Field Study News

August 2017

Reduced physiologic stress in children with autism using Roger™ technology

It is established that children with Autism Spectrum Disorder (ASD) have greater difficulties processing speech in the presence of background noise compared to their peers. Research has shown that wireless communication systems that significantly improve the auditory signal delivered to the ear are beneficial to these children. In a research study conducted at the University of Melbourne, Australia, listening-related stress in children with ASD was examined with and without the use of either Roger Focus receivers or Roger DigiMaster 5000 soundfield amplification systems installed in classrooms. Results of the study show significantly improved listening, communication, and social interaction, as well as reduction in physiologic stress levels (salivary cortisol concentration) during structured listening tasks.

Introduction

It is widely recognized that children need higher signal-to-noise ratios (SNR) compared to adults in order to achieve equal speech recognition scores (Nabelek & Robinson, 1982). This is due to both an immature central auditory system and a less robust language system limiting their ability to "fill in the blanks." Since understanding happens at the brain rather than at the ear, many factors including attention, memory, language, and cognition contribute to our ability to process auditory information.

The ability to process speech and maintain concentration in children with ASD has been suggested to be the most significant predictor of academic performance (Ashburner et al. 2008). Therefore, the identification and management of auditory deficits in this population is critical. For children with ASD, speech perception is further compromised due to auditory processing deficits thought to be related to a distorted representation of temporal cues in the central auditory pathways (Alcántara et al. 2012; Rance et al. 2014a). This makes it especially difficult to listen effectively in the presence of background noise and can often intensify other communication issues experienced (Rance et al. 2014a).

Abnormal stress responses in children with ASD have been shown through physiological measures, including cortisol concentration (Corbett et al. 2008; Kidd et al. 2012; Putnam et al. 2015). Cortisol is a hormone released from the adrenal gland upon stimulation of the hypothalamic-pituitary-adrenal (HPA) axis (Hennessey & Levine, 1979; Herman & Cullinan, 1997) that can have wide-ranging biological effects (Sapolsky et al. 2000).

Auditory processing deficits in children with ASD could contribute to the high levels of baseline cortisol in this population.

It has been established that the communication challenges associated with hearing impairment can affect this stress response (Bess et al. 1998, 2016; Bess & Hornsby 2014); however, the link between auditory processing deficits, auditory intervention and stress is yet to be explored.

This research study is the first to consider the interplay of these factors. Salivary cortisol levels were measured in primary and secondary school-aged children with ASD to determine whether Roger Focus and/or Roger DigiMaster 5000 technology could alleviate listening and communication difficulties and result in lower stress levels.

Methodology

Twenty-six children (6 girls and 20 boys) aged 7 to 16 years old participated in the research study. All participants had previously been diagnosed with ASD via a multidisciplinary approach using a range of diagnostic instruments. All children were able to verbally communicate and attended a mainstream school. Sixteen of the younger children (6—12 years old) who attended primary school and had one consistent teacher were assigned to study group A. The remaining 10 children aged 13—16 years were assigned to study group B. They attended secondary school and had a number of different teachers. Twenty of the twenty-six children were classified as clinically anxious through the anxiety subscale of the Child Behavior Checklist (CBCL) (Achenbach et al., 1991).

Younger children of study group A were fit with a Roger Focus receiver paired to a Roger inspiro transmitter. Participants in study group B trialed the Roger DigiMaster 5000 speakers set up in a classroom setting.

Study group A procedure (Roger Focus paired with Roger inspiro)

Study group A participants were assessed on three separate occasions within their family homes. The initial assessment involved a baseline hearing test and administration of a questionnaire (Abbreviated Profile of Hearing Aid Benefit [APHAB]) (Cox & Alexander, 1995) to each child to gain insight into their degree of listening and communication difficulty across a range of environments (parental help with the APHAB was allowed if required). Children were then monaurally fit with a Roger Focus receiver (no gain) paired with a Roger inspiro transmitter worn within 20 cm from the mouth of the talker. Roger Focus receivers were fit to the ear with better hearing thresholds, or if in the case of no difference between the ears, the child's preferred ear. Consonant-Nucleus-Consonant (CNC) words (Peterson & Lehiste, 1962) were used to assess speech perception in noise before and after being fit with Roger Focus. Speech stimuli were delivered in front of the child at 65 dB SPL and 4-talker babble was delivered from behind, also at 65 dB SPL, to create a 0 dB signal-to-noise ratio (SNR) at the child's head for testing. Participants were then able to use the Roger devices at home and school for 1—2 weeks at 4—6 hours/day. Each child repeated the APHAB questionnaire at the completion of the trial.

The second and third assessments occurred at least two weeks after the completion of the Roger Focus trial. These sessions were generally scheduled for two consecutive days at the same time. Children participated in a speech perception task (CNC words) and a speech comprehension task (CELF-4) (Semel et al., 2003) tailored to each child's level of intellect and speech language abilities. Both assessments were presented in the presence of noise, again at 0 dB SNR. The tester wore the Roger inspiro around his/her neck within 20 cm of the mouth, and the child wore the Roger Focus on the better or preferred ear. Devices were turned on in one session and off (but still worn) in the other. Saliva samples were collected before and after each of these structured listening sessions for further analysis of cortisol concentration. Refer to Figure 1A for a diagram of the test set-up.

Study group B procedure (DigiMaster 5000)

Study group B participants were also assessed on three separate occasions in a classroom setting. The initial assessment involved a baseline hearing measure in quiet. The second and third sessions were scheduled on two consecutive days at the same time. Five participants were involved per session. The same listening and comprehension testing as per study group A was conducted. One session was conducted with the tester's voice unamplified arriving at the children at approximately 65 dB SPL. The other session was conducted with the tester's voice amplified through the Roger DigiMaster 5000 system arriving at the children at approximately 75 dB SPL. The tester was positioned 2.5 m in front of the children wearing the Roger inspiro transmitter around his/her neck within 20 cm of the mouth. A speaker that delivered noise (4-talker babble) was positioned behind the children. The DigiMaster 5000 was situated at a 45° angle front-right of the children. The SNR delivered to the center of the group of children was +10 dB SNR. Saliva samples were collected before and after sessions two and three for further analysis of cortisol concentration. Refer to Figure 1B for a diagram of the test set-up.

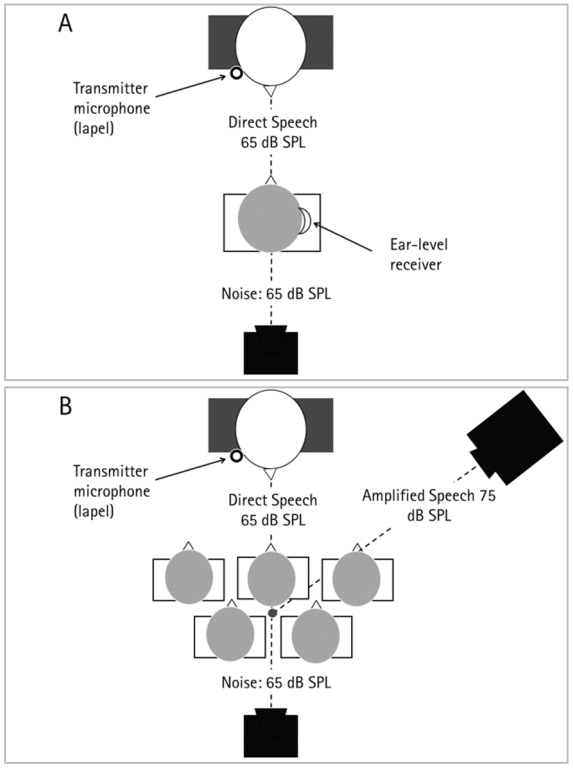

Figure 1: Test configurations for the structured listening sessions. *Panel A* shows the set-up for the ear-level listening device with tester (top) seated in front of the single subject and loudspeaker behind. *Panel B* shows the layout for the soundfield experiment with five participants situated between the tester (top) and loudspeaker behind. For the amplified-speech condition, the tester's voice was 10 dB more intense than the noise(+10 dB SNR) at a calibration point in the center of the group.

Results and discussion

Study group A outcomes (Roger Focus paired with Roger inspiro)

Speech perception scores in background noise with the Roger Focus (M = 76.5%, SD = 8.2%) were significantly higher than those without (M = 55.5%, SD = 13.8%; t(15) = −8.49, p < 0.001, d = −2.12) (Figure 2). Importantly, the scores of children who performed poorly in the unaided condition were boosted to within the normal range for their particular age group with the use of the Roger device.

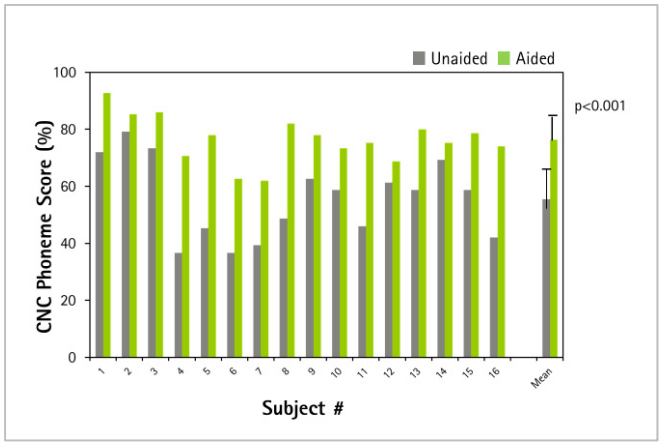

Figure 2: Unaided and device-aided speech perception in noise (0 dB SNR) scores for each participant (Study A). Group scores represent the mean + 1 SD.

Study participants reported significantly reduced perceived listening and communication difficulties after the Roger Focus trial through the APHAB questionnaire (Figure 3).

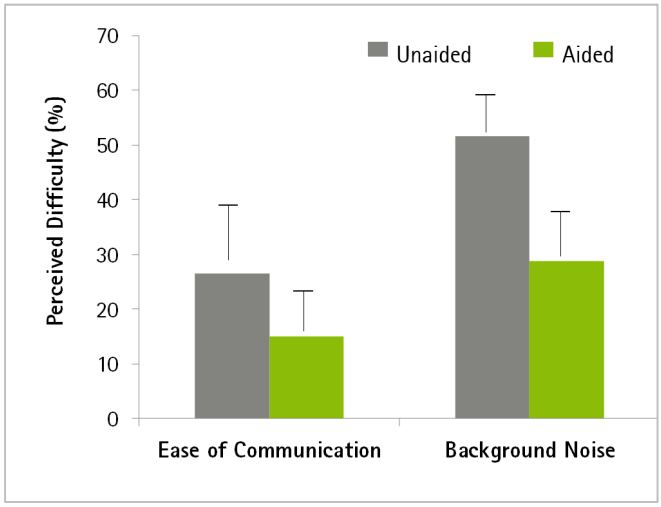

Figure 3: Abbreviated Profile of Hearing Aid Benefit questionnaire results for unaided and aided listening conditions. Shown are the group means for the Ease of Communication and Listening in Background Noise subscales in each listening condition. Error bars represent SD.

Analysis of relative changes in cortisol concentration between the unaided (M = 0.30 nmol/L SD = 0.56 nmol/L) and aided (M = −0.18 nmol/L, SD = 0.45 nmol/L) listening conditions revealed a significant reduction in stress levels with use of the Roger Focus (t[9] = 4.45, p = 0.003, d = 1.48) (Figure 4).

Multiple regression analysis showed no correlation between relative change in cortisol concentration across the unaided and aided conditions and test order, participant age, hearing level, full scale IQ or CBCL anxiety score (p > 0.05).

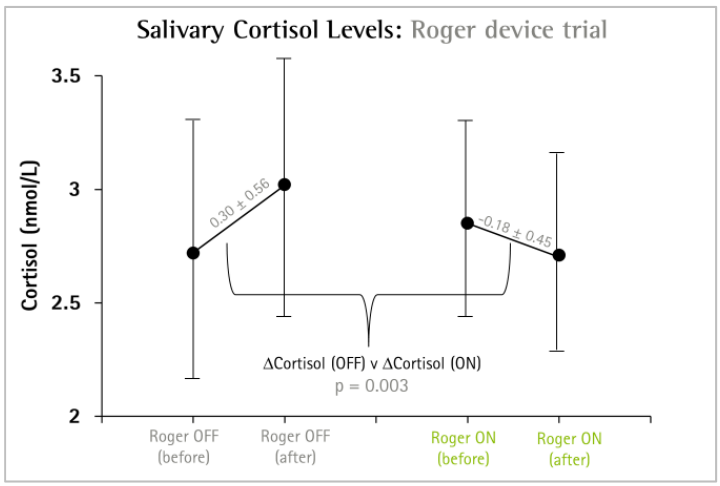

Figure 4: Mean cortisol concentrations (nmol/L) for children wearing the ear-level listening system.

Study group B outcomes (DigiMaster 5000)

Average cortisol concentrations significantly decreased during the aided listening task with DigiMaster 5000 switched on (amplified baseline: M = 3.40 nmol/L, SD = 1.04 nmol/L; amplified post-session: M = 2.53 nmol/L, SD = 0.66 nmol/L; t[9] = 3.00, p = 0.015, d = 0.95). A significant difference between cortisol levels was found when comparing individual results for unaided and aided conditions (unamplified change: M = 0.48 nmol/L, SD = 0.88 nmol/L; amplified change: M = −0.87 nmol/L, SD = 0.81 nmol/L); t[9] = 3.64, p = 0.005, d = 1.15) (Figure 5).

Multiple regression analysis showed no correlation between relative change in cortisol concentration across the unaided and aided conditions and test order, participant age, hearing level, full scale IQ or CBCL anxiety score (p > 0.05).

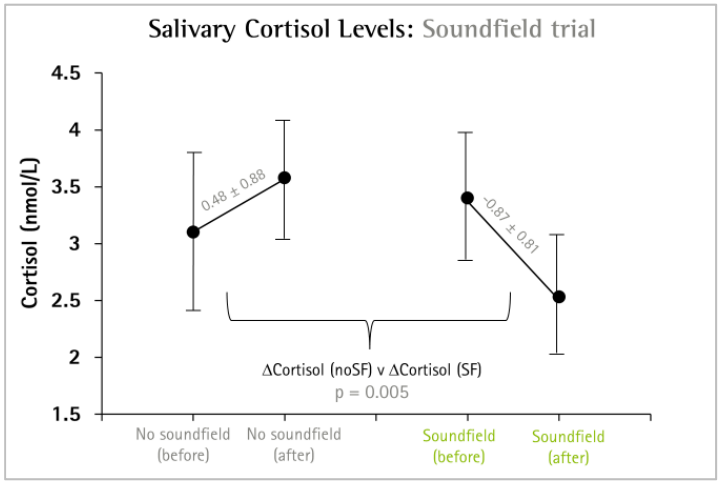

Figure 5: Mean cortisol concentrations (nmol/L) for children using soundfield classroom distribution.

Conclusion

The outcomes of this study are congruent with the results of previous studies highlighting the audiologic benefits of wireless remote microphone technology in children diagnosed with ASD. Use of Roger Focus receivers resulted in significantly improved speech perception in background noise and fewer reported listening and communication challenges in this group of children.

This study is the first to demonstrate a reduced physiologic stress response with use of Roger technology. Relative salivary cortisol levels were significantly lower during participation in complex one-on-one and group listening tasks with use of Roger technology compared to without.

Given that communication difficulties are a core feature and major source of anxiety in individuals with ASD, the results of this study have important implications for the general health and well-being of children affected by ASD.

Authors & Investigators

Philippa James is working within the Global Phonak pediatric team, and with the Sonova HQ Science & Technology team, to develop a clinical model for the audiologic management of children with autism. Her prior work history includes hearing aid fitting and counseling, and auditory processing assessment and management. She earned a MClinAud in 2012 from the University of Melbourne and an Au.D. from the University of Florida in 2017.

Associate Professor Gary Rance is an audiologist, a full-time researcher and teacher at the University of Melbourne and a part-time sculptor. He is currently Director of Academic Programs and Coordinator of Clinical Research for the Department of Otolaryngology. His current research areas involve various aspects of auditory evoked potential measurement, assessment of long-term communication outcomes in hearing-impaired children, and the diagnosis and management of auditory pathway disorder.

References

Primary reference: Rance, G., Chisari, D., Saunders, K., & Rault, J. L. (2017). Reduced Listening-Related Stress in School-Aged Children with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders,* 1–13.

Achenbach, T. M. (1991). *Manual for the child behavior check-list/4-18 and 1991 profile*. Burlington: University of Vermont.

Alcántara, J. I., Cope, T. E., Cope, W., & Weisblatt, E. J. (2012). Auditory temporal-envelope processing in high-functioning children with autism spectrum disorder. *Neuropsychologia, 50*, 1235–1251.

Ashburner, J., Rodger, S., & Ziviani, J. (2008). Sensory processing and classroom emotional, behavioral, and educational outcomes in children with autism spectrum disorder. *American Journal of Occupational Therapy, 62*, 564–573.

Bess, F. H., Dodd-Murphy, J., & Parker, R. A. (1998). Children with minimal sensorineural hearing loss: Prevalence, educational performance, and functional status. *Ear and Hearing, 19*(5), 339–354.

Bess, F. H., Gustafson, S. J., Corbett, B. A. et al. (2016). Salivary cortisol profiles of children with hearing loss. *Ear and Hearing, 37*(3): 334–344.

Bess, F. H., & Hornsby, B. W. (2014). Commentary: Listening can be exhausting. Fatigue in children and adults with hearing loss. *Ear and Hearing, 35*(6), 592–599.

Corbett, B. A., Mendoza, S., Wegelin, J. A., Carmean, V., & Levine, S. (2008). Variable cortisol circadian rhythms in children with autism and anticipatory stress. *Journal of Psychiatry & Neuroscience, 33*, 227–234.

Cox, R. M., & Alexander, G. C. (1995). The Abbreviated Profile of Hearing Aid Benefit. *Ear and Hearing, 16*(2), 176–186.

Hennessy, J. W., Levine, S. (1979). Stress, arousal, and the pituitary-adrenal system: A psychoendocrine hypothesis. *Progress in Psychobiology and Physiological Psychology, 8*, 133–178.

Herman, J. P., Cullinan, W.E. (1997). Neurocircuitry of stress: Central control of the hypothalamo-pituitary-adrenocortical axis. *Trends in Neurosciences, 20*(2), 78–84.

Kidd, S. A., Corbett, B. A., Granger, D. A., Boyce, W. T., Anders, T. F., & Tager, I. B. (2012). Daytime secretion of salivary cortisol and alpha-amylase in preschool-aged children with autism and typically developing children. *Journal of Autism and Developmental Disorders, 42*(12), 2648–2658.

Nábělek, A. K., & Robinson, P. K. (1982). Monaural and binaural speech perception in reverberation for listeners of various ages. *The Journal of the Acoustical Society of America, 71*(5), 1242–1248.

Peterson, G. E., & Lehiste, I. (1962). Revised CNC lists for auditory tests. *Journal of Speech and Hearing Disorders, 27*(1), 62–70.

Putnam, S. K., Lopata, C., Thomeer, M. L., Volker, M. A., & Rodgers, J. D. (2015). Salivary cortisol levels and diurnal patterns in children with autism spectrum disorder. *Journal of Developmental and Physical Disabilities, 27*, 453–465.

Rance, G., Saunders, K., Carew, P., Johansson, M., & Tan, J. (2014a). The use of listening devices to ameliorate auditory deficit in children with autism. *The Journal of pediatrics, 164*(2), 352–357.

Rance, G. (2014b). Wireless technology for children with autism spectrum disorder. *Seminars in Hearing, 35*, 217–226.

Sapolsky, R. M., Romero, L. M., & Munck, A. U. (2000). How do glucocorticoids influence stress responses? Integrating permissive, suppressive, stimulatory, and preparative actions. *Endocrine Reviews, 21*, 55–89.

Schafer, E. C., Mathews, L., Mehta, S., et al. (2013). Personal FM systems for children with autism spectrum disorders (ASD) and/or attention-deficit hyperactivity disorder (ADHD): An initial investigation. *Journal of Communication Disorders, 46*, 30–52.

Schafer, E. C., Wright, S., Anderson, C., Jones, J., Pitts, K., Bryant, D., et al. (2016). Assistive technology evaluations: Remote microphone technology for children with Autism Spectrum Disorder. *Journal of Communication Disorders, 64*, 1–17.

Semel, E., Wiig, E. H., & Secord, W. A. (2003). *Clinical Evaluation of Language Fundamentals, Fourth Edition* (CELF-4). Toronto: The Psychological Corporation / a Harcourt Assessment Company.