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An exploration of sensory processing patterns and their association with demographic factors in healthy adults

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Abstract

Purpose – Previous research has provided limited evidence on whether and how demographic factors associate with sensory processing patterns (SPP) in adults. This paper aims to examine relationships between SPPs and sociodemographic factors of age, sex, education and ethnicity in healthy adults.

Design/methodology/approach – A cross-sectional study design was used. A total of 71 adult participants was recruited from the community, using convenience sampling. Each participant completed the Adolescent/Adult Sensory Profile (AASP) and the Depression Anxiety Stress Scales – short version (DASS-21). Demographic information on age, sex, education and ethnicity was collected. Results were analysed using descriptive statistics and multivariate analyses of covariance (MANCOVA).

Findings – SPPs, as measured by the AASP, were significantly correlated to demographic factors of age and education after controlling for emotional distress using the DASS-21. A statistically significant multivariate effect was found across the four dependent variables (low registration, seeking, sensitivity and avoiding) for the age category, $F = 6.922$, $p = 0.009$, $\eta_p^2 = 0.145$, in the presence of a covariate DASS. The education category showed significance only in the seeking domain ($p = 0.008$, $\eta_p^2 = 0.10$) after controlling for DASS. There was no significant correlation between SPPs and gender or ethnicity. Results also indicated that mean scores of participants in this study were "similar to most people" as standardised in the AASP.

Research limitations/implications – This was a cross-sectional study with limitations including that the study used a relatively small sample and was based on self-reported healthy participants.

Practical implications – SPPs may correlate with healthy adults' age and to a lesser extent education. This suggests that it might be helpful to consider such demographic factors when interpreting SPPs in clinical populations, although further research in larger samples is needed to reach firmer conclusions about possible implications of demographic variables.

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Originality/value – The findings in this paper add to the growing evidence that suggest that SPPs vary with sociodemographic factors.

Keywords Sensory processing, Healthy adults, Age, Gender, Education, Ethnicity

Paper type Research paper

Introduction

Sensory processing is a concept that summates the human being's ability to receive, organise and use sensory information in everyday occupations. Some authors have referred to this ability as being an essential component of preparation for use of sensory information in everyday life (Ayres, 2005; Miller and Lane, 2000). Sensory processing and behavioural patterns have been studied in clinical populations, primarily with children (Blanche *et al.*, 2014; Koenig and Rudney, 2010). Sensory processing patterns (SPPs) in adults and their associations with demographic factors and behavioural patterns are less understood. The Adolescent/Adult Sensory Profile (AASP) is a 60-item, standardised self-report questionnaire for people aged 11 years and over (Brown *et al.*, 2001). The purpose of this study was to examine the associations of SPPs with age, sex, education and ethnicity in healthy adults. Increased understanding of how to interpret individuals' SPPs is necessary for intervention planning when addressing what an individual wants to do, needs to do or is expected to do.

Literature review

Sensory processing

Sensory processing refers to a person's ability to take in, organise and respond to sensory information in the context of his or her environment (Dunn, 2001). SPPs are not diagnostic categories but styles of managing sensory information. Every individual is unique in that they vary in their sensory preferences and in the style of processing sensory information (Brown, 2002; Dunn, 2007).

The most well-researched and widely used model of conceptualising sensory processing in occupational therapy literature was developed by Dunn (1997). Dunn's (1997) model views these styles as a result of the interaction of neurological thresholds and behavioural self-regulation strategies. On the neurological threshold axis, a low threshold indicates that the individual needs little sensory information to register the stimuli and a high threshold indicates that a lot of stimulation is needed (Brown *et al.*, 2001; Dunn, 2001; Hebert, 2015). People with low neurological thresholds often show fear, negative affect, anxiety, rigid and controlling behaviours including aggressive responses or sensory avoidance (Engel-Yeger and Dunn, 2011a, 2011b, 2011c). On the behavioural self-regulation axis, individuals use behavioural strategies ranging from passive to active to deal with sensory input. Dunn (1997) identified four sensory processing styles:

(1) *Low registration* is where individuals have a high neurological threshold and a passive behaviour strategy, where they are either bystanders or passive self-regulators to sensory input. Individuals with Low Registration may have difficulties with recognising and expressing internal emotional states and interpreting emotions from others' behaviours (Dunn, 1997).

(2) *Sensation seeking* is when individuals have a high neurological threshold and an active behavioural strategy where they self-regulate by seeking sensory input. Sensation seekers enjoy intense sensory environments, and this often manifests as risk-taking behaviour (Brown *et al.*, 2001; Dunn, 2001; Hebert, 2015).

(3) *Sensation avoiding* is when individuals have a low neurological threshold and an active behavioural response characterised by sensory over-responsivity, also called sensory defensiveness, or heightened arousal accompanied by feelings of discomfort and anxiety (Blanche *et al.*, 2014).

(4) *Sensory sensitivity* is when individuals have a low neurological threshold and a passive behavioural strategy. They have difficulties in the detection of, and reaction to, sensory information, including information from the taste, touch, vision and smell senses (Dunn, 2014). Sensory sensitivity predisposes individuals to be more sensitive to sensory input and reflects increased functioning of the behavioural inhibition system (Aron *et al.*, 2012). Individuals with Sensory Sensitivity show increased emotional, biological and stress reactivity to sensory stimuli (Aron *et al.*, 2012). This implies that those people who are highly sensory sensitive are susceptible to being overwhelmed by sensory stimuli and are likely to experience the world as highly unpredictable provoking anxiety. As an example, children with sensory processing problems are often unable to filter out responses to repeated sensory information (Davies *et al.*, 2009).

Sensory processing in healthy adults

Studies of sensory processing in adults have investigated relationships between sensory processing styles and behavioural, cognitive or emotional responding in either healthy individuals or clinical populations (Chung, 2006; Engel-Yeger and Dunn, 2011b, 2011a, 2011c; Engel-Yeger and Shochat, 2012; Hebert, 2015; Pohl *et al.*, 2003). Consistent with Dunn's model, previous studies have concluded that an adult's reactions to daily sensory experiences reflect both a particular sensitivity threshold (high or low) and a particular self-regulation or responding strategy which is either passive or active (Dunn, 2014).

In healthy adults, studies have found that individuals with Sensory Sensitivity and Sensory Avoiding processing patterns have greater anxiety, neuroticism and negative affect (Engel-Yeger and Dunn, 2011a, 2011c), as well as elevated pain catastrophising (Engel-Yeger and Dunn, 2011b) and more sleep problems (Engel-Yeger and Shochat, 2012). Similar, but smaller magnitude, correlations have been shown between Low Registration in healthy adults and greater anxiety, neuroticism, negative affect and pain catastrophising (Engel-Yeger and Dunn, 2011b, 2011a, 2011c). Low Registration did not correlate with sleep problems (Engel-Yeger and Shochat, 2012) but did correlate with higher impulsivity in healthy adults (Hebert, 2015). In contrast, a Sensation Seeking pattern on the AASP tends to correlate with more adaptive behaviour, such as higher positive affect (Engel-Yeger and Dunn, 2011a) and lower sleep disturbances (Engel-Yeger and Shochat, 2012). Correlates of SPP in healthy adults show continuity with similar studies in people with affective and anxiety disorders, which have shown that such disorders correspond with higher rates of Sensory Sensitivity, Sensory Avoidance and Low Registration patterns and with lower rates of Sensation Seeking (Serafini *et al.*, 2017).

Sensory processing patterns and occupational engagement and participation

The effect of SPPs in everyday functioning was first discussed by Dr Jean Ayres in 1963 and further explored by Dr Winnie Dunn in 1997. Typical SPPs, although unique for individuals, are normal and would not ordinarily affect occupational engagement. It is however problematic when an individual's sensory processing is much more or much less than most people. In such cases, where individuals have atypical SPPs, they may avoid or prefer certain experiences (Brown *et al.*, 2001; Dunn, 2001). Atypical sensory processing results in

difficulties with registering, modulating and organising sensory input needed to successfully carry out activities of daily living (Bar-Shalita *et al.*, 2014; Champagne *et al.*, 2010).

Dunn's model asserts that individuals with low sensory thresholds may be quick to notice and respond to sensory stimuli and that those with high neurologic thresholds may not be as responsive as they tend to miss stimuli. Sensory Sensitivity, for example, is known to relate to selective eating (Farrow and Coulthard, 2012). Although Farrow and Coulthard's (2012) study was with children the same principles are likely to apply in an adult population. Sensation avoiders have been found to limit their engagement in daily occupational functioning (Seraffini *et al.*, 2017). Atypical SPPs can impact individuals' functional ability and interfere with performance and engagement in meaningful activities (Bar-Shalita *et al.*, 2014; Champagne *et al.*, 2010).

There is ongoing debate amongst health professionals regarding whether atypical SPPs are a disorder or just part of the diversity of being human. At present sensory processing disorder is a recognised as a disorder in children as described in the Diagnostic Manual for Infancy and Early Childhood but not recognised as a disorder in the latest diagnostic manual for adults, DSM – 5 (Lane, 2019). What has been established however is that atypical sensory processing can affect occupational engagement and participation (Brown and Dunn, 2002). According to Brown and Dunn (2002), SPPs become a concern of occupational therapy when the person's SPP does not seem to match their chosen daily occupations. SPPs have been identified as an underlying factor to individuals' performance, participation and well-being (Engel-Yeger and Dunn, 2011b).

Associations between sensory processing styles and demographic factors

Most previous studies in healthy adults have not focused on associations between SPPs and demographic factors. However, some investigations of associations between demographic factors and SPP have been reported.

Gender. Among 290 healthy adults aged 18-50 years, women had significantly higher scores than men for Sensory Sensitivity (Engel-Yeger and Dunn, 2011b). A study of 882 people aged 11-94 years found higher scores for females than males in Sensation Seeking, Sensory Sensitivity and Sensation Avoiding in the 11-17 and 18-64 age groups, but no gender differences in the 65-94 age group (Engel-Yeger, 2012). In contrast, an association between a Low Registration pattern and higher trait anxiety was stronger in men than women: men with Low Registration pattern were higher in trait anxiety than women with Low Registration (Engel-Yeger and Dunn, 2011c). One study used the Elderly Sensory Responsiveness Questionnaire (ESRQ) to measure SPP in older adults. The results of this study indicated that females showed higher sensitivity in some sensory modalities when compared to males (Engel-Yeger, 2013). Similarly, in adults aged between 19 and 62 years, women had lower touch pressure threshold and thermal detection thresholds on average than men, indicating greater sensitivity (Yekta *et al.*, 2010). A separate study of 226 people aged 18-60 years, however, found no significant differences in SPP between men and women (Hebert, 2015). Previous research has therefore found that, although some samples and age groups show no gender differences in SPP, gender differences when present tend to be in the direction of higher scores for females than males.

Age. In Hebert's (2015) study of individuals aged 18-60 years, no significant correlations were found between age and SPPs. Age, however, was found to have a significant association with SPP in other studies that included people aged in their 60 s and beyond (Engel-Yeger *et al.*, 2012; Pohl *et al.*, 2003). Engel-Yeger *et al.* (2012) studied adults aged 31 to more than 76 years and found reduced Sensation Seeking and increased Low Registration

with aging, as well as partial mediation of aging effects on handwriting difficulties by age-related changes in Sensation Seeking and Sensory Sensitivity. Among Hong Kong Chinese adults aged 65 and above (33 with dementia and 96 without dementia), AASP scores showed decreased Sensation Seeking with age but no age associations with the other processing patterns (Chung, 2006). Pohl *et al.* (2003) found that older and middle-aged adults noticed less sensory stimuli on the AASP measure (high neurological threshold continuum) when compared to young individuals. This reduction in attention to sensory stimuli in older adults is reported to impact on their occupational performance (Hasher *et al.*, 2007; Healey *et al.*, 2008). Davies *et al.* (2009) also found that sensory gating abilities, that is the ability to filter out unnecessary stimuli expressed in evoked response potential (ERP), increase with age. Adults who are more sensory sensitive have been found to be more anxious than those who are less sensory sensitive (Liss *et al.*, 2005). In sum, adults in older age ranges have tended to show reduced Sensation Seeking in previous research, but there have not been consistent findings about associations between age and other SPPs.

Ethnicity. Biopsychosocial factors influence neurological thresholds and behavioural responses (Rieke and Anderson, 2009). Furthermore, Sensory Sensitivity has been found to be genetically based, present at birth and located in the central nervous system (Aron and Aron, 1997; Dragan *et al.*, 2012 and Liss *et al.*, 2005). Sensory Sensitivity has also been associated with one's family environment (Liss *et al.*, 2005). Therefore, it is plausible that SPPs might be associated with ethnicity. To the authors' knowledge, associations between SPPs and ethnicity have not been tested directly previously. However, versions of the AASP administered in Hebrew to people in Israel (Engel-Yeger *et al.*, 2012) and in Chinese to people in Hong Kong (Chung, 2006) have not shown marked differences in sensory processing profile scores to people in majority English-speaking countries (Hebert, 2015), which provides some indication that variability in SPP associated with ethnicity might not be markedly higher than variability among individuals.

Education. Possible associations between SPPs and education do not appear to have been a focus of previous research. The literature suggests that biopsychosocial factors such as genetics, experience and context can influence sensory processing (Rieke and Anderson, 2009). It is therefore plausible that education level might be associated with SPPs as it can be associated with genetics, experience and context. Interestingly, aging effects in SPPs were similar between a highly educated sample of older individuals in the USA where more than half the sample aged 65 years or more had a baccalaureate degree or higher (Pohl *et al.*, 2003) and a Hong Kong Chinese sample aged 65 years or more of whom most had no education or elementary education (Chung, 2006). However, direct comparisons of education levels within one study would be more informative.

Aims of the study

The purpose of this study was to examine the relationship between SPPs and demographic factors. Currently, there is limited and inconclusive information about associations between SPPs and sociodemographic factors. Multiple studies have found previously that emotional distress can be associated with variations in sensory processing. We therefore used a measure of emotional distress as a covariate (Lovibond and Lovibond, 1995) so that we could evaluate associations between SPPs and sociodemographic factors after accounting for any relations between sociodemographic factors and emotional distress. We hypothesised that there would be an association between SPP and age, including reduced Sensation Seeking with increased age. We hypothesised that gender differences, if present, would be in the direction of increased low neurological threshold patterns among women than men. Potential associations of SPP with education and ethnicity were also investigated.

Method

We used a cross-sectional survey with standardised instruments in a convenient general population.

Participants

The setting for this research was the city of Gold Coast in Australia. Participants were included if they were living in the community and had no diagnosed mental illness or intellectual disability and were able to provide consent. A total of seventy-one healthy individuals (45 females and 36 males) participated in this study with ages 18 and over. Participants were categorised into three groups: 18-34 years (25 participants), 35-64 years (30 participants) and 65 and above (16 participants) in line with Pohl *et al.*'s (2003) study. Volunteers were excluded from participation if they had a history of mental illness.

Measures

Depression anxiety stress scale 21. Emotional distress was assessed using the Depression Anxiety Stress Scale 21 (DASS 21) (Lovibond and Lovibond, 1995). This is a 21-item self-report inventory that assesses the severity of core symptoms of depression, anxiety and stress in the past seven days (Lovibond and Lovibond, 1995). Each domain has seven items scored from 0 to 3. Items were summed and multiplied by two to give a total score with equivalence to full version DASS 42 scores and a possible range of 0 to 126. Use of DASS-21 total score is supported by high loading of items on a general factor in non-clinical samples and Cronbach's alpha for the total score of 0.93 (Henry and Crawford, 2005).

The Adolescent/Adult Sensory Profile. The AASP is a self-report measure, divided into two sections (Brown *et al.*, 2001). The first section of the AASP is composed of 60 items which include questions related to each of the sensory systems: taste, smell, vision, audition, movement and touch. Each item corresponds to one of four quadrants: low registration, sensation seeking, sensory sensitivity and sensation avoiding, reflecting different sensory processing (Brown *et al.*, 2001). The AASP measures the respondent's frequency of responses to specific sensations by means of a Likert scale. The respondents reflected on their everyday sensory experiences by indicating how often they respond to particular sensory experiences using a five-point Likert scale from 1 = *almost never* to 5 = *almost always*. Responses in each quadrant are scored categorically in relation to distance from the normative mean: much less than most people, less than most people, similar to most people, more than most people and much more than most people (Brown *et al.*, 2001; Dunn, 2001).

Norms have been defined for three age groups: 11-17, 18-64, 65 and older (Pohl *et al.*, 2003). The AASP has fair internal consistency for ages 18 and above (Pohl *et al.*, 2003). For ages 18 to 64 years, the coefficient alpha values are 0.69 for Low Registration, 0.64 Sensation Seeking, 0.66 Sensory Sensitivity and 0.70 Sensation Avoiding (Brown and Dunn, 2002). For age 65 years and above the coefficient alpha values are 0.75 for Low Registration, 0.75 for sensation seeking, 0.73 for Sensory Sensitivity and 0.78 for sensation avoiding. The initial standardisation sample consisted of 92 per cent White people living in the USA (Brown and Dunn, 2002). Reliability and validity of AASP translations for Israeli Hebrew speakers (Engel-Yeger, 2012) and Hong Kong Chinese speakers (Chung, 2006) have also been demonstrated.

Procedure

After the study received ethics approval from Gold Coast Health and Griffith University Human Research Ethics Committees, participants were recruited from targeted communities, such as university outpatient clinics, university staff and students, sports

clubs, shopping centres and churches. Participants were recruited by email invitation and word of mouth and provided written consent. Participants would then be asked to complete the required instruments, the AASP and DASS-21 as well as demographic details. Participants could choose to complete forms at home and these participants were given a stamped, addressed envelope containing the study materials, including the consent form. Involvement in the research was voluntary and no incentives were offered.

Data analysis

Descriptive statistics are presented as mean (SD) or median (range) for continuous variables and counts (percentage) for categorical variables. Differences between age groups for other sociodemographic variables were tested using chi-square for categorical variables. DASS was compared between age groups using a one-way ANOVA on the log-transformed score. Scores on the four domains of the Adult Sensory Profile were compared across groups using a series of one-way multivariate analyses of covariance (MANCOVA), using Wilks' lambda as the test statistic. Independent variables of age group, sex, ethnicity and education level were each examined in a separate MANCOVA, with DASS total as a covariate for each analysis. Before conducting the MANCOVAs, the data were examined to ensure all of the underlying assumptions were met. To account for multiplicity, the probability level of making a Type I error for each MANCOVA was adjusted using Bonferroni corrected $p = 0.0125$. Partial eta square (η_p^2) was used as an effect size measure (small >0.01, medium >0.059, large >0.138). Univariate analyses of covariance (ANCOVA) were reported for significant MANCOVAs. All analyses were carried out using Statistical Package for the Social Sciences (version 23) statistics software and statistical significance was set at $p < 0.05$ unless otherwise specified.

Results

Characteristics of participants

After excluding 9 participants with incomplete data, a total of 71 participants was included in the analysis, with 25, 30 and 16 participants in the young, middle and older age group, respectively. Table I shows the distribution of gender, education, ethnicity and DASS scores across the age groups. One-way ANOVA on DASS showed no evidence of any difference between groups ($p = 0.57$). Chi-square tests showed no association of age group with either gender or ethnicity. However, there was a statistically significant association ($p < 0.001$) between age and education when results were analysed using the chi-square test. As shown in Table I, 80 per cent or more of younger and middle aged participants had undertaken tertiary education, whereas in the older age group 75 per cent had not completed tertiary education.

Relationship between sensory processing patterns and age

A statistically significant multivariate effect across the four dependent variables (low registration, seeking, sensitivity and avoiding) was found for age category, $F = 6.922$, $p = 0.009$, $\eta_p^2 = 0.145$, in the presence of a covariate DASS as shown in Table II. Results of univariate ANCOVAs for the individual dependent variables showed an effect of age category for Low Registration, $p = 0.043$, $\eta^2 = 0.09$ and Sensory Sensitivity.

The results showed that the young age group (18 to 34) had lower Low Registration scores than the 65 and over age group (mean difference = 3.8). The young age group also had significantly higher Sensory Sensitivity as compared to people 65 and over (mean difference = 4.7, $p = 0.03$ $\eta_p^2 = 0.10$).

Relationship between sensory processing patterns and education

Like the age category, there was also a significant difference in the group of SPPs across education categories ($p = 0.001$; $\eta^2 = 0.24$) in the presence of a covariate DASS (Table II). In the education category, individual significance was found only in the seeking domain ($p = 0.008$, $\eta^2 = 0.10$). The mean Sensory Seeking scores for those with tertiary education (49.2) were higher for than those with lower education (43.7). When looked at independently, sensitivity was also significant for the education category. For Sensory Sensitivity, people with tertiary education scored on average 5.7 points higher than those without tertiary education (95per cent CI: 1.0, 10.4, $p = 0.018$, $\eta_p^2 = 0.08$); this difference approached but did not reach statistical significance at the 0.0125 level. Group means and standard deviations for each dependent variable are presented in Table III. Comparison of means after controlling for DASS showed that those with a tertiary education were more sensory seeking than those without a tertiary education (mean difference of 5.5).

Table I
Characteristics of participants ($N = 71$)

Variable	18-34 years ($n = 25$)	35-64 years ($n = 30$)	>65 years ($n = 16$)
Gender			
Female	17 (68.0)	19 (63.3)	9 (56.3)
Male	8 (32.0)	11 (36.7)	7 (43.8)
Education			
With tertiary education	22 (88.0)	24 (80.0)	4 (25.0)
Without tertiary education	3 (12.0)	6 (20.0)	12 (75.0)
Ethnicity			
Caucasian	12 (48.0)	20 (66.7)	13 (81.3)
Non-Caucasian	13 (52.0)	10 (33.3)	3 (18.7)
DASS Total, median (range)	16 (2-52)	12 (2-58)	10 (2-64)

Note: Data are presented as *n* (%), unless otherwise specified

Table II.
MANCOVA test results assessing the associations of sociodemographic predictors with sensory profile scores, after adjusting for DASS

Independent variable	F	*p*-value	Partial eta squared η_p^2
Sex	1.70	0.158	0.10
Education	5.16	0.001*	0.24
Ethnicity	1.00	0.444	0.06
Age	2.70	0.009*	0.15

Note: *Statistically significant $p < 0.05$

Table III.
Estimated means (and standard deviations) for processing patterns by level of education

Education	Low registration	Sensation seeking	Sensory sensitivity	Sensation avoiding
With tertiary education ($n = 50$)	31.3 (7.3)	49.2 (7.1)	35.7 (7.1)	37.1 (8.7)
Without tertiary education ($n = 21$)	32.7 (9.0)	43.7 (8.5)	31.1 (6.2)	33.6 (7.6)

Relationship between sensory processing patterns and other demographic factors

There was no effect of ethnicity and sex on the outcomes when adjusted for DASS scores, as shown in Table II. For the sex category, no significance multivariate effect was found $p = 0.158$, [F (1.7), $\eta_p^2 = 0.10$] in the presence of a covariate DASS. Furthermore, no multivariate effect $p = 0.444$ was found for ethnicity category [F (1.0), $\eta_p^2 = 0.06$] in the presence of a covariate DASS as shown in Table II.

Discussion

This study explored the relationship between SPP and demographic factors in a sample of the general population living in South-eastern Queensland, Australia after controlling for emotional distress levels using the DASS. The AASP was chosen as the tool for measuring SPPs because unlike other neurological measures which measure single sensory modalities such as pain or auditory sensations, the AASP measures all sensory modalities as experienced in daily life (Engel-Yeger and Dunn, 2011a). The AASP also has good reliability and validity for ages 18 and above (Brown and Dunn, 2002).

The results from this study supported our hypothesis that there would be an association between SPP and age in the study population. We found a statistically significance across the four dependent variables (Low Registration, Seeking, Sensitivity and Avoiding) for the age category. These results are consistent with results from previous similar but larger studies that have also reported age related differences such as decreased Sensation Seeking with increasing age (Chung, 2006; Engel-Yeger *et al.*, 2012), increased Low Registration with increasing age (Engel-Yeger *et al.*, 2012), and decreased Sensory Sensitivity with increasing age (Davies *et al.*, 2009).

Results from this study indicate that younger individuals (18 to 34 years of age) had a significantly higher sensitivity (mean = 37.5) as compared to people 65 and over (mean difference = 4.7). Although the scores were significantly different between age groups the average scores for all groups were "similar to most people" when compared to standardised scores by age category in the AASP (Dunn, 1997). According to Dunn (1997), higher sensitivity implies that such individuals require minimal stimuli for activation of the central nervous system. People with this type of SPP would often experience discomfort with sensation but would allow the stimuli to occur (Dunn, 1997). These results indicate that younger adults in our study were more sensory sensitive than older adults. This confirms our hypothesis that older adults would be less sensitive due to natural ageing processes. These results are consistent with previous studies which established that middle and older age groups notice less stimuli when compared to younger adults (Pohl *et al.*, 2003). Pohl *et al.* (2003) concluded that middle and older aged individuals are neither distracted by sensory experiences nor overwhelmed by sensory experiences. These results are also consistent with Aron *et al.*'s (2012) study that established that younger people are likely to show increased emotional, biological and stress reactivity to sensory stimuli as these are known characteristics of Sensory Sensitivity.

We also found that the young age group (18 to 34) within our sample, had significantly lower scores on Low Registration (mean = 31.7) when compared to people 65 and over (mean difference = 3.8). The young people in our study had lower scores on average implying that they are more likely to respond actively to sensory stimuli due to their lower neurological threshold when compared to people 65 and over. Similarly, Pohl *et al.* (2003) found that older and middle-aged adults noticed less sensory stimuli on AASP (high neurological threshold continuum) when compared to young individuals. These results are also consistent with Engel-Yeger *et al.*'s (2012) study which found that older adults had higher Low Registration scores on the AASP. The scores of the young people in our study however, still fell into the

"typical for most people" range. Young people in our study had typical sensory processing styles when compared to the general population of similar age as measured by the AASP.

Our study did not support previous reports that older adults are more distracted by sensory stimuli due to a reduction in their ability to focus attention (Hasher *et al.*, 2007; Healey *et al.*, 2008). Similar to Pohl *et al.*'s (2003) study, within this sample of 71, we found that older adults were less sensory sensitive and, therefore, less likely to experience anxiety as a result of being overwhelmed by sensory stimuli. These results are consistent with Engel-Yeger *et al.*'s (2012) study that found reduced Sensation Seeking and increased Low Registration with aging. This association may be culturally bound as studies in non-Western cultures have produced different results. For example, in a study on Hong Kong Chinese adults aged 65 and above, AASP scores showed decreased Sensation Seeking with age but no age associations with the other processing patterns (Chung, 2006). The reduction in attention to sensory stimuli that we found in older adults is reported to impact on their occupational performance (Hasher *et al.*, 2007; Healey *et al.*, 2008).

Interestingly, we found that once individuals have become middle-aged adults (34 years and over), their SPP does not seem to differ with those in the older age group. This finding suggests stability of SPP; however, the result is to have been affected by the lack of power due to the relatively small size particularly in the adult range. However, our point of difference with other studies is that emotional distress was controlled for in our study; something not included in previous studies where demographic associations with AASP have been reported.

This study sought to explore the association between education and SPPs. We found that those with a tertiary education were more sensory seeking than those without a tertiary education (mean difference of 5.7). Mean scores for both those with a tertiary education and those without fell into the category "similar to most people" when compared to standardised AASP scores. Our results indicate that people with tertiary education may be more likely to actively self-regulate by seeking sensory input than those without a tertiary education. Sensory seekers enjoy intense sensory environments which can manifest as risk-taking behaviour (Brown *et al.*, 2001; Dunn, 2001; Hebert, 2015). The results of this study are however inconsistent with previous studies by Pohl *et al.* (2003) and Chung (2006) who found no education related differences. These results may have reflected the health status of students, who were disproportionately part of the younger age group. The unequal distribution of participants across groups may have impacted the results. Thus, further studies with equal distribution of participants between groups are needed to strengthen the evidence. Despite the confound between age and education, the age and education variables each showed associations with different SPPs. This argues against the associations with education being only due to a confound with age.

We hypothesised that gender differences, if present, would be in the direction of increased low neurological threshold patterns among women than men. We, however, did not find any significant correlation between SPP and gender in the general population. These results are not congruent with some previous studies which had concluded that women were more sensitive than men (Engel-Yeger and Dunn, 2011b; Engel-Yeger, 2013). Engel-Yeger (2013) however used the ESRQ in an elderly population which is less applicable to the general population when compared to the more widely used AASP used in our study. Our results are consistent with earlier findings by Hebert's (2015) study which concluded that there were no significant differences between men and women for sensory processing and impulsivity.

We had also hypothesised that there would be no ethnicity related differences in SPP. Our findings were consistent with this hypothesis as we found no such differences in our study. This might be due to small sample size, limited representation of ethnicity in the

measures and sampling, or might reflect underlying similarity in SPP in the ethnic groups represented in the present study. Further research with larger samples is needed to address this question.

Key points for occupational therapy

- There is a relationship between SPPs and age in healthy adults.
- There is a potential relationship between SPPs and education in healthy adults.
- There was no conclusive evidence on associations between gender or ethnicity with SPPs.

Limitations and future research

There were several limitations of this study that should be considered when interpreting the results. First, the study was based on a convenience sample of healthy adults living in Australia. The impact of Western culture on demographic factors such as ethnicity was not controlled. Furthermore, the validity of the AASP across cultures still needs to be examined as initial psychometric testing was done in the USA. Second, the sample included an unequal number of participants in each age group. Further studies with more equal distribution of participants between age groups would be informative. Third, the study used a relatively small sample ($N = 71$) and was based on self-reported healthy participants. The possibility of significant undiagnosed distress was, however, controlled by using DASS scores as a covariate. The sample may not accurately represent the general population. It is recommended that future studies should include larger samples and should also include clinical populations. This will give a more accurate picture of SPPs across the general population and enable comparisons across different groups.

Age was confounded with education, and the sample size precluded sufficient power for some types of multivariate analyses that could have assisted in resolving this confound. However, it is noted that the associations between education and SPP were not in the same domains as those associated with age, suggesting that confounding could not completely explain the results. Further studies with larger samples will enhance our understanding of the relationship between SPPs and demographic factors.

Conclusion

This study offers valuable insights into relationships between sensory processing styles and demographic factors and calls for further research in this area. The study supports the view that there is an association between SPPs and age in the study population. The generalisability of this observation to non-Western regions should be done with caution as the impact of culture was not controlled in the present study. A relationship between SPPs and education was also demonstrated to a lesser extent in this study. This study highlights that it might be helpful for occupational therapists to consider demographic factors when interpreting SPPs in individuals. Further studies with larger samples and clinical populations are needed to more fully understand the role of demographic factors in SPPs. This would assist in the development of effective interventions that enhance the participation of individuals in occupations that they want to, need to or are expected to do.

Declaration of authorship

We, the authors, declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. We wish to confirm that there

are no known conflicts of interest associated with this publication and there has been no financial support for this work that could have influenced its outcome. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing, we confirm that we have followed the regulations of our institutions concerning intellectual property.

We further confirm that any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author.

References

Aron, E.N. and Aron, A. (1997), "Sensory-processing sensitivity and its relation to introversion and emotionality", *Journal of Personality and Social Psychology*, Vol. 73 No. 2, pp. 345-368.

Aron, E.N., Aron, A. and Jagiellowicz, J. (2012), "Sensory processing sensitivity: a review in the light of the evolution of biological responsivity", *Personality and Social Psychology Review*, Vol. 16 No. 3, pp. 262-282, doi: 10.1177/1088868311434213.

Ayres, A.J. (2005), *Sensory Integration and the Child: Understanding Hidden Challenges-25th-Anniversary Edition*, Western Psychological Services, Los Angeles, CA.

Bar-Shalita, T., Vatine, J.J., Yarnitsky, D., Parush, S. and Weissman-Fogel, I. (2014), "Atypical central pain processing in sensory modulation disorder: absence of temporal summation and higher after-sensation", *Experimental Brain Research*, Vol. 232 No. 2, pp. 587-595, doi: 10.1007/s00221-013-3767-y.

Blanche, E.I., Parham, D., Chang, M. and Mallinson, T. (2014), "Development of an adult sensory processing scale (ASPS)", *American Journal of Occupational Therapy*, Vol. 68 No. 5, pp. 531-538, doi: 10.5014/ajot.2014.012484.

Brown, C., Tollefson, N., Dunn, W., Cromwell, R. and Filion, D. (2001), "The adult sensory profile: measuring patterns of sensory processing", *American Journal of Occupational Therapy*, Vol. 55 No. 1, pp. 75-82, doi: 10.5014/ajot.55.1.75.

Champagne, T., Koomar, J. and Olson, L. (2010), "Sensory processing evaluation and intervention in mental health", *OT Practice*, Vol. 15 No. 5, pp. CE1-CE7.

Chung, J.C.C. (2006), "Measuring sensory processing patterns of older Chinese people: psychometric validation of the adult sensory profile", *Aging and Mental Health*, Vol. 10 No. 6, pp. 648-655.

Engel-Yeger, B. (2012), "Validating the adolescent/adult sensory profile and examining its ability to screen sensory processing difficulties among Israeli people", *British Journal of Occupational Therapy*, Vol. 75 No. 7, pp. 321-329.

Engel-Yeger, B. and Dunn, W. (2011a), "Exploring the relationship between affect and sensory processing patterns in adults", *British Journal of Occupational Therapy*, Vol. 74 No. 10, pp. 456-464.

Engel-Yeger, B. and Dunn, W. (2011b), "Relationship between pain catastrophizing level and sensory processing patterns in typical adults", *American Journal of Occupational Therapy*, Vol. 65 No. 1, pp. e1-e10.

Engel-Yeger, B. and Dunn, W. (2011c), "The relationship between sensory processing difficulties and anxiety level of healthy adults", *British Journal of Occupational Therapy*, Vol. 74 No. 5, pp. 210-216.

Engel-Yeger, B. and Shochat, T. (2012), "The relationship between sensory processing patterns and sleep quality in healthy adults", *Canadian Journal of Occupational Therapy*, Vol. 79 No. 3, pp. 134-141.

Engel-Yeger, B., Hus, S. and Rosenblum, S. (2012), "Age effects on sensory-processing abilities and their impact on handwriting", *Canadian Journal of Occupational Therapy*, Vol. 79 No. 5, pp. 264-274.

Farrow, C.V. and Coulthard, H. (2012), "Relationships between sensory sensitivity, anxiety and selective eating in children", *Appetite*, Vol. 58 No. 3, pp. 842-846.

Hasher, L., Lustig, C. and Zacks, R.T. (2007), "Inhibitory mechanisms and the control of attention", in Conway, A., Jarrold, C., Kane, M., Miyake, A. and Towse J. (Eds), *Variation in Working Memory*, Oxford University Press, New York, NY.

Healey, M.K., Campbell, K.L. and Hasher, L. (2008), "Cognitive aging and increased distractibility: costs and potential benefits", *Progress in Brain Research*, Vol. 169, pp. 353-363, doi: 10.1016/S0079-6123(07)00022-2.

Hebert, K. (2015), "The association between impulsivity and sensory processing patterns in healthy adults", *British Journal of Occupational Therapy*, Vol. 78 No. 4, pp. 232-240, doi: 10.1177/0308022615575670.

Henry, J.D. and Crawford, J.R. (2005), "The short-form version of the depression anxiety stress scales (DASS-21): construct validity and normative data in a large non-clinical sample", *British Journal of Clinical Psychology*, Vol. 44 No. 2, pp. 227-239, doi: 10.1348/014466505X29657.

Lane, C. (2019), DSM 5–Fifth Edition of the Diagnostic and Statistical Manual Of Mental Disorders, available at: www.psyweb.com/content/main-pages/dsm-5-fifth-edition-of-the-diagnostic-and-statistical-manual-of-mental-disorders/diagnostic-and-statistical-manual-of-mental-disorders (accessed 12 June 2019).

Liss, M., Timmel, L., Baxley, K. and Killingsworth, P. (2005), "Sensory processing sensitivity and its relation to parental bonding, anxiety, and depression", *Personality and Individual Differences*, Vol. 39 No. 8, pp. 1429-1439, doi: 10.1016/j.paid.2005.05.007.

Lovibond, S.H. and Lovibond, P.F. (1995), *Manual for the Depression Anxiety Stress Scales*, Psychology Foundation, Sydney.

Miller, L.J. and Lane, S.L. (2000), "Toward a consensus in terminology in sensory integration theory and practice, part 1: taxonomy of neurophysiological processes", *Sensory Integration Special Interest Section Quarterly*, Vol. 23 No. 1, pp. 1-4.

Pohl, P.S., Dunn, W. and Brown, C. (2003), "The role of sensory processing in the everyday lives of older adults", *Occupational Therapy Journal of Research*, Vol. 23, pp. 99-106, doi: 10.1177/153944920302300303.

Rieke, E.F. and Anderson, D. (2009), "Adolescent/adult sensory profile and obssessive-compulsive disorder", *American Journal of Occupational Therapy*, Vol. 63 No. 2, pp. 138-145, doi: 10.5014/ajot.63.2.138.

Serafini, G., Engel-Yeger, B., Vazquez, G.H., Pompili, M. and Amore, M. (2017), "Sensory processing disorders are associated with duration of current episode and severity of side effects", *Psychiatry Investigation*, Vol. 14 No. 1, pp. 51-57.

Yekta, S.S., Smeets, R., Stein, J.M. and Ellrich, J. (2010), "Assessment of trigeminal nerve functions by quantitative sensory testing in patients and healthy volunteers", *Journal of Oral and Maxillofacial Surgery*, Vol. 68 No. 10, pp. 2437-2451, doi: 10.1016/j.joms.2009.12.013.

Further reading

Levit-Binnun, N., Szepsenwol, O., Stern-Ellran, K. and Engel-Yeger, B. (2014), "The relationship between sensory responsiveness profiles, attachment orientati[illegible]nd anxiety symptoms", *Australian Journal of Psychology*, Vol. 66 No. 4, pp. 233-240, doi: doi.org/10.1111/ajpy.12064.

Robotham, D. and Julian, C. (2006), "Stress and the higher education student: a critical review of the literature", *Journal of Further and Higher Education*, Vol. 30 No. 2, pp. 107-117, doi: 10.1080/03098770600617513.

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