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Development and validation of the highly sensitive child interview for the assessment of environmental sensitivity in primary school children

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ABSTRACT

Around a third of children perceive and process their environment more deeply and are more impacted by its quality. To obtain a more comprehensive and objective measure of this *Environmental Sensitivity* (ES) in primary school children, we developed a semi-structured, multi-informant interview. Study 1 captures the item development while Study 2 covers the psychometric analysis and initial validation of the interview in a small pilot sample of 61 parents, their 60 children, and nine teachers, recruited from a longitudinal study involving 7–9-year-old second-graders in Swiss primary schools. *Method:* Interviews were conducted by trained psychologists with expertise in ES. Questionnaire data was collected from parents, children, and teachers. *Findings:* Parent and child interviews had good internal consistency ($\alpha = 0.83$, $\alpha = 0.79$, respectively) and correlated highly with each other ($r = 0.535$). Parent-interview correlated well with the validated sensitivity questionnaire ($r = 0.514$). Teacher interviews diverged from parent and child views and may inform about differences in how sensitivity is reflected across contexts. *Conclusions:* The new Highly Sensitive Child Interview (HSC – I) is a promising tool for a comprehensive and reliable assessment of sensitivity in primary school children and will be of value to educational psychologists following larger-scale validation.

Declarations of Interest: None.

1. Introduction

Recently, individual differences in school children have received more attention in developmental and educational psychology due to a better understanding that children vary in their needs and preferences regarding their educational context. However, what has not yet been considered in depth are individual differences in sensitivity to environmental influences, a common temperament trait that refers to variation in the capacity to perceive and process internal and external stimuli (Pluess, 2015). According to theory and empirical evidence, children differ substantially in their sensitivity with around a third of children being more affected by both negative and positive aspects of their environment (Lionetti et al., 2019; Pluess et al., 2018). Such *Environmental Sensitivity* (ES; Pluess, 2015) can be measured in children using questionnaires completed by children themselves or their parents (; Sperati et al., 2022; Pluess et al., 2018; Lionetti, Pastore, et al., 2019)

as well as through behaviour observation (; Davies, Hentges, Coe, Parry, & Sturge-Apple, 2021). Although there is increasing scientific and societal interest in this trait and its implications for educational settings, knowledge is currently limited. Thus, to facilitate the identification of highly sensitive primary school children, we here present the development of a new measure, the Highly Sensitive Child – Interview (HSC – I), to be used by trained professionals in order to obtain reliable information about school children's sensitivity. In what follows, we will introduce the trait of environmental sensitivity in greater detail, review available studies on highly sensitive children in school, and discuss existing measures of sensitivity before introducing the current study.

1.1. Environmental sensitivity

The *Environmental Sensitivity* framework (Pluess, 2015) integrates three independent lines of research which approach the notion of

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sensitivity from developmental, biological-evolutionary, and personality psychology perspectives: *Biological Sensitivity to Context* (BSC; Boyce & Ellis, 2005), *Differential-Susceptibility Theory* (DST; Belsky & Pluess, 2009) and *Sensory Processing Sensitivity* (SPS; Aron & Aron, 1997). As discussed in detail elsewhere (Pluess, 2015), all agree that some individuals are more affected by both negative and positive characteristics of their environment due to a generally heightened sensitivity to environmental influences. According to empirical studies, sensitivity can represent a risk factor for various problematic outcomes, such as anxiety (e.g., Bakker & Moulding, 2012) and internalising behavioural problems (Boterberg & Warreyn, 2016), often in response to negative environmental influences such as certain types of parenting (Slagt, Dubas, van Aken, Ellis, & Deković, 2018). However, sensitive children also disproportionately benefit from positive influences such as psychological interventions (e.g., Ceccon et al., 2023). In a nutshell, highly sensitive children are generally more responsive to and more influenced by environmental influences in a *for-better-and-for-worse* manner (Belsky & Pluess, 2009, for a review see Greven et al., 2019).

At the behavioural level, sensitive individuals are characterized by a constellation of attributes which increase their sensitivity to the environment. Aron, Aron, and Jagiellowicz (2012) described deeper processing of stimuli, sensory sensitivity, a tendency for overstimulation, and increased emotional reactivity as key components of Sensory Processing Sensitivity, first proposed by the authors in 1997 (Aron & Aron, 1997). These characteristics are intertwined in that increased sensory sensitivity and deeper processing facilitate heightened awareness of the environment, which can then result in stronger emotions and overstimulation. Importantly, heightened sensory sensitivity is not only reflected in higher sensory discomfort but also in experiences of higher sensory pleasure (De Gucht et al., 2022). Highly sensitive individuals tend to be more inhibited and show a more cautious approach when confronted with new situations, objects, or people (Lionetti, Pastore, et al., 2019). Sensitivity has also been shown to affect the interpersonal domain as highly sensitive individuals tend to have higher empathy (Schaefer, Kühnel, & Gärtner, 2022), as well as higher awareness of others' emotional states (Li, Sturge-Apple, & Davies, 2021). Importantly, although sensitivity has been associated with mood and personality traits, such as negative affect, Neuroticism, and Openness to Experiences (Lionetti, Aron, Aron, Klein, & Pluess, 2019; Pluess et al., 2018), it does not fully overlap with these more established traits (Bröhl et al., 2020; Lionetti, Aron, et al., 2019).

1.2. Environmental sensitivity in school

Until recently, most research on sensitive children has focused on sensitivity in relation to the family environment with little consideration of other developmental contexts. So far, first empirical evidence shows that sensitivity influences socioemotional and academic outcomes of environmental quality across various contexts. For example, research into children with difficult temperament (which is often considered a marker of sensitivity; Belsky & Pluess, 2009), found that the quality of childcare influenced their academic and social outcomes, for better and for worse (Pluess & Belsky, 2010). Essex, Armstrong, Burk, Goldsmith, and Boyce (2011), on the other hand, detected only a vulnerability effect when considering a physiological sensitivity marker: children with high mean arterial pressure had the highest levels of internalising and externalising symptoms in grade 7 when they experienced high teacher-child conflict or low teacher-child closeness at the start of primary school. In the same study, a behavioural marker of sensitivity (high inhibition/low disinhibition) increased children's vulnerability to teacher-child conflict. However, several studies also provide evidence for heightened sensitivity to positive influences (i.e., Vantage Sensitivity; Pluess & Belsky, 2013) with highly sensitive children and adolescents benefitting more from school interventions than less sensitive children, showing larger effect sizes or the presence of an improvement for sensitive children in the absence of a change for less sensitive children

(Ceccon et al., 2023; Nocentini, Menesini, & Pluess, 2018; Pluess & Boniwell, 2015). As highly sensitive individuals are generally more affected by their experiences with effects likely having long-lasting influence on their development (Liss, Timmel, Baxley, & Killingsworth, 2005; Lionetti et al., 2021), understanding, researching, and assessing sensitivity in childhood across multiple contexts is important and requires objective and reliable measurement of sensitivity.

1.3. Measures of sensitivity in children

The first questionnaire for investigating sensitivity in children was presented in Elaine Aron's book *The Highly Sensitive Child* (2002), and later assessed empirically by Boterberg and Warreyn (2016). Since then, several self-report questionnaires (Pluess et al., 2018; Weyn et al., 2021) and parent-reports (Slagt et al., 2018; Sperati et al., 2022) as well as observational measures (Davies et al., 2021; Lionetti, Pastore, et al., 2019) have been developed and shown to moderate outcomes for-better-and-for-worse in line with environmental sensitivity theories.

For school-aged children, the leading measure is the extensively validated *Highly Sensitive Child* (HSC) scale (Pluess et al., 2018). The HSC scale (Pluess et al., 2018) is a 12-item self-report for children from eight years onwards that reflects a bi-factor structure with a general factor and three distinct factors (i.e., Aesthetic Sensitivity, Ease of Excitation, and Low Sensory Threshold). Children who score high on this scale have been shown to be more sensitive to environmental influences: they benefit more from positive influences such as an intervention aimed at promoting resilience (Pluess & Boniwell, 2015), but are also more affected by negative influences such as harsh parenting practices and parenting stress as reported in studies adopting the measure in a parent-report format (Slagt et al., 2018; Sperati et al., 2022). More recently, novel observational measures specifically developed for pre-schoolers, such as the *Highly Sensitive Child Rating System* (HSC-RS; Lionetti, Pastore, et al., 2019) and a measure designed to capture the "dove temperament" (Davies et al., 2021) allowed for more objective measurement of sensitivity in children who are too young to complete questionnaires, with promising evidence supporting their validity (further discussed in Davies et al., 2021 and Lionetti et al., 2021).

While these existing measures provide valuable tools for the assessment of sensitivity, they are subject to limitations. Much like most self-report measures, the questionnaires on sensitivity suffer from potential biases (e.g., social desirability, subjectivity) and it can't be ascertained whether items are understood correctly. For example, some aspects of sensitivity may be particularly challenging to report by children or on behalf of children, such as depth of processing. Observational measures, on the other hand, are more objective but also more laborious and impractical in practice as they require lengthy lab-based tasks. In addition, they do not capture the more introspective aspects of sensitivity. Thus, there is a need for a measure that is objective and practical while also capturing internal aspects of sensitivity, such as an interview-based measure of sensitivity. Finally, recent papers have further highlighted the need to consider sensitivity through the lens of multiple informants (Costa-López et al., 2023).

1.4. The current study

Study 1 presents the development of interview items for a multi-informant (children, parents, teachers) interview for the assessment of environmental sensitivity in primary school children, while Study 2 presents the psychometric analysis and initial validation of the interview in a pilot sample. The administration in the form of an interview allows for follow-up questions as well as clarifications from both the interviewer and the participant with the potential of resulting in a more accurate assessment of sensitivity. This may be particularly important for younger children, who may find it more challenging to respond to questions about their inner world. Given the challenges in assessing children's thoughts and feelings, the questions aimed at identifying

behaviours in the school context that are salient to children as well as parents and teachers. The goal was to develop a comprehensive and objective assessment of sensitivity that has a) good psychometric properties, b) shows strong correlations between informants, and c) is associated with existing sensitivity measures. The present approach is in line with Sensory Processing Sensitivity (Aron & Aron, 1997), characterising sensitivity as a measurable temperament trait, as well as Differential Susceptibility Theory (Belsky & Pluess, 2009), given that we expect that children scoring high on the new interview measure will be more affected by the quality of their environment (a notion to be confirmed in future studies on the interview).

2. Study 1: Interview item development

A large set of items was developed in an iterative process involving teachers and sensitivity experts with the aim of creating questions that capture easily observable behaviours of primary school children (items were initially developed for a new teacher report questionnaire; “blinded”). Out of this item pool, 17 items were identified as suitable for inclusion in the interview and rephrased into Harter (1982) response format which juxtaposes two statements and asks which one describes the child better. This method reduces social desirability (Harter, 1982) and is widely used for a variety of measures including attachment (Brumariu, Madigan, Giuseppone, Movahed Abtahi, & Kerns, 2018). Each question was carefully phrased to offer two types of possible behaviours that are equally acceptable (e.g., “Some children prefer being in smaller groups whereas other children prefer being in larger groups. Which of these two groups is more like this child?”). The informants were then prompted for examples supporting their responses. The themes covered by the parent and teacher interviews were a) *overstimulation*, b) *social behaviour*, c) *response to new situations and changes*, d) *sensitivity to other people's needs and emotions*, e) *emotional reactivity*, f) *response to the physical environment*, g) *depth of processing*, and h) *response to feedback*. To create a child version of the interview that would not be too tiring nor too complex, the number of items from the parent and teacher interviews was reduced to 11 items by omitting items capturing the same theme. Hence, the child interviews still captured the same themes as the parent interview but with fewer questions (except items

for social behaviour which were considered more challenging for children to report). In addition to the 17 questions, the parent interview featured follow-up questions (“Has the child always been like you have described them now? Have there been any changes?”) to ensure the information reflected the child's general behaviour rather than the response to a current situation. The item content of the questions of HSC – I for parents, children, and teachers are provided in Table 1. As conducting the interview requires training, the detailed interview is only available upon request.

3. Study 2

3.1. Method

3.1.1. Participants

3.1.1.1. Inclusion and exclusion criteria. The interviewed children, parents, and teachers were part of a longitudinal study in Switzerland ($N = 265$; November 2019–May 2021) following children from the first year of primary school till the end of the second year. The study was approved by the Queen Mary Ethics of Research Committee (QMERC2019/51). All children in the participating schools who attended first year primary school classes and whose parents and teacher provided informed consent were included in the study. No children were excluded due to any diagnoses given that we did not have information on neurodevelopmental or other conditions. All families involved in the third data collection wave in the second primary school year ($n = 206$) were invited to partake in the interview. Ninety-six families (36 % of the original sample) agreed to be contacted about the interview and were subsequently contacted multiple times via phone or email to schedule the interviews. Children provided verbal assent. Finally, at least one informant's view per child was obtained on 72 children. For the full sampling procedures, please see Appendix A in Supplementary Documentation.

3.1.1.2. Participant characteristics. Interview data from at least one informant was obtained for a total of 72 children (47.2 % female). More specifically, the interviews were conducted on 60 children, 61 parents,

Table 1
Item content of the questions of HSC – I.

Interview Items and themes in bold
Overstimulation
1. Need for quiet time after exciting activities/playing with others *
2. Overwhelmed under pressure *
Social behaviour
3. Preference for smaller groups
4. Preference for listening and waiting to be called by a teacher, rather than raising a hand
5. Shy in new situations
Response to new situations and changes
6. Wait and observe a new place before engaging with it *
7. Quick to notice small changes *
Sensitive to other people's needs and emotions
8. Easily notices others' feelings even when they are not showing them clearly*
Emotional reactivity
9. Strong emotions in response to good and bad events *
10. Upset when experiencing or observing an injustice and keep thinking about it
11. Upset when other children are fighting/arguing/raising their voices *
Response to the physical environment
12. Easily disturbed by noise *
Depth of processing
13. Spending a lot of time thinking about what they have learned or experienced*
14. Slow decisions
15. Interest and engagement with complex topics (e.g., animal welfare, other ethical issues)
Response to feedback
16. Remembers punishment for long*
17. Remembers praise for long*

Note. Shortened descriptions of the items that were administered in Harter's response format for teachers and parents. The themes discussed during the development process are in **bold**. The items with an asterisk (*) were included in the child interview.

and nine teachers. All child interviews ($n = 60$) had a corresponding parent interview, 22 of which also had a matching teacher-interview. In addition, we had one child with only parent and teacher interview ($n = 1$), and 11 children with only teacher interviews ($n = 11$), constituting the total number of children we had interview data for ($N = 72$). The discrepancies in the number of informants per child were due to scheduling difficulties. The interviews took place 1,5 years after the beginning of the study when children attended the second grade and were aged between 7 and 9. Participating families had nationally average incomes (the gross mean household income in Switzerland is 9582 CHF/month; Bundesamt Für Statistik, 2021) but were homogeneous in terms of nationality and home language and slightly more educated than on average in the region (Ticino, 2021). For the full demographic variables, see Appendix B in Supplementary Documentation. Whilst the sample was drawn from both urban and rural populations, the standard of living across the whole sample was relatively high.

The sample of children for which interview data were available did not differ from the total longitudinal sample in terms of parent-reported sensitivity using the Highly Sensitive Child (HSC) scale (Pluess et al., 2018) with a mean HSC score of 5.2 for the 'agreed to be interviewed' group of children, and 5.0 for the others, $t(149) = 1.86, p = .07$. Similarly, teacher-reported sensitivity scores did not differ between the two groups, $t(131) = 0.05, p = .96$ ($M_1 = 4.0, M_2 = 4.0$), nor did the child-reported sensitivity, $t(132) = 0.44, p = .66$ ($M_1 = 4.8, M_2 = 4.8$).

3.1.2. Measures

A large set of measures was collected as a part of the longitudinal study, but these were not a focal point for the current paper (for the full list of variables, please see Appendix C in Supplementary Documentation).

3.1.2.1. The highly sensitive child – interview. The new Highly Sensitive Child – Interview described above was used to interview teachers, parents, and children. Interviewers rated each answer, following the instructions and drawing on their expert knowledge of environmental sensitivity. Answers were scored from 1 to 5 with scores 1 and 2 indicating that the response and examples provided by the interviewee are reflective of low sensitivity. Score 3 indicates medium sensitivity and scores 4 and 5 were given if the interviewer concluded that the answer and provided examples reflected high sensitivity. For an example item in Harter's response format, please see Appendix D in Supplementary Documentation. The interviewers also noted down a more qualitative impression they got on the child based on the full interview, writing down low, low/medium, medium, medium/high, or high sensitivity.

3.1.2.2. The highly sensitive child scale. The Highly Sensitive Child scale (HSC; Pluess et al., 2018) measures children's self-reported sensitivity. The HSC scale can also be employed as a parent-report (Sperati et al., 2022). The 12 items of the scale are scored on a Likert scale ranging from 1 to 7 (1 = *Not at all*, 7 = *Extremely*) and reflect a bifactor structure with one general factor and three individual factors; Aesthetic Sensitivity (e.g., "I love nice tastes"), Low Sensory Threshold (e.g., "Loud noises make me feel uncomfortable"), and Ease of Excitation (e.g., "I don't like it when things change in my life"). The mean across all 12 items is used as the total score. The HSC scale was applied at multiple waves of the main longitudinal study. The data chronologically closest to the interview date was used for validation. Parents' HSC report had an acceptable internal consistency ($\alpha = 0.76, 90\% \text{ CI } [0.69, 0.82]$). However, child reported data had lower reliability ($\alpha = 0.50, 90\% \text{ CI } [0.33, 0.65]$), likely due to the fact that the sample was at the lower end of the age range of the questionnaire (8–18-year-olds).

3.1.2.3. The highly sensitive child in school scale. The Highly Sensitive Child in School scale (HSC – School; "blinded") was primarily devised as teacher-report but was also applied as parent- and child-report to

measure sensitivity behaviours in the school context. As the other sensitivity measure, this scale is rated on a 1–7 Likert scale (1 = *Not at all*, 7 = *Extremely*). The measure includes six items assessing core sensitivity (e.g., "Is thinking deeply about things") used to identify sensitive children and three items on overstimulation (e.g., "Struggles to focus in loud and chaotic situations") that are used to assess potential difficulties that sensitive children may encounter at school. The overall teacher-report had a good internal consistency ($\alpha = 0.80, 90\% \text{ CI } [0.74, 0.85]$). Parent-report also had good internal consistency across the whole scale ($\alpha = 0.83, 90\% \text{ CI } [0.78, 0.88]$). Children reported on the same items using a simpler 1–5 scale. The child report's overall score had a low internal consistency ($\alpha = 0.60, 90\% \text{ CI } [0.47, 0.71]$). As the interview taps into both core sensitivity and overstimulation, the interview scores were compared to the total scores of HSC – School which were derived by taking the mean across all nine items.

3.1.2.4. BIS/BAS. The Behavioural Inhibition System (BIS) and Behavioural Approach System (BAS) were assessed using a parent-report of the BIS/BAS scales by Vervoort et al. (2015). To assess discriminant validity, parents reported on BIS/BAS in the last assessment wave. Most of the factors had an acceptable internal consistency; BIS ($\alpha = 0.79, 90\% \text{ CI } [0.72, 0.85]$), BAS Reward Responsiveness ($\alpha = 0.67, 90\% \text{ CI } [0.56, 0.76]$), BAS Drive ($\alpha = 0.90, 90\% \text{ CI } [0.86, 0.93]$), and BAS Fun Seeking ($\alpha = 0.72, 90\% \text{ CI } [0.62, 0.80]$). Each factor was scored separately by taking the mean across the relevant items.

These scales were selected because behavioural inhibition has been identified as a related characteristic of sensitivity (e.g., Pluess et al., 2018). While behavioural approach correlates with sensitivity in some research ($r = 0.41$; Pluess et al., 2018), there is no theoretical basis for why sensitivity should be associated with behavioural approach.

3.1.3. Data collection

Parent and teacher questionnaires were collected online. Child questionnaires were collected in class using pen and paper. Researchers read the individual questions aloud to children, provided examples and answered any queries children had. The interviews were largely conducted via Zoom with a few teacher interviews carried out in person. Interviews were conducted, assessed, and coded by three interviewers who were all trained in developmental and educational psychology and highly knowledgeable in environmental sensitivity.

3.1.4. Quality of measurements

Two senior psychologists with expertise in environmental sensitivity interviewed parents and children. The two interviewers coded five parent and five child interviews independently to estimate interrater reliability. All scores were within one point of each other or closer. The two interviewers then critically discussed the rating before conducting the rest of the interviews. A third interviewer, a psychologist who had previously worked as a teacher and school consultant, was then trained, and observed teacher interviews before interviewing five of the teachers.

3.1.5. Data analysis

All statistical analyses were conducted in R (v3.6.2; R Core Team, 2019). First, item-level descriptive statistics (mean, standard deviation, and within-scale bivariate polychoric correlations) were calculated and data were visualised using histograms. Second, internal consistency was assessed by calculating the polychoric alpha to account for the ordinal nature of the data. Respective 90% confidence intervals were calculated following the formula in Feldt, Woodruff, and Salih (1987). Third, the number of components to retain in the interviews were identified using parallel analysis (Horn, 1965), after which the questions were entered into principal component analysis (PCA) using Oblimin rotation and polychoric correlation given the use of ordinal 1–5 scale. Given the small a number of teacher-reports for PCA (Guadagnoli & Velicer, 1988), the

structure of the teacher-report was not analysed in a separate PCA. Instead, we report how the solution identified in the parent-data fits the teacher-reported data. Fourth, interview scores were created by averaging ratings across all questions, resulting in a score from 1 to 5. An average was preferred over a sum of scores to render interview scores across the different versions of the interview comparable (the child interview has fewer items). Fifth, Pearson's correlation was calculated between different informants' interviews to establish agreement between parent, child, and teacher data. A parent-child agreement that is higher than 0.50 is considered good concordance (Cohen & Holliday, 1982). Sixth, convergent validity was determined by calculating Pearson's correlations between the interviews and the same informants' scoring on sensitivity questionnaires. Seventh, correlation between interview scores and parent reports on behavioural inhibition and approach scales were calculated for discriminant validity (e.g., Pluess et al., 2018; Smolewska, McCabe, & Woody, 2006). For completeness, *p*-values are reported but given the size of the sample, we focus the discussion on the size of the correlation coefficients. Correlation coefficients between 0.1 and 0.3 were considered small, while 0.3–0.5 were considered medium/moderate and over 0.5 large.

3.2. Results

No participants were excluded from all analyses. Some interview data was missing, which applied to 1 % of parent interview responses, 0.3 % of child responses and 0.5 % of teacher responses. To increase power, results are reported on imputed data but PCA was run with and without imputed data to ensure that the factor structure and items identified for exclusion were not biased by imputation. Furthermore, when assessing convergent validity, we also compared correlations between interview and questionnaire scores within informants with and without imputation. Importantly, imputation did not change the significance level, nor the effect sizes meaningfully. Pairwise-complete observations were included in the correlational analyses on total scores. One parent did not provide questionnaire data and child-reported questionnaires were not available for all interviewed children: out of the 60 interviewed children, 12 lacked the HSC scale and two missed the HSC – School scale. Among the HSC scale, 3 % of the items were missing. Among the HSC – School data, 1 % of the item responses were missing. For detailed description of how missing data was handled, see Appendix E in Supplementary Documentation.

3.2.1. Item-level descriptive statistics and internal consistency

Means, standard deviations, range, skew and 'not applicable' responses for all interviews are reported in the Appendix F in Supplementary Documentation (see Tables F1, F3 and F5, respectively). For polychoric within-item correlations for each interview, see Appendix F (Tables F2, F4, and F6). For histograms, please see Figs. G1, G2 and G3 in the Appendix G in Supplementary Documentation.

3.2.1.1. Parent interview. Most questions approximated normal distribution, except question 7 ("notices changes") which had a high skew (1.23). All questions correlated with at least some other interview questions apart from questions 7 and 8 ("notices others' feelings") which mainly correlated with each another. Standardised polychoric alpha across the main 17 interview questions was 0.83 (90 % CI [0.77, 0.88], *N* = 61), suggesting good internal consistency.

3.2.1.2. Child interview. Child items were normally distributed and no item had a strong skew. Polychoric alpha for the total 11 child interview questions was acceptable (α = 0.79, 90 % CI [0.72, 0.85], *N* = 60).

3.2.1.3. Teacher interview. Three teacher interview items had a strong (> 1) negative skew (items 7, 9, and 17). Polychoric alpha for the 17 questions was 0.66 (90 % CI [0.50, 0.79], *N* = 34). Notably, question 3

("preference of small groups or big groups"), question 4 ("raising the hand in the classroom"), and question 6 ("behaviour when entering a new room") were negatively correlated with the rest of the scale despite not being designed to be reverse-coded.

3.2.2. Principal component analysis

3.2.2.1. Parent interview. In order to investigate the distribution of variance within the interview, Principal Component Analysis (PCA) using an Oblimin rotation and polychoric correlation was run on the 17 interview questions. Items loaded on two components (eigenvalues 3.91 and 3.76), explaining 51 % of the variance. Two questions did not have a primary loading higher than 0.33 (question 7 on "noticing small changes" had a primary loading of 0.29 and question 8 on "noticing feelings in others" had a primary loading of 0.17) and one was complex with loadings of 0.34 and 0.42 (question 12 on "being easily disturbed by noise"). Removing these three questions led to a 2-component model (eigenvalues 3.78 and 3.53) explaining 52 % of the variance. Half of the items loaded on the first component (eigenvalue 3.78) which was named inhibition-overstimulation as it captures questions related to shy behaviours and overwhelm. The second component (eigenvalue 3.53) was titled core sensitivity as it encompasses questions addressing core aspects of sensitivity such as depth of feeling and thinking. Each of these components consist of seven interview questions, are normally distributed, and correlate with each other, $r(59) = 0.264, p = .04, 95\% \text{ CI } [0.01, 0.48]$. For the rotated component matrix and shortened item names, see Table 2. Internal consistency was high for both core sensitivity ($\alpha = 0.83, 90\% \text{ CI } [0.77, 0.88]$) and inhibition-overstimulation ($\alpha = 0.84, 90\% \text{ CI } [0.78, 0.89]$) scales.

3.2.2.2. Child interview. Parallel analysis suggested retaining one component for the 11 child interview questions. PCA using polychoric correlation was run and the resulting model explained 35 % of the variance (eigen value 3.80). Similar to the parent interview, questions 7 ("notices changes") and 8 ("notices others' feelings") did not produce a primary loading. Alpha-analyses also suggested that internal consistency of the scale would improve without these questions. Thus, these items were excluded from child interviews. Parallel analysis suggested that one component describes the remaining data best and PCA using polychoric correlation was run on the remaining nine questions. The 1-component solution (eigen value 3.69) explained 41 % of variance. The final score was normally distributed. For the rotated component matrix, see Table 3. The internal consistency of the final scale was good ($\alpha = 0.80, 90\% \text{ CI } [0.73, 0.86]$).

Table 2
HSC - I, shortened 14-question parent report, rotated component matrix.

Interview item	Inhibition-overstimulation	Core sensitivity
1. Quiet time	0.80	-0.06
2. Overwhelmed under pressure	0.57	0.22
3. Group size	0.62	0.05
4. Raises hand	0.69	-0.13
5. Shy in new situations	0.79	0.08
6. Wait & observe	0.84	-0.07
9. Strong emotions	-0.28	0.85
10. Upset by injustice	0.10	0.76
11. Upset by fights	0.20	0.54
13. Time spent thinking	0.09	0.68
14. Slow decisions	0.59	0.20
15. Engagement with complex topics	0.04	0.66
16. Remembers punishment for long	0.29	0.65
17. Remembers praise for long	-0.03	0.66

Note: The rotated component matrix on the 14 items of the reduced interview scale reveals two distinct components with primary loadings >0.50 and no cross-loadings.

Table 3
HSC - I, shortened 9-question child-report, rotated component matrix.

Interview question	Sensitivity
1. Quiet time	0.34
2. Overwhelmed under pressure	0.77
6. Wait & observe	0.79
9. Strong emotions	0.44
11. Upset by fights	0.70
12. Disturbed by noise	0.78
13. Time spent thinking	0.53
16. Remembers punishment for long	0.53
17. Remembers praise for long	0.72

Note: A rotated component matrix for a shortened child interview with nine questions.

All the Principal Component Analyses were run with and without imputation and the results were consistent. Please see Appendix I for the results without imputation.

3.2.2.3. Teacher interview. Given the small teacher sample, we only report polychoric alphas for the teacher data, based on the structure identified in the parent data on the same set of questions (but see Appendix H for an exploratory PCA on the teacher-interview). Both teacher-reported inhibition-overstimulation and core sensitivity had an acceptable internal consistency ($\alpha = 0.66$, 90 % CI [0.49, 0.79], for both). The two components were not associated, $r(32) = -0.001$, $p = .99$, 95 % CI [-0.34, 0.34].

3.2.3. Agreement between parent, child, and teacher – Interviews

To analyse correlations between interviews from different informants, total scores were created by taking a mean across questions. Subsequently, we obtained continuous interview scores ranging from 1 to 5. Pearson's correlation coefficient showed a good concordance between the mean score of the parent interview with 14 questions and the child interview with nine questions, $r(58) = 0.535$, $p < .001$, 95 % CI [0.32, 0.69]. The 14-item parent and teacher interviews were not correlated with each other, $r(21) = 0.013$, $p = .95$, 95 % CI [-0.40, 0.42]. Total scores of teacher and child interviews were positively associated but this relationship was not statistically significant, $r(20) = 0.260$, $p = .24$, 95 % CI [-0.18, 0.61].

3.2.4. Convergent validity

3.2.4.1. Parent interview. Pearson's correlation coefficient between the 14-item parent interview score and parent-reported HSC scores showed a large correlation, $r(58) = 0.514$, $p < .001$, 95 % CI [0.30, 0.68]. Both interview components correlated moderately with HSC, with inhibition-overstimulation, $r(58) = 0.436$, $p < .001$, 95 % CI [0.20, 0.62], showing a slightly higher association than core sensitivity, $r(58) = 0.378$, $p = .002$, 95 % CI [0.14, 0.58].

Pearson's correlation between the total 14-item parent interview score and the total parent HSC – School score was moderate, $r(58) = 0.450$, $p < .001$, 95 % CI [0.22, 0.63]. Further inspection of the component scores showed moderate associations between the HSC – School and inhibition-overstimulation, $r(58) = 0.314$, $p = .01$, 95 % CI [0.07, 0.53], as well as core sensitivity, $r(58) = 0.407$, $p = .001$, 95 % CI [0.17, 0.60].

3.2.4.2. Child interview. Pearson's correlation between the 9-item child interview and the child-reported HSC scale approached a moderate association, $r(46) = 0.276$, $p = .06$, 95 % CI [-0.01, 0.52]. Comparing the child interview to the total score of the child HSC – School which, which is similar to the interview, showed a moderate correlation, $r(56) = 0.346$, $p = .008$, 95 % CI [0.10, 0.56].

3.2.4.3. Teacher interview. There was moderate association between the

14-item teacher interview and the overall HSC-School score across all the nine items, $r(32) = 0.338$, $p = .05$, 95 % CI [-0.00, 0.61]. The association was small between inhibition-overstimulation and the total HSC – School score, $r(32) = 0.102$, $p = .57$, 95 % CI [-0.24, 0.42], but moderate between the core sensitivity component and the total HSC – School score, $r(32) = 0.400$, $p = .02$, 95 % CI [0.07, 0.65].

3.2.5. Discriminant validity

Pearson's correlation coefficient between the total parent interview score and parent-reported behavioural inhibition (BIS) was moderate, $r(58) = 0.477$, $p < .001$, 95 % CI [0.25, 0.65]. This correlation is similar to the association between the HSC scale and BIS when reported by 12-year-old children ($r = 0.55$; Pluess et al., 2018). The associations between BIS and the parent interview subcomponents were moderate, with inhibition-overstimulation, $r(58) = 0.428$, $p < .001$, 95 % CI [0.20, 0.62], showing a slightly higher association than core sensitivity, $r(58) = 0.325$, $p = .01$, 95 % CI [0.08, 0.53].

Pearson's correlation coefficients between the parent interview score and parent-reported behavioural activation (BAS) were all very small. Parent interview scores did not correlate with BAS Drive, $r(58) = 0.064$, $p = .63$, 95 % CI [-0.19, 0.31], BAS Fun, $r(58) = -0.171$, $p = .19$, 95 % CI [-0.41, 0.09], or BAS Reward Responsiveness $r(58) = 0.014$, $p = .91$, 95 % CI [-0.24, 0.27]. BAS subfactors did not have significant associations with either of the parent interview components, except for a significant negative correlation between BAS fun seeking and inhibition-overstimulation, $r(58) = -0.339$, $p = .008$, 95 % CI [-0.55, -0.09].

3.2.6. Scoring and identification of sensitive children

The psychometric analyses suggested that teacher-ratings differ from parent- and child-ratings and should not be included when creating a composite score. Therefore, we explored a composite score focusing solely on parent (14 items) and child interviews (nine items). The composite was created by taking the average of the parent and child interview total scores for those children for whom we had data from both informants ($n = 60$). The composite scores ranged from 2.2 to 4.3, with a mean of 3.2. Interviewers' qualitative impressions recorded after the interview (i.e., whether child reflects low, medium, medium/high, or high sensitivity) were compared to the top quartile of the composite scores. Interviewers' impressions matched the results well: 13 of 16 children in the top quartile had a 'high' rating and the remaining three were rated 'medium/high' based on parent or child interviews. Similarly, the bottom quartile scoring lower than 2.7 were all rated 'low' or 'medium' by the interviewer. Moreover, the top quartile averaged 5.8 on the HSC scale (parent-report) whereas the low sensitive group's mean was 4.7.

4. Discussion

Individual differences in environmental sensitivity influence both children's everyday experiences and development over time (Pluess, 2015). We aimed to develop an interview to assess environmental sensitivity in primary school children across several informants (parent, child, and teacher) and piloted these interviews with over 60 parent and child interviews and 34 teacher interviews. While our findings require further replication in larger samples, our results suggest that a combination of parent and child interviews provided a well-rounded view of children's sensitivity. Interestingly, the present findings do not encourage relying on the teacher report as the first choice or the sole informant as teacher scores did not correlate with parent and child interviews. The interview had good internal consistency (for parent and child interviews, but lower for teacher interviews, $\alpha = 0.66$), reflected a substantial correlation between parent and child data, and each informant's responses had moderate to large association with corresponding sensitivity questionnaires completed by the informants.

As for the parent interview, the original interview including 17 questions had good internal consistency. Following principal component

analysis, the first component of the shortened interview captured items related to inhibited and overwhelmed behaviours such as slowly approaching new situations and needing quiet time. The second component captured emotional reactivity (being strongly affected by praise, punishment, and injustice) and depth of processing (thinking long and engaging in complex discussions) and was thus titled core sensitivity. These two distinct 7-item components had loadings ranging from 0.54 to 0.85, and no cross-loadings. As the size of the sample has more implications on replicability in the presence of low loadings (0.40) and its importance decreases with higher loadings of 0.60 and 0.80 (Guadagnoli & Velicer, 1988), the identified structure has promise to replicate despite our small sample size. However, other authors highlight the importance of considering communalities (i.e., what portion of the variance is accounted for by the common factors) alongside sample size, suggesting that in the conditions identified in our PCA results (low communalities ranging from 0.37 to 0.73 with eight communalities below 0.50 and few larger components), the sample should exceed 100 for good recovery of population factors (MacCallum, Widaman, Zhang, & Hong, 1999). Thus, while these pilot results show some promise (good component loadings but low communalities) to be stable in other samples, it is important to replicate the result in larger samples. As for convergent validity, the parent interview correlated highly with the parent-reported HSC scale, suggesting that there is significant but not complete agreement between the measures. Thus, the interview appears to tap into the same construct but provides additional and different information than the questionnaire.

Children were interviewed using a shortened interview with 11 questions. As for the parent interview, the child interview had acceptable internal consistency, yet two items did not relate strongly to the remaining set of items (questions 7 and 8 on noticing small changes and others' feelings). This may be due to a ceiling effect as the majority of children scored high on these items in both parent and child reports. These items were dropped and the final child interview included one component with nine items. This structure differed from the parent interview likely due to the smaller number of questions administered to children. Out of the retained items, item 1 regarding needing quiet time had the smallest loading (0.34) and communality (0.11), which may be due to the higher level of self-awareness this question requires, and subsequently this item may work better in older children. Loadings and communalities were overall lower than in the parent-interview, suggesting that the child interview results may be more impacted by the small sample (Guadagnoli & Velicer, 1988; MacCallum et al., 1999). Similar to the parent interview, the child interview had a moderate association with child-reported questionnaires, providing evidence of convergent validity. Moreover, the child and parent interviews had good concordance, suggesting that interview scores from parents and children could be combined into a composite score. Combining parent and child scores may strengthen the conclusions drawn from the interview as some questions may be easier for either children or parents to report on. While child report benefits from children's subjective perception regarding their behaviour across school and home settings, their responses might be more informed by very recent experiences and events rather than their general responses to their environment. On the other hand, while parents can draw on a wealth of memories of their child's behaviour, they may already have preconceptions of their child's sensitivity, which may affect their responses. Thus, combining data from parents with child data likely provides a more accurate picture of the child's sensitivity.

Only a small number of teachers were interviewed on a handful of children in their classes. Hence, findings on teacher interview data need to be considered exploratory, and further research with larger samples is needed. Although teacher interview data corresponded well with teacher questionnaire scores (with a good agreement on the core sensitivity factor but low agreement on the inhibition-overstimulation factor which has little item overlap with HSC – School), the agreement between teacher interviews and child or parent interviews was low. This

suggests that teachers perceive children's sensitivity differently than parents and children themselves. We can hypothesise that this could be due to children showing different behaviour at school than at home. In other words, the manifestation of sensitivity behaviours may be context-specific, which is also supported by other researchers finding low correlations between parents' and teachers' views on child sensitivity (Costa-López et al., 2023). Alternatively, it is also possible that teachers just have less knowledge or awareness of children's sensitivity. Interestingly, children's sensitivity was less uniform in the teacher interview compared to the parent interview: the two components were not associated with one another, and some items correlated negatively with others. For example, item 15, which captures engagement with complex topics, had a negative correlation with many of the inhibition-overstimulation items. It may be that when children are less vocal in the classroom, teachers are less aware of their ability to process complex topics. Parents, on the other hand, know their children's behaviour in different contexts and have more opportunities to experience their ability to engage in activities that they are less likely to manifest in the context of school. Highly sensitive children may also mask some of the challenging aspects of their sensitivity in the school context (i.e., they may 'push through' the school day without showing their overstimulation until they get home, see for an applied discussion around this topic also Aron, 2002). Indeed, it makes conceptual sense that children who are more attuned to their environment would adjust their behaviour to different environmental settings.

5. Strengths and limitations

This study is characterized by several strengths. The questions were carefully developed drawing on the existing literature on sensitivity as well as international experts' views on sensitivity and the primary school context. Data was based on interviews of multiple informants (teachers, parents, children). Going beyond self-reports, interview data rated by trained individuals are likely more objective. As the interview format allows both the interviewer and the interviewee to ask clarifying questions, the scores are less subject to biases and misunderstandings. Moreover, Harter's response format (Harter, 1982) was applied which likely reduces social desirability.

However, findings need to be considered in light of several limitations. The main limitation of the present study is the small sample, which has at least the following implications: a) *p*-values do not meaningfully represent the significance of the findings and therefore we mainly focus on assessing the size of the correlations, b) alpha-analyses are less reliable in small samples and therefore we have provided 90 % confidence intervals for the reported values c) teacher-interview had a particularly small sample which further complicated interpretation and did not allow for robust exploration of its component structure, d) we could not run exploratory factor analysis, which could have provided more information on the structure, nor moderation analyses to see whether the interview scores moderate the relationship between the quality of the environment and child wellbeing. Larger samples in future studies may enable further specification of the factors, such as separating inhibition and overstimulation items, and emotional and cognitive aspects (i.e., depth of feeling and thinking) of the core sensitivity component, as well as exploration of the factor structure of the teacher interviews. Finally, results must be considered in light of the specific context in which data have been collected, that is in Ticino, Switzerland, a country characterized by very high quality in terms of social services, environmental quality (including the school context), and socio-economic status of the general population. Hence, future studies should replicate findings in larger samples and also consider the generalisability and applicability of this measure to other cultural and socio-economic contexts.

6. Practical implications

Following further development and validation, educational psychologists will be able to administer HSC – I (with appropriate training) in order to identify highly sensitive children and assess their needs in primary school. For example, a child presenting with sensitivity to loud noises and difficulties when having to do many things at once might experience difficulties at school, such as being distracted or not meeting their full potential. If confirmed as a highly sensitive child, teachers might be able to take specific action to improve the school context for that child. Given the low agreement between teacher interviews with those from parents and children, it is recommended to complete the interview with all three informants, but at least teachers and either the parent or the child. These different informants will provide important information on the child's behaviour in different contexts. This is especially relevant if a child masks their sensitivity in class or where certain sensitivity behaviours occur in only one context (home or school). For example, if a child shows high levels of inhibited behaviours at school but not in other settings, this might indicate that something specific about the school environment impacts the child's behaviour.

There are two points that should be considered when applying HSC-I more broadly in primary schools. Firstly, the child should be observed throughout the interview to acquire corroborating evidence of the child's sensitivity. This could be more informal or include an additional behavioural scale (to be developed) on which the interviewer scores how cautious and cooperative the child is with the interviewer (in line with the observational measure by Lionetti, Pastore, et al., 2019), how inhibited they are, and whether their behaviour changes over the interview as they get more familiar with the interviewer. The interviewer should also observe whether the child takes long to decide between different options and whether they are highly affected by praise when they are thanked for participation, which could corroborate the evidence provided by the informant. Such additional information would further increase the objectivity of the assessment.

The second point refers to the potential overlap between the questions in this interview and the symptomology of Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Condition (ASC), which have prevalence rates of around 2–7 % and 2–3 %, respectively, in children and are common reasons that children are referred to educational psychologists (McConkey, 2020; Sayal, Prasad, Daley, Ford, & Coghill, 2018). Some similarities with environmental sensitivity include for example, sensitivity to injustice and rejection in the case of ADHD (Bondü & Esser, 2015) and sensory sensitivity and attention to detail in the case of ASC (Liss, Mailloux, & Erchull, 2008). Given that sensitivity is a temperamental trait ranging from low to high (with highly sensitive children making up around 25–35 % of children; Pluess et al., 2018), being highly sensitive does not exclude the possibility of other diagnoses such as ADHD and ASC (especially at the level of shared traits, see Damatac et al., 2023). Therefore, if there are reasons to believe that a child might be meeting the criteria for ADHD and/or ASC, a clinical assessment of neurodevelopmental conditions such as ADHD and ASC should be considered. Moreover, if the child's sensory processing patterns are affecting daily life or expand to symptomology beyond sensitivity to environmental stimuli (e.g., sensory discrimination difficulties), it may be worthwhile to assess the presence of sensory processing disorders (Mulligan, Douglas, & Armstrong, 2021). While the investigation of how HSC – I relates to these conditions was beyond the scope of this study,² exploring these relationships is an important avenue for future

² We have begun exploring this by holding an expert panel involving researchers on ADHD and ASC who feedbacked on the item content. The discussion did not identify problematic questions but highlighted the significance of more structured follow-up questions and prompting for examples from both social and non-social scenarios to better understand reasons for the child's behaviour.

research.

7. Conclusions

The present paper introduced a new sensitivity assessment interview, HSC – I, which can be used to interview teachers, parents, and children regarding children's sensitivity. Findings suggest that the new measure has acceptable internal consistency and correlates with existing and established sensitivity measures, but the parent and child interviews performed more strongly than the teacher report. Low agreement with teachers suggests that children's sensitivity may manifest differently in the school versus home. Following further validation, HSC – I will provide a useful tool for educational psychologists in order to objectively and accurately assess children's sensitivity.

CRedit authorship contribution statement

Jenni E. Kähkönen: Data curation, Formal analysis, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. **Francesca Lionetti:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Luciana Castelli:** Investigation, Project administration, Supervision, Writing – review & editing. **Michael Pluess:** Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Writing – review & editing.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT in order to paraphrase Appendix A. Sampling Procedures as a version of the same information is used in our other manuscripts drawing on the same longitudinal study. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.paid.2024.112592>.

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