A User Guide to the Pediatric Versions of the Vanderbilt Fatigue Scale (VFS-Peds)©

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1. Rationale for the VFS

For some children the simple act of trying to listen and understand family, friends and teachers can require substantial effort, especially in noisy conditions. When this effort is sustained over time it can lead to feelings of significant listening-related fatigue.[1, 2, 3, 4] Given that the mental effort needed for active listening is often increased in adults and children with hearing loss, this population may be particularly susceptible to listening-related fatigue. Mounting evidence suggests that severe fatigue can have negative psychosocial and academic effects[5,6,7,8,9,10,11] – this evidence provided the motivation for the creation of the Vanderbilt Fatigue Scales (VFSs) described here. These tools were specifically designed to assess listening-related fatigue. While this manual focuses on the pediatric versions of the VFSs, adult versions are also available. Additional information and copies of the pediatric and adult versions of VFSs can be found at the VFS website (https://www.vumc.org/vfs).

2. Introduction to the VFS-Peds

There are **three** (3) versions of the Vanderbilt Fatigue Scale designed to assess listening-related fatigue in **school-age children (VFS-Peds)— child self-report (VFS-C), parent proxy-report (VFS-P), and teacher proxy-report (VFS-T).**[12] More information about each version is found in the following sections. While the scales were originally developed to target fatigue in children who are deaf/hard of hearing (DHH), they may potentially be useful for other populations of children. For example, while evidence is limited, any child who must exert substantial mental effort when listening and/or processing auditory information (e.g., language disorders, non-native speakers, second language learners, children with auditory processing, or any learning difficulties) may be expected to struggle with listening-related fatigue.[13]

The VFS-Peds are designed to assess "long-term" listening-related fatigue, not the fatigue a child is feeling "right now". Thus, the respondent is instructed to reflect back on the past **WEEK** (or a typical week if the past week has been very unusual) and choose the response option that best describes how often they (or the child/student for parent or teacher proxy reports) have felt or acted during that time period. Response options for all scales utilize a 5-point (0-4) Likert frequency response scale. Response options include: Never (0), Rarely (1), Sometimes (2), Often (3), and Almost Always (4). The respondent should select a single response category (e.g., Never (0), Sometimes (2), etc.). An "in-between" response cannot be scored. Those administering the scales should ensure that a response was provided for all scale items. Scoring options for scales with missing responses are limited (see below).

The VFS-C: child self-report version
The VFS-C is a **unidimensional** scale designed to assess listening-related fatigue in children **ages 6-17 years**. This self-report measure quantifies listening-related fatigue from the child's own perspective. The VFS-C is comprised of **10 test items.** Please note that different test administration methods are recommended for children ages 6-10 versus those ages 11-17 (see Administration section on pages 4-5).

The VFS-P: Parent proxy-report version
The VFS-P is a **multidimensional** scale designed to assess the physical and mental (social/emotional and cognitive) domains of listening-related fatigue in children **ages 6-17** years via proxy-report from the child's parent**.** For more information about the multidimensionality of this scale, see Hornsby et al., 2022. The VFS-P is comprised of **12 items**. Seven items assess mental aspects of listening-related fatigue (i.e., cognitive, social and emotional factors) and five items assess physical aspects of listening-related fatigue.

The VFS-T: Teacher proxy-report version
The VFS-T is a **unidimensional** scale designed to assess listening-related fatigue in children **ages 6-17 years** proxy-report by the child's teacher*. The VFS-T is comprised of **8 test items.**

*Note, the VFS-T should be completed **only** by professionals with **direct knowledge** of the child's classroom behaviors and function. In most cases, this will be the child's primary classroom teacher. Specialists, such as deaf educators, educational audiologists, and speech-language pathologists can distribute the VFS-T to classroom teachers and utilize the findings as part of their assessment test battery.

3. Development of the VFS-Peds

The VFS-Peds were developed following best practices for item and test development, test assessment, and test validation.[12] Results from Hornsby and colleagues (2022) revealed the scales are valid and sensitive to variations in listening-related fatigue across a wide range of fatigue severity levels. In addition, all scales have good reliability and test-retest stability. For example, acceptable test-retest stability will likely vary based on multiple factors (e.g., the construct being measured, the reliability of the test and the duration between testing points); however, reliability based on intraclass correlation coefficients (ICCs) is considered excellent for ICCs >.75 and fair to good for ICCs ranging from .40-.75.[14] Using these guidelines, test-retest reliability for all VFS-Peds scales was good to excellent. ICCs were .72, .84 and .84/.90 for the VFS-T, the VFS-C, and the VFS-P physical and mental subscales, respectively.

4. Administration of the VFS-Peds

The VFS-Peds were designed for English-speaking individuals; therefore, caution should be observed when attempting to use the scale with individuals who are not proficient at understanding or speaking English. All versions of the VFS-Peds can be administered in person.

Online administration may be appropriate for some older children and adults (see below for details). Regardless, administration should be completed in a quiet, private, environment. If the respondent utilizes hearing technology (e.g., hearing aids, cochlear implants), the devices should be worn and functioning properly when providing instructions or during oral administration of the scales.

In-Person Administration:

Children ages 6-10 years: For children in this age range the examiner should read aloud all VFS-C directions and items, verbatim. Depending on the child's abilities, the child may record their response independently or the examiner may record the child's response to each scale item.

Children ages 11-17 years: For children in this age range the examiner should first offer to read all VFS-C directions and items (e.g., "I can read the items to you if you wish. Would you like for me to read the test to you?"). If the child denies the offer of help and is able to adequately read and understand the items, the child may complete the VFS-C independently.

- Regardless of whether the child needs, or accepts, help completing the VFS-C the examiner should ensure that the child is thoroughly reading and understanding the items (e.g., not answering "sometimes" for all questions without thoughtful consideration of their response). In such cases the examiner may offer again to read the questions aloud if the child does not appear to understand the directions or an item.
- Likewise, if there are any concerns regarding the respondent's ability to independently read and understand the test directions or any test item, the examiner should read all directions and items, verbatim, to the child.

Adults (Parents or Teachers): Most adults can complete the scale independently. However, if there are any concerns regarding the respondent's ability to independently read and understand the test directions or any test item, the examiner should read all directions and items, verbatim, to the respondent.

Online Administration: It is optimal to administer the scale in person as this allows the test administrator to be available to read the test instructions and scale items aloud and to provide clarification, if needed, regarding the response process. However, the scales were developed and validated utilizing online and in-person data collection methods. Our experiences with this process suggest that parents, teachers, and children aged 11-17 years are able to reliably complete the scales via remote presentation (e.g., email or online). However, for younger children (6-10 years old), as noted above, the scale should be administered in person to allow the examiner to read aloud scale instructions and items.

5. Scoring the VFS-Peds

All versions of the VFS-Peds can be scored by simply summing item responses (0-4) across all scale, or subscale, items or by using Item Response Theory (IRT) to calculate an IRT scale, or subscale, score. IRT scale scores take advantage of the unique sensitivity of

each test item to provide a more precise estimate of the respondents listening-related fatigue. However, IRT scoring requires knowledge of IRT analysis methods and the use of statistical software packages capable of such analyses. Additional details regarding scoring methods are provided below. It is anticipated that clinicians will primarily utilize the summed scoring method. In contrast, researchers may prefer to use IRT analysis methods. For those interested in calculating respondent IRT scale scores, and are familiar with the statistical software program R[15], custom computer software code can be found on the VFS website.

Summed Scoring: The **VFS-C** and **VFS-T** are unidimensional measures thus summing all test items provides a total listening-related fatigue score. In contrast, the Parent Version (**VFS-P**) is a multidimensional measure that provides a subscale score for the physical and mental domains of listening-related fatigue. Subscale scores are obtained by summing the relevant items for each subscale (Mental Fatigue: items 1-7; Physical Fatigue: items 8-12). Across all scales, *higher* summed scores indicate *more* listening-related fatigue. Given that each scale has a different number of test items, the maximum summed score varies across scales (see Table 1). Thus, summed scores should be compared to the scale specific standardization samples (see Interpreting VFS-Peds Scores section).

Missing Items: To calculate a valid summed score respondents must provide a rating on **all** test items (i.e., no missing responses are allowed). Researchers may use IRT scoring to estimate scores for respondents with 1-2 missing items (see IRT scoring section below).

Table 1. Number of test items and range of possible total (or subscale) summed scores for each version of the VFS.

VFS-Peds Version	Number of items	Range of scores
Child (VFS-C)	10	0-40
Parent (VFS-P)		
• Mental Fatigue	7	0-28
• Physical Fatigue	5	0-20
Teacher (VFS-T)	8	0-32

IRT Scale Scoring: When calculating a summed score, every scale item is equally weighted in its contribution to the total, or subscale, score. This scoring approach ignores the fact that some scale items provide a more precise estimate of an individual's listening-related fatigue than others. In contrast, IRT scoring weights the response to each scale item based on the item's information and discrimination ability and thus provides a more precise estimate of a given individual's listening-related fatigue.[12] IRT scale scores are similar to standardized scaled scores, such as z-scores. **For the VFS, an IRT scale score of 0 reflects the mean magnitude of listening-related fatigue across, in theory, all respondents in the population. Thus, IRT scores of -3 and +3 would suggest very low and very high ratings of listening-related fatigue, respectively.**

Given the potential increased sensitivity of an IRT scoring method, researchers may find this approach particularly useful. As noted above, to calculate IRT scale scores requires the use of statistical software capable of IRT analysis. Our laboratory has developed custom software for this purpose (using R-statistical software[15]) which may be of interest to researchers. It is available for free download here.

6. Interpreting VFS-Peds Scores

Clinicians can interpret respondent's scores in two ways: 1) compare individual scores to the distribution of scores from the standardization sample (see Appendix A) or 2) based on the frequency of listening-related fatigue problems.

VFS-Peds interpretation based on a standardization sample:

To identify children who may need additional follow-up we examined the distribution of VFS-Peds scores from control groups of typically developing children aged 6-17 years. Typically developing was defined as children without hearing loss or any other parent-reported disability.

Control group data were gathered from a convenience sample of typically developing children (N=120), from parents who reported on their typically developing children (N=158), and from teachers who reported on typically developing students (N=68). Demographic data on this sample is shown in Table 2.

TABLE 2. Demographics of children as reported by control group samples.

	Child	**Parent**	**School Professional**
Number of children reported on (N=??)	*N*=120	N=151	*N*=68
Child Age (mean/median & range in years)	13.2/13 (9-17)	11.2/11 (6-17)	10.2/9 (6-17)
Child Grade (mean/median & range)	7.9/8 (3-12)	6.3/7 (K-12)	6.4/4 (*K-12)
Gender (Number & Percentage of sample)			
Male	57 (47.5%)	79 (52.3%)	36 (53%)
Female	63 (52.5%)	71 (47%)	27 (40%)
Did not disclose	0 (0%)	1 (0.7%)	5 (7%)

*K= Kindergarten

These normative data were derived from summed scores for each participant and were used a) to generate percentile ranks for all VFS-Peds child and teacher scale scores and parent subscale scores and b) to identify cutoff scores based on values that were one and two standard deviations above the mean value for each normative group. To generate these data, a best-fit to each normative distribution of summed scores was determined using IBM SPSS Statistics for Windows, Version 23.0. The best-fit curves were then used to calculate percentile ranks for a given score. This approach also allowed for the imputation of the number of respondents for any summed scores that were not present in a data set,

enabling percentile ranks to be calculated for the entire range of scores covered by each scale.

Using the best-fit distributions and the percentile ranks shown in Appendix A we determined cutoff scores for each version of the VFS-Peds. These cutoff scores may be useful for identifying children with significant reports of listening-related fatigue. Cutoff scores reflect scores that are ≥ one, or two, standard deviations above the mean of the normative sample for a given VFS-Peds. Children reporting this level of fatigue may warrant additional follow-up, monitoring, or intervention to address the complaints.

Comparing a respondent's VFS score to the standardization sample allows clinicians to determine where their patient's fatigue levels fall relative to the scores from a control sample of typically developing children. Table 3 shows the one and two standard deviation cutoff scores for each version of the VFS-Peds.

Table 3. Cut-off points, based on VFS-Peds summed scores that are one or two standard deviations (st. dev.) above the mean summed score for each VFS-Peds normative sample.

VFS-Peds Scale	Summed Score Cut-off points	
	*1 st. dev.	**2 st. dev.
VFS-C (Child Self-report)- 10 items	27	37
VFS-T (Teacher Proxy-report)- 8 items	23	31
VFS-P (Parent Proxy-report)		
• Mental fatigue- 7 items	15	25
• Physical fatigue- 5 items	13	18

***Scores ≥ than the 1 standard deviation cut point suggests that problems with listening-related fatigue are relatively frequent for the child and thus additional follow-up may be warranted.**

****Scores ≥ than the 2 standard deviation cut point suggests that problems with listening-related fatigue are very common and thus may, potentially, have a significant impact on the child's academic and psychosocial function.**

Appendix A provide percentile ranks for each summed score for the child, teacher, and parent versions of the VFS-Peds. Future research include development of a large scale, systematic, normative sample. This would augment the data herein that is based upon convenience sampling.

Interpretation based on the frequency of complaints: The VFS-Peds use a 5-point Likert response format and ask about the *frequency* of listening-related fatigue problems that the child experiences. Response options range from 0, meaning the child *never* has these problems, to 4, meaning the child *almost always* has these problems. Scores of 1, 2 or 3 indicate the child has the specific complaint *rarely*, *sometimes*, or *often*, respectively. Thus, higher summed scores suggest the individual is experiencing more **frequent** problems with listening-related fatigue. Children experiencing fatigue related problems "often" or "almost

always" may thus warrant additional follow-up to ascertain the functional impact of these problems on the child's wellbeing.

For example, given that the VFS-C has 10 items, a child with a summed score ≤10 (i.e., a score of 0-10) means the child reported that problems with listening-related fatigue may occur sometimes but they were relatively rare or, with a score of 0, they never occurred. In contrast, a score ≥30 (i.e., a score of 30-40) means the child reported multiple problems with listening-related fatigue that occur often or almost always. Clearly, for this high-scoring child, problems with listening-related fatigue are a common occurrence which could, potentially, impact the child's academic and psychosocial wellbeing. Thus, this child may warrant additional monitoring/follow-up.

The total summed score indicating that problems occur "sometimes", "often", or "almost always", depends on the total number of test items on the scale and will vary across the different versions of the VFS-Peds. It is worth noting that the cutoff scores of ≥ one standard reported in Table 3 suggest the child is experiencing listening-related fatigue problems at a frequency of "sometimes" to "often" and thus may warrant additional follow up or monitoring. Scores that are ≥ the two standard deviation cutoff suggests the child's listening-related fatigue problems occur "often" or "almost always" and thus may potentially impact the child's academic and psychosocial well-being.

7. Accessing the VFS-Peds

All versions of the VFS-Peds are copyrighted and may not be rented, leased, sold, sub-licensed, or distributed for commercial purposes. Those interested in using the scale for personal, educational, research, or clinical purposes can access all scales from their original publications (see reference list) or from the VFS website.

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Appendix

Appendix A. Percentile ranks for summed scores for each VFS-Peds scale. Percentile ranks are based on best-fits to the control group summed score distributions. See text for details.

Percentile Ranks of VFS-Peds Control Groups							
VFS-C Score	Child	VFS-P Score	Parent (Mental)	VFS-P Score	Parent (Physical)	VFS-T Score	Teacher
0	99.2	0	89.5§	0	98	0	95.6
1	96.1	1	79.3	1	95.2	1	93.3
2	92.9	2	71.1	2	89.8	2	92
3	91.6	3	67.1	3	87.8	3	90.7
4	89	4	63.2	4	85.7	4	89.3
5	86.6	5	62.5	5	78.2	5	85.3
6	84.3	6	57.2	6	74.1	6	82.7
7	81.9	7	49.3	7	68	7	81.3
8	78.7	8	45.4	8	55.8	8	84.7
9	72.4	9	38.8	9	44.2	9	80.7
10	70.1	10	34.9	10	40.1	10	78
11	64.9	11	32.9	11	30.6	11	64
12	65.4	12	27	12	21.4	12	58.7
13	61.4	13	23	13*	15.0	13	53.3
14	55.9	14	19.1	14	10.9	14	52
15	51.2	15*	15.2	15	6.8	15	49.3
16	48	16	13.8	16	4.8	16	45.3
17	45.7	17	11.8	17	4.1	17	42.7
18	40.2	18	8.6	18**	2.0	18	33.7
19	37	19	7.2	19	0.7	19	30.7
20	33.1	20	6.6	20	0.01	20	26.7
21	30.7	21	5.9	--	--	21	22.7
22	27.6	22	3.9	--	--	22	17.3
23	25.2	23	3.3	--	--	23*	16.0
24	22.8	24	2.6	--	--	24	13.3
25	19.7	25**	2.0	--	--	25	12
26	17.3	26	1.3	--	--	26	9.3
27*	15.7	27	0.7	--	--	27	8
28	15	28	0.01	--	--	28	6.7
29	14.2	--	--	--	--	29	5.3
30	12.6	--	--	--	--	30	4
31	11	--	--	--	--	31**	2.7
32	7.9	--	--	--	--	32	0.01
33	7.1	--	--	--	--	--	--
34	4.7	--	--	--	--	--	--
35	3.9	--	--	--	--	--	--
36	3.1	--	--	--	--	--	--
37**	2.4	--	--	--	--	--	--
38	0.6	--	--	--	--	--	--
39	0.8	--	--	--	--	--	--
40	0.01	--	--	--	--	--	--

*One standard deviation above the mean cut-off score

**Two standard deviations above the mean cut-off score

§Because the Parent (Mental fatigue) normative distribution is skewed, a score of 0 includes all percentile ranks between 89.5 through 99.9.