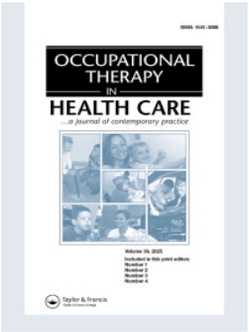

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# The Sensory Processing Measure, Second Edition, Adolescent Self-Report Form; Swedish Translation, Cross-Cultural Adaptation, and Establishment of Reliability and Face Validity

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**ABSTRACT**

The Sensory Processing Measure, second edition (SPM-2), is an American assessment guiding person-centered sensory processing interventions, but it lacks Swedish adaptation for occupational therapists. In eight phases, this study translated the SPM-2 into Swedish and assessed its face validity and preliminary psychometric properties, including internal consistency and inter-scale/item correlations. The findings suggest the Swedish SPM-2 is valid and reliable, although the Social Participation scale showed weak internal consistency. A larger normative study ($N$=130) is needed before clinical use.

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Adolescents; occupational therapy; participation; pilot testing; self-report questionnaire; young adults

Adolescence is a period when youths seek out new roles, activities and environments for their growth, well-being and identity development (Becht et al., 2016; Branje, 2022; Lawford et al., 2012; Rodger et al., 2015; White et al., 2021; Youngblade et al., 2007). Everyday activities, such as academic tasks, leisure activities and tending to meaningful relationships are all performed in physical environments with different sensory stimuli, which may facilitate or hinder participation (Dean et al., 2024; Gentil-Gutiérrez et al., 2021; Stark et al., 2015). Analyzing, modulating, organizing and acting upon external sensory input are dependent on fundamental neurobiological systems for proper functioning and adaptability as humans (Ayres, 1972; Carey, 2015; Galiana-Simal et al., 2020; Merchie & Gomot, 2023). When sensory processing is atypical, it may result in difficulties with detecting, modulating, interpreting, and responding to various sensory experiences in daily life (Ayres, 1972; Mulligan et al., 2021; Passarello et al., 2022). Sensory processing difficulties, or sensory processing disorder, may therefore amplify the risk for restricted possibilities and participation in meaningful everyday activities and roles (Andersson et al., 2021; Ashburner et al., 2008; Carey, 2015; Dean et al., 2024). However, through

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structured assessments, subsequent treatments and evaluations, the negative effects of a sensory processing disorder can be lessened, for example by sensory modulation strategies, environmental modifications or sensory integration therapy (Dean et al., 2024; DuBois et al., 2017; Forsberg et al., 2024; Omairi et al., 2022).

The *Sensory Processing Measure*, *second edition*, 'SPM-2', (Brown et al., 2024; Parham et al., 2021a) is one of the most used tools for assessing sensory processing in children (Galiana-Simal et al., 2020). The SPM-2 forms are designed to assess clients across the lifespan at five different ages: Infant/Toddler, Preschool, Childhood, Adolescence, and Adulthood. All forms are based on the theoretical constructs of Ayres' Sensory Integration (Brown et al., 2021). It is a norm-referenced measure of function covering multiple sensory modalities: vision, hearing, touch, taste and smell, body awareness, and balance and motion, as well as planning and ideas, and social participation (Brown et al., 2024; Parham et al., 2021a). The SPM-2 is an efficient, self-reported questionnaire with strong psychometric properties that assesses everyday challenges and discriminate adolescents and young adults with sensory processing issues from those without (Narzisi et al., 2022; Parham et al., 2021a). Reliability and validity from the SPM-2 standardization and clinical validity studies are described in detail by Parham et al. (2021a). Multiple approaches have been used to estimate the reliability of SPM-2, such as internal consistency, test-retest reliability, standard error of measurement, interrater reliability, cross-rater concordance, and an online and paper form equivalence study. Validity has been tested for content validity, construct validity and criterion-related validity (Parham et al., 2021a). Compared to the predecessor *Sensory Processing Measure* (SPM), which was developed for children between the ages 5-12, the second version now covers the adolescent and young adult age level of 12 to 21 years[1], consisting of three subtests measuring the environmental impact in school, at home and the self-report capturing the adolescents' and young adults' own experiences. The SPM (5-12 years old) was translated and cross-culturally adapted in 2012 and is frequently used in a Swedish clinical context (Andersson et al., 2012). Unfortunately, Swedish adolescents' and young adults' sensory processing cannot be assessed by this tool. However, given the existence of the SPM-2, it is now of urgency to co-develop a valid and reliable translation and cross-cultural adaptation of it from English into Swedish.

Harnessing world-wide research and innovations on standardized clinical instruments for the use and provision for various populations and groups requires transferability across languages and cultural nuances (Beaton et al., 2000; Sousa & Rojjanasrirat, 2011). Undertaking the task of ensuring and bridging the usability between an instrument's source language to the target language demands attention to different types of equivalence, including

*semantic, idiomatic, experiential* and *conceptual* equivalences (Beaton et al., 2000). *Semantic* equivalence means that the words and sentences are translated grammatically correct and have a similar cultural meaning in both languages, while *idiomatic* sayings that are difficult to translate directly can be swapped for more suitable ones with close bearings in the target language. *Experiential* equivalence can be attained through involving the experiences and perspectives of everyday life lived by the group whom the assessment is for, thus securing real-life bearings. Tending to the *conceptual* meanings behind words, their similarities, or differences, between two languages and the cultures they reflect are of high importance in the translation and cross-cultural adaptation process. Realizing these above-mentioned equivalences highlights the need of involving users and recipients as the focal points of the translation process. Co-development of different solutions and innovations between researchers and the end-users within health science research is deemed essential for a delivery contributing to efficient and participative treatments (Denvall & Iwarsson, 2022; Larsson et al., 2018). Thus, the aim of this study was to co-develop a cross-culturally translated and adapted reliable Swedish version of the SPM-2; Adolescent Self-Report Form, and to establish its face validity.

## Materials and methods

### Design

This mixed-method study comprised three main parts; commencing with a qualitative co-developed proceeding with a descriptive approach utilizing expert committees recommended by Beaton et al. (2000). Secondly, semi-structured cognitive "Think-aloud interviews" were held with both neurotypical and neurodiverse developed adolescents to ensure both target groups' insights and perspectives were considered (Wolcott & Lobczowski, 2021). Finally, a psychometric pilot testing with a cross-sectional study design investigating the data accuracy of the translated and cross-culturally adapted version was conducted. Consistent involvement of adolescents, as well as occupational therapists with experiences and training in identifying sensory needs of children and youth was deemed essential for producing a clinically and contextually relevant Swedish version of *Sensory Processing Measure*, second edition.

This study adhered to the research-ethical principles set by the Declaration of Helsinki (World Medical Association, 2013) and was approved by the Swedish Ethical Review Authority Dnr 2024-01791-01.

### Participants

For the initial forward-translation, two independent translators were part of this study; one occupational therapy student and a student with another educational background. The three expert committees included a total of

one adolescent representative and six occupational therapists, each with extensive expertise in sensory processing disorders and 20 to 30 years of experience working with adolescents and young adults. The participants attending the expert committee reviews are further described in Table 1.

Lastly, nine adolescents and young adults between the ages of 15—21 (5 females, 4 males, mean age = 16.8) participated in the semi-structured interviews. Six were pursuing a high school diploma, two were attending secondary school and one was enrolled in university studies. Six were belonging to the neurotypical group (individuals with no known sensory processing disorder, autism spectrum disorder or any other diagnosis), and three to the neurodiverse group (individuals diagnosed with ASD or ADHD by a professional, and receiving support from clinical health care) (Galiana-Simal et al., 2020; Mulligan et al., 2021; Parham et al., 2021a).

The psychometric pilot testing consisted of $N = 78$ Swedish young adolescents and young adults (aged 12-21), of which $n = 64$ (82%) in the neurotypical group (NT) and $n = 14$ (18%) in the neurodiverse group (ND). The occupational therapists, forward- and back-translators and adolescents participating as experts for the translation and cross-cultural adaptation were recruited using a purposive sampling approach with convenience- and snowballing methods. Suitable candidates were recruited and informed about the study through email and a study information letter.

The neurotypical and neurodiverse groups involved in the psychometric pilot were recruited through different methods. The neurotypical group was recruited through the distribution of posters and flyers at information stands in high schools and at various locations on the streets across different cities in southern Sweden. Additionally, snowball sampling was employed for the wider regional inclusion (Parker et al., 2019). The neurodiverse group was recruited through occupational therapists.

## Procedure

Prior to any translation and data collection, a formal agreement and written consent with the instrument publisher *Western Psychological Services*

**Table 1.** Study participants attending the expert committee reviews.

| Country | Participant role | Participation in study stage |
|---|---|---|
| Sweden | Adolescent representative | Stage II |
| Sweden | Occupational therapist | Stage II |
| Sweden | Occupational therapist | Stage II |
| Sweden | Occupational therapist, ASI therapist | Stages II & VII |
| Sweden, Finland | Occupational therapist, ASI therapist | Stages II, IV & VII |
| Sweden | Occupational therapist, ASI therapist[a] | Stages VII & VIII |
| Sweden | Occupational therapist, ASI THERAPIST[a] | Stages II – VIII |

*Note.* ASI Therapist: Ayres Sensory Integration Therapist.
[*]Researchers responsible for the SPM translation and cross-cultural adaptation to Swedish.

(WPS) was signed for the facilitation of a translated and cross-cultural adapted version of the Adolescent School Form, Adolescent Home form and Adolescent Self-Report Form. The procedures are described in Figure 1.

### *Stage I: Forward-translations*

The translation and cross-cultural adaptation process began with two independent forward translations of the English original version into Swedish, translated by one person with a background in occupational therapy whereas the other translator had no prior knowledge of the subject.

### *Stage II: Synthesis*

The two translations were evaluated in two expert committee reviews, each lasting 120 min and conducted through online video conferencing. The committees consisted of one adolescent representative and five pediatric occupational therapists experienced in sensory processing assessments and treatments. Four occupational therapists participated in the first review. For the second review, three of the original occupational therapists returned, joined by one additional occupational therapist, making four participants in total for each session. The consensus and collective decisions made by the expert committees aimed to choose one initial alternative per instrument item to discard or move on with for further development and refinement. The discussions and reasoning hovered around ensuring the four types of equivalence put forth by Beaton et al. (2000); i.e. *semantic, idiomatic, experiential* and *conceptual equivalence.* The two-hour meetings

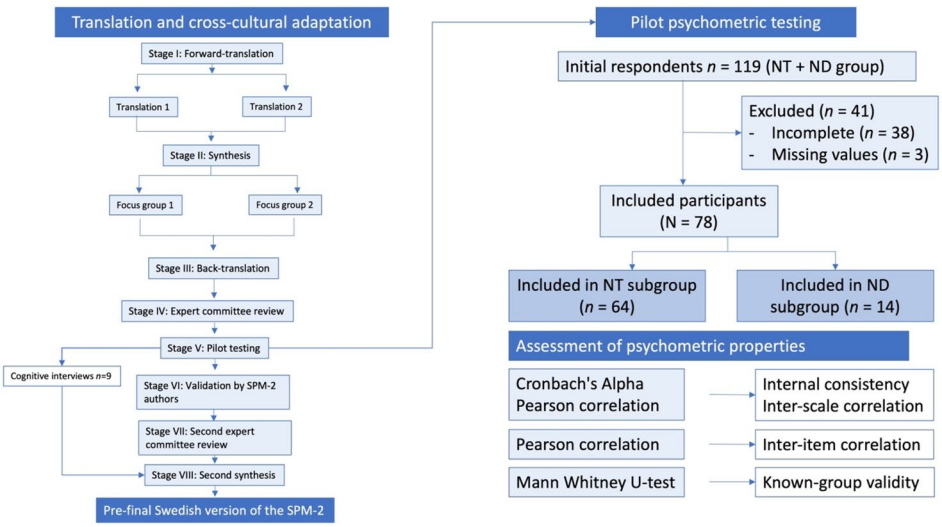


**Figure 1.** The translation and cross-cultural adaptation Procedure in this study, as recommended by Beaton et al. (2000).

took place online through a video-conference software and were recorded for transcription.

### *Stage III: Back-translation*

Another essential step to ensure equivalence between English and Swedish was to engage two independent back-translators with proficiency in both languages. The two U.S. based occupational therapy scholars were tasked to translate the synthesized forward-translation from Swedish to English, in order to trial the accuracy and preservation of the assessment qualities within each item.

### *Stage IV: Expert committee reviews*

This stage addressed and managed the discrepancies between the previously synthesized version and the two back-translations through consensus and collective decision making. The outcome of this stage resulted in a pre-final translation and cross-cultural adaptation.

Thereafter, the pre-final version was sent to the instrument authors of SPM-2 for review.

### *Stage V: Pilot testing*

This stage marked the beginning of piloting and testing the version generated by the expert committee on adolescents who were previously not engaged in the project. Semi-structured "Think-aloud interviews" (Wolcott & Lobczowski, 2021) were conducted to collect opinions of readability and comprehension for each item and the assessment as a whole. Before each interview, an interactable online version of the translated and adapted assessment was sent to each interviewee as means of preparation and usage. The participants were instructed to note any item or spelling they did not understand, as well as suggestions of different spellings. The 45-minute interviews took place digitally or face-to-face, based on the preference of each participant. During the interviews all items and scales were scrutinized to detect any uncertainties, questions or suggestions surrounding the aspects of the Swedish translations and wordings. General questions about the whole instrument, such as *"How do you find the language tone and level of the assessment instrument?"* and *"How would you describe the language in the assessment instrument?"*, were asked. The answers were protocolled simultaneously as the ongoing interview proceeded. Concurrently with the semi-structured interviews, the psychometric pilot with 78 young adolescents and young adults was conducted to enquire about the Swedish translation and adaptation's psychometric properties. Participants were requested to complete the online self-reported questionnaire, comprising all 80 items of the SPM-2, which would typically require

10 min to complete. The data were collected to assess floor/ceiling effects, internal consistency, inter-scale consistency, inter-item correlation, and the known-group validity of the pre-final translation of the Swedish SPM-2. The collected data were stored in REDCap (Research Electronic Data Capture), which is a highly secure web-based application to capture data for clinical research developed by Vanderbilt University (Patridge & Bardyn, 2018).

#### *Stage VI: Validation by SPM-2 authors*

The back-translations and the pre-final translation of the Swedish SPM-2 were reviewed by the authors of the SPM-2. The authors provided detailed feedback to the last author, who adjusted the Swedish version accordingly.

#### *Stage VII: Second expert committee review*

Finally, an expert group of four University certified Sensory Integration therapists reviewed the revised translation to achieve agreement on the final word choices for each item, ensuring the Swedish SPM-2 to be readily understood by a Swedish population of adolescents and young adults.

#### *Stage VIII: Second synthesis*

The translation and cross-cultural adaptation concluded with a second synthesis merging the results from the cognitive interviews and the second expert committee review. This stage was carried out by two University certified Sensory Integration therapists and Occupational therapists (described in Table 1), previously involved in the translation and cross-cultural adaptation of the SPM to Swedish (Andersson et al., 2012). In order to further simplify future validation of the translated School and Home Forms, the assessment instrument items were designed and transferred into a digital and printable format, similar to the original version of *Sensory Processing Measure*, second edition (SPM-2).

### *Data analysis*

In the present study, data were collected *via* an online self-reported questionnaire. The questionnaire consisted of 80 questions, divided across 8 scales consisting of 10 items each. The scales were Vision; Hearing; Touch; Taste and Smell; Body Awareness (Proprioception); Balance and Motion; Planning and Ideas; and Social Participation. All SPM-2 related questions were answered on a 4-point Likert scale, ranging from Never = 1, Occasionally = 2, Frequently = 3, to Always = 4. The questions for each scale were phrased like the following statements: *'I am bothered by bright light.', 'I avoid places with loud music or noise.', 'I dislike the feel of certain*

*clothes,'*, or *'I dislike tasting unfamiliar food'*. Raw scores were calculated by the sum of the item scores within each scale. For interpretation, raw scores were converted into normalized T-scores, enabling comparison of an individual's test results across different scales and with a reference group. The T-scores could be interpreted as follows; *typical development* ranges from 40 to 59; *moderate difficulties* ranges from 60 to 69; and *severe difficulties* ranges from 70 to 80 (Parham et al., 2021a).

For the statistical analysis, the Statistical Package for the Social Sciences (SPSS), Version 29.0 for Windows was used (IBM, 2021). Descriptive statistics were provided to compare the composition of the neurotypical and the neurodiverse participant groups. The effect of 'gender' on the total SPM-2 outcome was analyzed with a t-test, the effect of 'age' was analyzed with Kruskal-Wallis test due to the small sample not representing all ages equally (Streiner & Norman, 2008). Floor and ceiling effects were measured to assess whether the scale adequately covered the range of the construct. The floor and ceiling effects were assessed on scale levels (Hobart & Cano, 2009). Internal consistency was measured to evaluate how consistently the items of the tool were interrelated and measured the same underlying construct. The focus in the U.S. SPM-2 psychometric property analysis is on the internal consistency in the standardization sample, so for a good comparison in analyzing internal consistency, the present study focused on the neurotypical group (Parham et al., 2021a). To assess internal consistency, Cronbach's alpha was used as the statistical measure, where a higher Cronbach's alpha indicates greater internal consistency among the items (Collet et al., 2023; Streiner & Norman, 2008). The inter-scale correlation was analyzed by using Pearson's correlation coefficient (Leung et al., 2010). The inter-scale correlation measures the degree of association between scales. Scales that measure unique concepts will score lower on their correlation coefficient than on their internal consistency (Leung et al., 2010). Inter-item correlation was measured to analyze the degree of association between pairs of items within each scale by using Pearson's correlation coefficient (Benesty et al., 2009; BrckaLorenz et al., 2013; Rattray & Jones, 2007; Streiner & Norman, 2008). The known-group validity was analyzed to assess whether the Swedish SPM-2 could discriminate between neurotypical and neurodiverse adolescents and young adults. This was assessed by comparing the SPM-2 scores of the neurotypical and the neurodiverse participants, using the Mann-Whitney U-test (Brown and Subel, 2013).

## Results

The translation and cross-cultural adaptation resulted in a complete Swedish translation of all items within the three subtests (Adolescent *Home, School and Self Report Forms*) of Sensory Processing Measure, second edition

(SPM-2), whereas the *Self Report Form* underwent qualitative and quantitative pilot-testing researching the concurrency of adolescents and young adults. Consensus and approval of equivalences were reached through co-developing the material together with different stakeholders at various stages.

### Addressed equivalences between English and Swedish

The majority of items translated were agreed and approved upon by the expert committees, as well as the adolescents participating in the cognitive interviews. The participating adolescents attending the cognitive interviews described the overall language tone and understanding as clear and explicit. Several of them expressed the item language to be a suitable balance between "clinical" associations with health care, as well as words and sentences used by themselves in their everyday lives. The adolescents characterized the instructions connected to the response sheet as "easy to understand" and apprehensible. Some items were, however, highlighted as in need of clarification. Showcased in Table 2 are examples of item wordings, which needed discussions and subsequent approval by the expert committees and cognitive interviewees to obtain *semantic, idiomatic, experiential* and *conceptual* equivalences.

### Preliminary testing of the internal consistencies

Firstly, no significant differences were found for gender ($p = 0.394$) (t-test), nor age ($p = 0.06$) (Kruskal-Wallis test) on the total SPM-2 score. Furthermore, the neurodiverse group scored higher mean T-scores than the neurotypical group on all scales (2.61 on average across all the eight scales). However, the differences in mean T-scores were not significant in any scale comparing the neurodiverse and the neurotypical group (based on Mann-Whitney U tests). No ceiling effects were found, and the floor effects were so minimal none exceeded the 15% cutoff value.

Table 3 presents the internal consistency results of the neurotypical group, for the total group (ages 12-21, $n = 64$) and stratified by age group. Additionally, it presents the internal consistency for the neurodiverse group and for the total (NT+ND). In the total neurotypical group, all scales, except for Social Participation, demonstrated an Internal Consistency Coefficient of 0.74 or higher. Notably, Taste and Smell, Body Awareness, Balance and Motion, and Planning and Ideas scales exceeded 0.83 (Cronbach's alpha), with the Sensory Total scoring the highest at 0.92. The Social Participation scale exhibited the lowest internal consistency, with a Cronbach's alpha of 0.64. In the neurodiverse group, a different pattern emerged, mirroring the neurotypical group's low internal

**Table 2.** Examples of item wordings discussed by the expert committees and cognitive interviewees to obtain semantic, idiomatic, experiential and conceptual equivalences.

| English version | Swedish translation | Point of discussion | Expert committees or cognitive interviewees |
|---|---|---|---|
| "PA announcement" | "Allmänt meddelande *via* högtalarsystemet" | Swedish schools seldomly experience PA announcements, so an addition of "*via* högtalarsystem" ("through speakers") was added as a way of clarification, as the direct translation of "PA announcement " became "allmänt meddelande", which can be interpreted in several ways. | Expert committee |
| "Air conditioner" | "Ventilation" | Culturally adapting "air conditioner" into "ventilation" was based on the discussions held by the expert committees arguing that ventilation systems are more common in public buildings and at homes in a Swedish context. | Expert committee |
| "Him/his –Her/hers" | "Hen/hens" | The reasoning behind widely used "hen" as the noun in the Swedish version is that it is considered to be a neutral, inclusive and functional non-binary term. It is also used by the Swedish National Board of Health and Welfare. | Expert committee |
| "Extracurricular activities" | "Fritidsaktiviteter" | "Extracurricular activities" was translated into "leisure activities" ("fritidsaktiviteter") since there is no widely used, matching term or culture of describing children's or adolescents' activities outside school except for "fritidsaktiviteter" in a Swedish context. | Expert committee |
| "People opening snack food packages" | "Någon öppnar en godispåse" | The expert committee thought that it is closer to Swedish daily language to address "people" in the situational context above as "somebody" ("någon") instead of translating "people" into "publik" or "personer". "Snack food packages" was translated into "godispåse" ("candy bag"), since the expert committee and the adolescent representative saw it more culturally appropriate in a Swedish context. | Expert committee |
| "Noticing" | "Uppmärksamma" | "Noticing", which the expert committee previously had translated to "notera" in Swedish, was a word not perceived straightforward enough. This got changed to "uppmärksamma" ("noticing"). | Cognitive interviewees |
| "Estimate" | "Uppfatta" | "Uppskatta" ("estimate") was another translation expressed as confusing with potentially several meanings (e.g."cherish") in Swedish. To ensure face validity, this was changed into "uppfatta" ("perceive") as a translation of "judging" (in …"the oncoming speed of cars"). | Cognitive interviewees |

consistency in the Social Participation scale (Cronbach's alpha = 0.36). Additionally, the Touch, Taste and Smell, Balance and Motion, and Planning and Ideas scales scored below 0.70. The Sensory Total remained high at 0.88, with the Vision scale surpassing it at 0.90. Combining both groups, the Internal Consistency distribution closely resembled the neurotypical

group's, with the Sensory Total scale maintaining the highest score (Cronbach's alpha = 0.91). All scales achieved an Internal Consistency Coefficient of 0.73 or higher, except for the Social Participation scale (Cronbach's alpha = 0.61).

The inter-scale correlations all scored between 0.46 and 0.90, with the lowest correlation between the Body Awareness scale and the Taste and Smell scale, and the highest correlation between the Sensory Total and the Balance and Motion scale. For each scale, its inter-scale correlation coefficient was lower than its internal consistency coefficient.

Lastly, the inter-item correlations were between 0.20 and 0.50 in most scales, including Vision, Taste and Smell, Body Awareness, Balance and Motion, and Planning and Ideas. In the Hearing scale scores were mostly between 0.00 and 0.50.

Only item 21 (*"I dislike eating food with certain textures"*) in the Touch scale and items 77 (*"I join activities with others without disrupting the ongoing activity."*) and 80 (*"People tell me that I speak too softly or too loudly.")* in the Social Participation scale score a mean inter-item correlation <0.15.

## Discussion

The present study entailed a structured translation and cross-cultural adaptation process, actively involving stakeholders for its development, resulting in the first reliable and valid Swedish version of the SPM-2. It is now ready for a subsequent sufficiently powered normative data collection.

The study demonstrated that the equivalences between the English and Swedish versions are sound, as well as successful in balancing the language level to contain both clinical expressions and relatable wordings used by Swedish adolescents and young adults in their everyday lives. These vital findings are crucial to fully realize evidence-based assessments and screenings of adolescents and young adults for sensory processing difficulties in Sweden. The necessity of adapting globally used health care instruments to locally used languages and cultural phenomena part of a population's daily lives lay in ensuring their reliability and validity across different contexts. Performing rigorous studies testing face validity, linguistic nuances and internal consistencies compared to the testing of an instrument's original version is needed to transfer the evidence-based properties into a new language and context (Beaton et al., 2000; Sousa & Rojjanasrirat, 2011).

The results of the psychometric property pilot testing demonstrated reliability and validity of the Swedish version of the SPM-2. The psychometric properties of the Swedish version were then compared to the psychometric properties of the original U.S. sample (Parham et al., 2021a).

**Table 3.** Mean SPM-2 T-score, internal consistency and SEM of the Swedish SPM-2 in the NT, ND, and total sample across all 80 items.

| Scale | No. of items | NT Mean T-score[a] | ND Mean T-score | NT 12-15 α[b] | NT 16-17 α | NT 18-19 α | NT 20-21 α | All NT 12-21 α | | ND 12-21 α | NT+ND 12-21 α |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *n* = 11 | *n* = 25 | *n* = 21 | *n* = 7 | *n* = 64 | SEM[c] | *n* = 14 | *N* = 78 |
| VIS | 10 | 54.3 | 59.4 | .85 | .76 | .79 | .68 | .78 | 3.72 | .90 | .82 |
| HEA | 10 | 55.8 | 59.1 | .83 | .81 | .58 | .25 | .78 | 3.79 | .81 | .79 |
| TOU | 10 | 53.0 | 57.0 | .74 | .77 | .70 | .23 | .74 | 4.50 | .63 | .73 |
| T&S | 10 | 54.8 | 55.4 | .85 | .87 | .85 | .84 | .86 | 3.69 | .62 | .84 |
| BOD | 10 | 53.5 | 54.5 | .87 | .86 | .70 | .85 | .83 | 3.74 | .85 | .83 |
| BAL | 10 | 53.1 | 56.9 | .84 | .91 | .81 | .95 | .89 | 3.53 | .49 | .87 |
| ST | 60 | 54.8 | 57.9 | .94 | .92 | .91 | .67 | .92 | 2.66 | .88 | .91 |
| PLN | 10 | 52.5 | 54.8 | .88 | .85 | .83 | .73 | .85 | 3.49 | .65 | .83 |
| SOC | 10 | 53.8 | 54.6 | .67 | .63 | .67 | .53 | .64 | 5.56 | .36 | .61 |

*Note.* Outcomes are presented for the Neurotypical group (NT), the Neurodiverse group (ND) and the total study population.

[a]Mean T-scores were calculated per subscale, Sensory Total (ST) is the sum of the scores in the Vision (VIS); Hearing (HEA); Touch (TOU); Taste and Smell (T&S); Body Awareness (Proprioception) (BOD); Balance and Motion (BAL) subscales. Planning and Ideas (PLN); and Social Participation (SOC) are not included in ST.

[b]Cronbach's alpha is given for the Self-Report Form 12- to 15-year-old (*n* = 11), 16- to 17-year-old (*n* = 25), 18- to 19-year-old (*n* = 21), and 20- to 21-year-old (*n* = 7) strata, 12- to 21-year-old NT sample (total NT sample, *n* = 64), 12- to 21-year-old ND sample (total ND sample, *n* = 14), and the total sample NT+ND (*N* = 78).

[c]Standard error of measurement of the T-score units, based on the total NT sample (12-21) for each subscale.

Firstly, gender and age did not show a significant effect on the SPM-2 results, meaning that the same questionnaire can be used for the two most common genders and across the target ages. However, the analysis for age should be repeated in a larger sample, as not all age groups were represented equally.

The neurotypical group scored lower mean T-scores than the neurodiverse group on all scales. This is in line with the assumption that the clinical sample is more likely to experience sensory processing difficulties symptoms than the typically developing adolescents and young adults (Galiana-Simal et al., 2020; Ghosh et al., 2022). The difference in mean T-scores between the two groups was approximately 3 points on average, whereas in the U.S. sample this difference was larger with approximately 10 points on average. In the U.S. sample, the mean T-scores of the neurotypical group were lower on all scales than among the Swedish counterparts, whereas the mean T-scores of the neurodiverse group were almost similar as for the Swedish neurodiverse sample. This poses the questions: What caused the Swedish neurotypical group to score higher than the U.S. sample? and Did they experience more sensory processing difficulties than the neurotypical participants in the U.S. sample? A possible explanation is that some participants in the neurotypical group might not have been diagnosed yet, and therefore should have been included in the neurodiverse group, distorting the results. Conditions like ASD or ADHD are regularly undetected until a later age, especially in females where symptoms are less straightforward (D'Mello et al., 2022; Lundin et al., 2021; Merikangas & Almasy, 2020; Rynkiewicz et al., 2019; Wood et al., 2021). Another

possible explanation for the higher T-scores in the neurotypical Swedish group is that adolescents and young adults might have been more likely to participate when they identified with the subject of the study. This could mean that adolescents who experience some sensory problems were more likely to participate when recruitment took place.

Furthermore, the known-group validity analysis demonstrated no significant difference between the neurotypical and the neurodiverse group for any of the scales, indicating that the SPM-2 could not clinically differentiate both groups. However, this lack of significance is most likely due to the small sample size (low power). Especially since all neurodiverse mean T-scores were higher than the neurotypical mean scores, so a significant difference is likely to be found in a larger sample that matches the proportions of the original SPM-2 analysis. The U.S. version of the SPM-2 was validated to discriminate between the neurotypical and the neurodiverse groups when a sample was used that consisted of $n = 100$ participants (Parham et al., 2021a). With a critical alpha value of 0.05, a sample size of 100 people with an attrition rate of 30%, i.e. $N = 130$, would generate a power of 80% to detect a standardized difference of $d = 0.53$. Based on a large-scale study (Parham et al., 2021b) with a SPM-2 T score SD of 8.1 on the scale ranging from 40-80, a sample mean difference of 4 scoring points would thereby be detectable.

In the neurotypical group, the Vision, Hearing, and Touch, scales were above the 0.7 threshold, showing a 'good' internal consistency. Furthermore, the scales Taste and Smell, Body Awareness (proprioception), Balance and Motion, and Planning and Ideas, scored a Cronbach's alpha >0.8, showing a 'very good' internal consistency. The Taste and Smell scale scored a Cronbach's alpha >0.9, meaning its internal consistency can be considered 'excellent'. Only the Social Participation scale scored a Cronbach's alpha <0.7, showing a 'weak' internal consistency (Collet et al., 2023). These results are well in line with the internal consistency in the U.S. standardization sample, with the most important difference being that the internal consistency in Social Participation is 'good' in the U.S. sample, as opposed to 'weak' in the Swedish neurotypical sample. All inter-scale correlations were lower than the corresponding Internal Consistency coefficients, so it can be concluded that the items within each scale are more strongly related to each other than they are to other scales. This supports the separate scoring and interpretation of the SPM-2 scales, and therefore indicates the structural validity of the instrument (Parham et al., 2021a).

The inter-item correlations found can be interpreted as 'good', since most Pearson correlation coefficients ranged between 0.2-0.5 (BrckaLorenz et al., 2013; Cohen & Swerdlik, 2005; Nawi et al., 2020). However, there were three exceptions, for Item 21 in the Touch scale, and Items 77 and 80 in the Social Participation scale, the mean correlation coefficients were

<0.15. For these items, deletion would result in a notable increase in the internal consistency of the corresponding scale. Item 21 concerns the question, *'I dislike eating food with certain textures.'*, therefore, the translation or cultural applicability for this question should be revised or clarified. A possible explanation could be that food textures might associate more strongly with 'taste' than with 'touch'. To emphasize that this item concerns 'touch' instead of 'taste', perhaps the understanding of *textures* should be outlined in more detail. Item 77 entails the following, '*I join activities with others without disrupting the ongoing activity.*' and Item 80 '*People tell me that I speak too softly or too loudly.*'. Deletion of items 77 and 80 in the Social Participation scale, which now is the only scale showing a 'weak' internal consistency, would lead to an increase in internal consistency of the scale to be considered as 'good' (>0.7). During the revision of the back translation, a difference in interpretation became evident; entering an *ongoing* activity should be emphasized more strongly in the Swedish translation. This adjustment could improve the inter-item correlation of Item 77, and thereby the internal consistency of the Social Participation scale. A possible explanation for why Item 80 correlates less strongly in the Swedish population than in the U.S. population could be that the Swedish society is known as quieter, slower-paced, and more introverted than the American (Barker, 2016).

Availability of an evidence-based assessment instrument covering adolescents' and young adults' sensory processing difficulties is important in the light of the current state of health care, social welfare services and school attendance in Sweden. Similarly to the rest of the Western world, Sweden is reporting high and increasing numbers of mental illnesses among adolescents and young adults, with subsequent risks for occupational deprivation due to environmental stressors (Folkhälsomyndigheten, 2023). The number of adolescents with psychiatric disorders, such as ADHD, ASD and anxiety have risen in its incidence, whilst these diagnostic groups' academic performance, attendance and well-being in school domains are declining (Socialstyrelsen, 2023). Coupled with elevated risks for sensory processing difficulties among these youths and young adults, lack of assessments and person-centered treatments may lead to unmanageable demands, constraints, and stressors in school environments (Cervin, 2023; Fabio et al., 2024; Little et al., 2018).

A current paradigm shift in Swedish health care policies, labeled as *"Good and near health care"*[2] (Socialdepartementet, 2022; Socialstyrelsen, 2023), emphasizes the reallocation of resources to preventive, person-centered and community based interventions to lessen the challenging demographic burden of disease and rehabilitation needs. Fostering opportunities for healthy activities, roles and societal belonging are increasingly gaining appreciation as essential for improving the public health of adolescents in

Sweden (Skolverket, 2024; Socialstyrelsen, 2022). Success with these policies and visions is dependent on co-created youth specific services designed for health promotion efforts and participative interventions during adolescence and young adulthood (Folkhälsomyndigheten, 2023). Prevalent knowledge gaps exist in understanding the occupational needs of today's adolescents and young adults, as well as provision of effective occupational therapy interventions for this group. The present study methodology is one example of how *"Good and near health care"* can be realized; namely through inviting adolescents to influence and decide upon their future health care. Providing usability of the SPM-2 in Sweden may be a stepping stone for research studies investigating the correlations and experiences of sensory processing disorder in adolescence and young adulthood, and everyday participation.

### *Limitations*

The methodological strengths of this study are the close adherence to the translation and cross-cultural adaptation stages set by Beaton et al. (2000), as well as consistent involvement of experienced clinicians and adolescent representatives as decision makers to ensure valid equivalencies. Face validity of the co-developed Swedish version was tested during nine in-depth cognitive interviews with neurotypical and neurodiverse adolescents and young adults spanning between the ages of 15-21. One study limitation of importance was the skewed imbalance between the number of participating adolescents belonging to the neurotypical ($N = 6$) and neurodiverse development groups ($N = 3$) in the cognitive interviews. In the psychometric testing this imbalance was also present, with sixty-four participants representing neurotypical development, and only fourteen participants representing the neurodiverse development group, limiting the statistical power to detect significance differences between both groups. This imbalance was due to difficulties in finding willing adolescents and young adults with neurodiverse development combined with restraints in time and resources. Although the inclusion of 30–40 cognitive interviews is the aspired recommendation for pre-testing, similar studies have reported sufficiency with eight to eleven participants (Hocaoglu et al., 2020; Křemenová & Vlčková, 2022; Uhrmann et al., 2019; Wild et al., 2005). Other guidelines on performing structured translations and cross-cultural adaptations set the suggested number of cognitive interviews at five to ten participants (Anthoine et al., 2014; Sousa & Rojjanasrirat, 2011).

Another study limitation was the narrow geographical spread of the participating adolescents and young adults, as everybody lived in the southern parts of Sweden. This may potentially have led to a knowledge gap and limited influence of northern Swedish language usage and

linguistic nuances during the translation and cross-cultural adaptation. A wider geographical spread was, however, accomplished during the expert committee reviews with the experienced clinicians stemming from northern Sweden and the Swedish speaking community in Finland. The clinicians were recruited with the convenience sampling method and mainly found within the 'Swedish Association of Sensory Integration', potentially leading to biassed interactions and discussions during the expert committee reviews.

Yet another limitation was that the age range 12-21 encompasses many very distinct developmental stages. Even though age did not show a significant effect on SPM-2 outcome in this study, adolescents undergo significant changes during this age range, potentially influencing their sensory processing abilities and responses. This should be considered in future studies, when a bigger sample is available wherein all age groups are represented equally. Another explanation is that neurodiverse conditions like ASD or ADHD often go undiagnosed until later in life, particularly in females, where symptoms can be less obvious (D'Mello et al., 2022; Lundin et al., 2021; Rynkiewicz et al., 2019; Wood et al., 2021). This suggests that some participants in the study, while classified as neurotypical, may not yet have a formal diagnosis but still experience sensory processing difficulties in their daily lives, potentially affecting the study's results.

## Conclusions

The groundwork for a sufficiently powered full-scale normative data collection of the Swedish version of the SPM-2 has been accomplished through the co-developed processes showcased in the present study. *Semantic, idiomatic, experiential,* as well as *conceptual* equivalences have been explored, suggested and decided by consensus-based decision making.

Preliminary psychometric properties, including the floor/ceiling effect, the internal consistency, and the inter-scale- and inter-item correlations, indicate the Swedish cross-cultural adaptation of the SPM-2 to be valid and reliable according to clarifications and adjustments made. However, before it can be implemented for clinical use, it is important to repeat the known-group validity analysis in a sufficiently powered study to assure the SPM-2's ability to distinguish between typical and atypical development in adolescence and young adulthood. If new analysis shows that the T-scores and interpretive ranges in the Swedish population align with the U.S. version of the SPM-2, the Swedish version of the SPM-2 can be rolled out in clinical practice.

Aiming to ensure that the evidence-based properties of the original SPM-2 have been properly transferred during the development of the Swedish version, a sufficiently powered subsequent normative study

involving 130 neurotypical and neurodiverse developed adolescents and young adults needs to be carried out. Hopefully, that normative study will be the final hurdle to for clinical availability of the SPM-2 assessment tool in Sweden.

## Notes

1. While the original American version considers 19-21 years old persons as 'adolescents', the present study labels them as 'young adults', which is in alignment with Swedish nomenclature.
2. The manuscript authors' own translation since an official translation is missing at the date when this manuscript was written. The Swedish original wording is as follows: "God– och nära vård".

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