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Classroom Noise and Fatigue in Children with Normal Hearing and Children with Hearing Loss

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INTRODUCTION

Children with hearing loss experience greater difficulty understanding speech in noise and in reverberant conditions[1,7]. The effortful hypothesis posits that individuals with hearing loss are required to invest greater processing resources when identifying speech when compared to listeners with normal hearing[3]. This reduction in available processing resources is thought to cause increased listening effort, stress, and fatigue.

Modern classrooms exhibit noise levels exceeding minimal standards. Symptoms of stress and fatigue increase as classroom noise levels increase for children with normal hearing[8]. It is reasonable to assume that these effects may also be present in children with hearing loss. Because adults with hearing loss experience more stress and fatigue in the workplace when compared with adults with normal hearing[4], it is not unreasonable to believe that children with hearing loss may show greater negative effects of noise on stress and fatigue.

PURPOSE

The purpose of this study was to determine if children with hearing loss show different patterns of stress and fatigue when compared to children with normal hearing. A secondary purpose was to examine if classroom noise level has an effect on stress and fatigue in children with hearing loss and children with normal hearing.

METHODS

Data were obtained as part of a larger ongoing study examining listening effort and fatigue in school-age children with hearing loss.

Participants
Children with normal hearing (n=30, 19 males)

- Hearing thresholds ≤ 20 dB HL in both ears from 250-8000 Hz.
- Mean = 8.27 years (Range = 6-12 years)

Children with hearing loss (n=14, 6 males)

- Mild to severe sensorineural or mixed hearing loss. Mild hearing loss was defined as average pure tone air conduction threshold at 0.5, 1, 2 kHz between 20 and 40 decibels hearing level (dB HL) or pure tone air conduction thresholds greater than 25 dB HL at two or more frequencies above 2 kHz (i.e. 3, 4, 6, 8 kHz)[5].
- Mean = 10.07 years (Range = 7-12 years)

All participants were monolingual speakers of English. Children with diagnoses such as cognitive impairment, autism, and other development disorders were excluded.

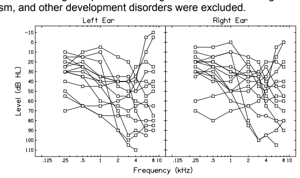


Figure 1. Hearing thresholds of the children with hearing loss.

Measures
Classroom noise and fatigue data were obtained from children on two separate days in which the child attended school. Salivary cortisol was used as an objective measure of stress, which is considered an antecedent to fatigue.

Table 1 shows the schedule for collection of cortisol samples and noise measurements on each day.

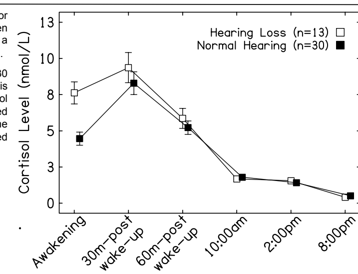
Time	Measure	Obtained by
Awakening	Salivary cortisol	Parent
30 min. post-awakening	Salivary cortisol	Parent
60 min. post-awakening	Salivary cortisol	Parent
10:00am	Salivary cortisol Classroom Noise Measurement	Research Assistant
2:00pm	Salivary cortisol Classroom Noise Measurement	Research Assistant
8:00pm	Salivary cortisol	Parent

Classroom noise measurements were ten minutes in duration and obtained using a dosimeter placed at least one foot away from the wall or other reflective surfaces in the classroom.

RESULTS

Figure 2. Mean cortisol levels (standard error bars) at all times of collection for children with normal hearing (filled squares) and with hearing loss (open squares). This includes children with missing data points. These data show a similar pattern as that seen when children with missing data points are excluded.

Children with hearing loss exhibited higher cortisol levels at awakening and at 30 and 60 min post awakening when compared to children with normal hearing. This increase in cortisol after awakening is a phenomenon referred to as the cortisol awakening response. Increased cortisol awakening responses are associated with chronic stress, perceived stress, and worrying about the burdens of the upcoming day[2,9]. As the day progresses, children with hearing loss showed cortisol patterns similar to children with normal hearing.



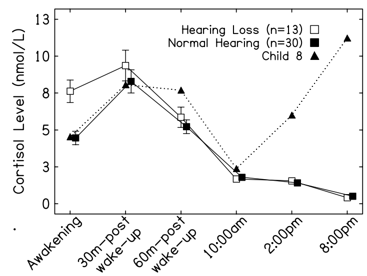


Figure 3. One child with hearing loss showed a cortisol pattern that deviated from the rest of the children with hearing loss. The child's data, averaged across both days, are shown along with the mean data from children with normal hearing and children with hearing loss. It is unknown if this child was using hearing technology at the time of data collection and activities during the school day were reported as typical.

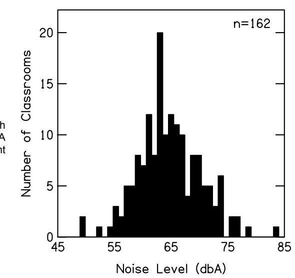


Figure 4. Individual classroom noise levels obtained during morning and afternoon visits on both school days are shown in this figure. The average recorded classroom noise level was 64.64 dBA (SD=5.73). In general, classroom noise was consistent across days. These levels are consistent with past research showing noise levels exceeding minimal standards[6,7,8].

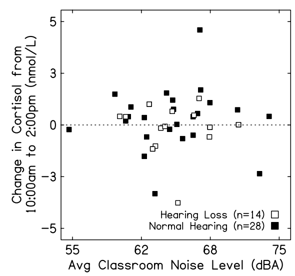


Figure 5. Difference in cortisol levels at 10:00am and 2:00pm are shown as a function of average classroom noise level for children with normal hearing (filled squares) and children with hearing loss (open squares). Data falling above zero indicate that the child's recorded cortisol level decreased as the day progressed, whereas data below zero indicate the child's recorded cortisol level increased from morning to afternoon visits. Based on typical cortisol patterns in humans, we would expect cortisol levels to decrease from morning to afternoon, thus showing data falling above zero on this chart.

In general, children showed varied cortisol changes in response to classroom noise levels. In our sample, a greater percentage of children with normal hearing show the expected pattern of decreasing cortisol while half of the children with hearing loss show an increase of cortisol from morning to afternoon. These patterns do not appear to be related to the level of classroom noise.

RESULTS

Child	Age (years)	PTA (Left/Right)	Day 1		Day 2	
			Hearing Aids	FM System	Hearing Aids	FM System
1	7	53/53	X	X	X	SF (AM only)
2	7	32/30	X	SF	X	SF (AM only)
3	8	72/47	X	X	X	X
4	9	63/72	X	X	DNT	DNT
5	10	38/43	X	X	X	X
6	10	42/43	X	X	X	X
7	10	47/53	X	X (AM only)	X	X (PM only)
8	10	42/35	Unknown	Unknown	Unknown	SF (AM only)
9	11	23/10	X	--	--	--
10	11	77/28	--	--	--	--
11	12	32/28	X (AM only)	--	X (AM only)	--
12*	12	43/33	--	--	--	--
13	12	10/13	--	SF (PM only)	--	--
14	12	33/30	--	--	--	--

PTA = Pure Tone Average (500, 1000, 2000 Hz), SF = Sound Field, DNT = Did not test
**Only child whose parent reported that he does not wear hearing aids*

Table 2. Characteristics of device use for children with hearing loss during 10:00am and 2:00pm data collection on both visit days. Children ages 7-10 years were consistent users of hearing technology, whereas children ages 11 and 12 years used hearing aids sporadically and rarely used FM systems in the classroom.

SUMMARY & CONCLUSIONS

Children with hearing loss showed elevated cortisol awakening responses, suggesting the possibility of chronic stress and subsequent fatigue.

Classroom noise levels continued to exceed minimal recommended standards for classroom acoustics.

Classroom noise levels did not appear to affect changes in cortisol levels from morning to afternoon. Although cortisol levels are expected to fall through the day, preliminary data suggest this pattern may be reversed for some children with hearing loss. Further research is needed to determine factors that may influence this abnormal cortisol pattern such as age, severity of hearing loss, technology use, and classroom noise levels.

Younger children with hearing loss in this study were consistent users of hearing aids and FM systems in the school setting. Children ages 11-12 years exhibited reduced hearing aid use at school and minimal use of FM systems in the classroom, regardless of the severity of hearing loss.

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