out the activation of the sympathetic nervous system due to the perceived threat of the exam (Shcherbatykh, 2000). Activities such as focusing on breathing and on the body involve focusing on interoceptive signals of the body, and thus demonstrate how interoceptive awareness can improve homeostasis and counteract sympathetic nervous system dominance or overload.

Pertinent for post-crisis, targeted therapeutic approaches have been developed which attempt to resolve the underlying problems with interoceptive functioning in individuals who have experienced trauma. Somatic Experiencing Therapy (SET) focuses on interoceptive awareness of somatic sensations in order to treat those with trauma-induced psychological distress (Payne, Levine, & Crane-Godreau, 2015). It focuses attention on interoceptive, proprioceptive, and kinaesthetic sensations in order to regulate the Core Response Network

(CRN). The CRN is comprised of the autonomic nervous system, emotional motor system, reticular activating system and limbic system. It is hypothesised that regulating activity of these interconnected systems may help reduce psychological distress (Payne, Levine & Crane-Godreau, 2015). SET has been used to treat social service workers from Hurricane Katrina and Rita and found that it decreased psychological distress and increased resilience (Leitch, Vanslyke & Allen, 2009). Mind Awareness Body Therapy (MABT) has also found to be effective in treating trauma patients through interoceptive awareness. MABT connects the patient with their internal states in order to improve emotional processing and regulation. Research indicates this has been beneficial with trauma patients, as these individuals often find it difficult to be attuned to their interoceptive state (Price & Hooven, 2018).

The Department for Education in South Australia has trialled teaching interoception as a strategy for developing self-regulation and decreasing challenging behaviour for two years and is now rolling this strategy out state wide, with over 250 schools currently implementing interoceptive awareness teaching as a proactive positive behaviour management strategy. These schools teach students Siegal's (2010) 'Hand model of the brain' and a regulation scale based on the link between the expression of their autonomic nervous system and the hand model of the brain. Educators were also taught how interoception relates to the mindfulness part of the brain, to explain why students can move into a state of being 'ready to learn' through using the variety of interoception activities provided free via resources from the Department for Education's website, that educators can use together or separately to introduce and teach interoception:

- Ready to Learn – Interoception Kit (2019) for preschools and primary schools, families and allied health professionals;
- Interoception Activity Guide 301 (2019) for upper primary, intermediate and secondary schools, families and allied health professionals;
- YouTube videos about interoception and managing behaviour (Healthy Possibilities, 2019); and
- Linking Interoception to the Australian Curriculum, General Capabilities and Embedding in Classroom Practices (Goodall & McAuley, 2019).

Initial data from a range of schools, confirmed observations of a significant decrease in challenging behaviour over 8-10 weeks of implementation, with pro-social behaviour increasing after 16-20 weeks (Goodall, 2016). Data analysis demonstrates that after one year, these decreases are sustained with suspensions and other negative behaviour consequences dropping significantly in both primary and high schools. Qualitative data, collected over three years, suggests that once teachers have committed to implementing interoception two to three times a day, they see positive impacts within a term:

> "Students will even ask when we are going to do our interoception if I have forgotten. They really feel the benefit of it." Class teacher

Data repeatedly found that leadership in schools implementing interoception, felt that teaching interoception was not just improving the ability of individual students to self-regulate, but was impacting the overall culture of the school:

> "I am no longer spending all day on behaviour, but can actually focus on doing my job." Principal

Students were asked about what they understood interoception to be, and what they thought about it. All students responded in ways that illustrated a clear understanding that interoception was noticing their body signals and then being able to respond appropriately to those signals:

> "I hit all the time before interoception, now I don't." Student

> "Before I would get angry all the time. With the interoception, I just do the pulse activity and then I can control my anger." Student 2

In summary, the Department for Education's interoception trials implemented a universal design approach to decreasing challenging behaviour. This approach focused on the theoretical link between self-regulation and interoception and how these can be targeted through teaching to promote psychological, emotional and physical health and wellbeing. Results clearly demonstrated that students being taught interoceptive awareness activities, increased their self-regulation and pro-social skills over time. Effects were statistically significant in both primary and high school, with improvements equally observable in pre-school settings.

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