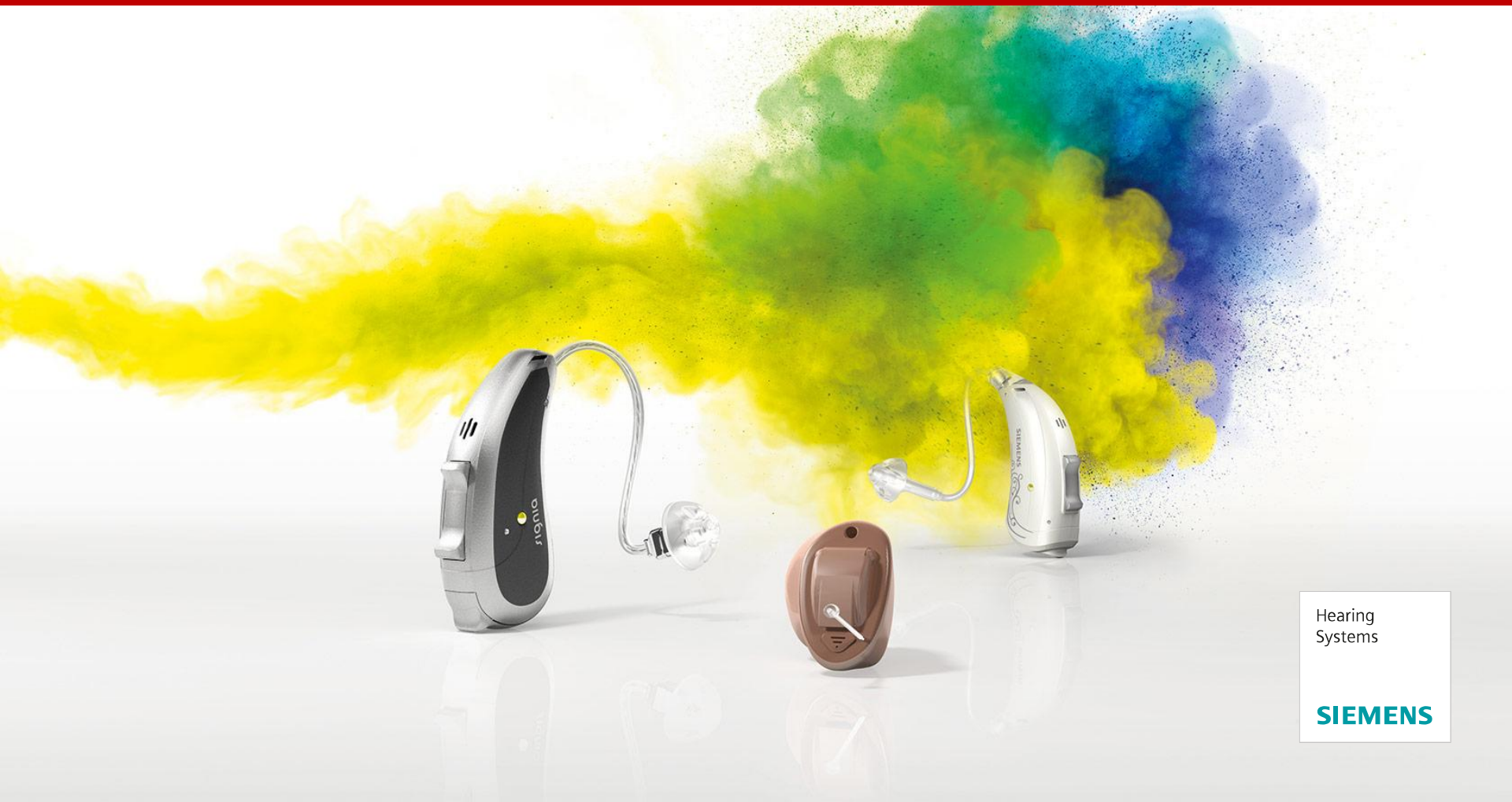
signia

Life sounds brilliant.

Technology in 10: Objective Measurement of Listening Effort



Hearing Systems

SIEMENS

signia
Life sounds brilliant.

Objective Measurements of Listening Effort

Presented by:
Navid Taghvaei, AuD
Board Certified in Audiology

Transmitted to you in cooperation with our colleagues at AudiologyOnline.
If you are experiencing audio or visual difficulties,
please contact AudiologyOnline (800-753-2160)

Hearing
Systems
SIEMENS

Published Research Article

signia
Life sounds brilliant.

Clinical Studies Show Advanced Hearing Aid Technology Reduces Listening Effort

https://pro.signiausa.com/wp-content/uploads/sites/80/2016/02/Hearing-Review-clinical-paper-article.pdf

Clinical Studies Show Advanced Hearing Aid Technology Reduces Listening Effort

By VERONIKA LITTMANN, PhD; JOEL BEILIN, MScEE; MATTHIAS FROEHLICH, PhD; ERIC BRANDA, AuD; and PATRICK J. SCHÄFER, MS

A novel study using EEG activity to assess listening effort suggests that the new Signia primax™ hearing aids do, indeed, reduce listening effort.

When we think of hearing aids that are optimal for a given patient, one of the first things that comes to mind is improved speech understanding, especially in background noise. However, one factor that does not receive the attention that it should is the amount of *listening effort* required by the patient to realize this optimal fitting in everyday use.

Even people with normal hearing experience situations that require increased listening effort. That is, we have to "work harder" to hear what we want to hear. Often this involves situations with excessive background noise, but it also occurs with soft speech, poor cell phone connections, trying to understand a speaker with a pronounced foreign accent, and many other difficult listening situations. When hearing loss is present, these challenges become even more pronounced.

Generally, listening effort relates to speech understanding; as effort increases, hearing-impaired individuals are forced to recruit additional cognitive resources to keep up. We know that effortful listening and cognitive load negatively impact simultaneous mental processes (eg, multi-tasking). The continued use of these additional cognitive resources also leads to listening fatigue, and often to the rejection of hearing aids.

Fatigue is usually thought of as tiredness or a lack of energy. It is commonly associated with feelings of diminished focus, lack of concentration, and mental deficiency. We know that even mild hearing loss causes increased listening effort, which in turn leads to increased listening fatigue. This can have significant consequences on patients' energy levels, which influences how much they engage in speech communication, or in some cases, any activity that requires mental energy.

It is clear that increased listening effort can impact the benefit obtained from hearing aids in at least two ways. In the short-term, because the increased effort requires additional cognitive resources, simultaneous mental activity will be impacted (dual-tasking). If that task is word recall or mentally filling in the word of a sentence that was not understandable, speech recognition suffers. Alternately, the simultaneous task might involve reaction time or cognitive decision-making, in which case the patient needs to decide what task is most important (eg, when driving a car and simultaneously trying to follow a difficult-to-understand conversation). Over several hours, increased listening effort leads to listening fatigue, and also indirectly results in reduced speech understanding, as the patient will not have the mental energy to stay "tuned in." Therefore, it's critical to keep listening effort at a minimum for all listening situations throughout the day, to reduce the likelihood of fatigue.

We can reduce listening effort by making the listening task easier. For people with hearing impairment, it is reasonable to think that the fitting of appropriate hearing aids will reduce listening effort. However, it's also important to point out that the most effective method of reducing listening effort is to *not listen*. This makes the task very easy, as there is no task. Hence, we need to optimize the hearing aid listening experience to prevent the latter from happening.

Research has shown that, as expected, the use of hearing aids does reduce listening effort for the hearing impaired.[1] We would assume that hearing aid features that are known to improve speech understanding in background noise (eg, directional technology) would reduce listening effort even more, but research in this area has not been conclusive.[2] This could be because of the specific technology that was studied, the design of the study, or the metric that was used to assess listening effort.

Methods to Assess Listening Effort

Several approaches have been used in research to assess listening effort. These include physiologic measures (eg, pupil dilation, heart rate, skin conductance, and salivary cortisol levels), recall and reaction time paradigms, and subjective assessment scales. While it may seem intuitive to simply ask the patient how difficult the listening experience might be, these scales are not always the most ideal measure. The patient might associate effort with something different, such as speech understanding, or the change in listening effort may be too subtle to observe. It's important, therefore, that a test of listening effort is sensitive, reliable, and valid. It's certainly likely that, when the most appropriate assessment of listening effort is used, it will be possible to identify hearing aid features and algorithms that do assist in reducing listening effort, and subsequently listening fatigue.

In the current study, we used an innovative objective method for measuring listening effort based on the electroencephalogram (EEG)

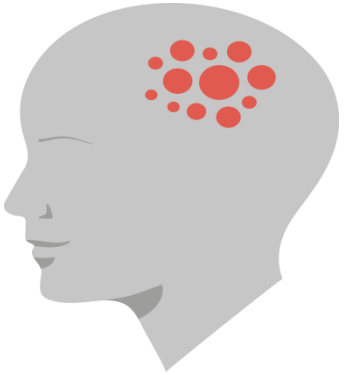
Veronika Littmann, PhD, is head of Audiology System Development, and **Matthias Froehlich, PhD**, is head of Product Management Audiology at Sivantos GmbH, in Erlangen, Germany; **Joel Beilin, MSEE**, is head of Global Audiology Relations at Sivantos Pte Ltd, Singapore; **Eric Branda, AuD**, is senior manager of Product Management at Sivantos Inc in Piscataway, NJ; and **Patrick J. Schäfer, MS**, is a researcher at Saarland University in Homburg, Germany.

Littmann V, Froehlich M, Beilin J, Branda E, Schaefer PJ. Clinical studies show advanced hearing aid technology reduces listening effort. Hearing Review. 2016;23(4)[Apr]:36-38

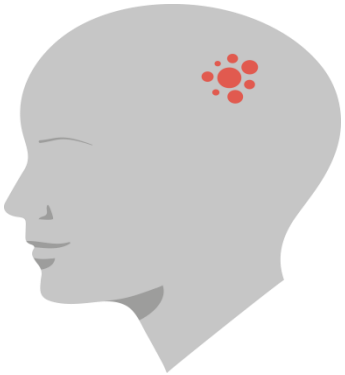
Introduction

signia
Life sounds brilliant.

- Listening Effort is the mental exertion listeners experience trying to solve an auditory task such as understanding speech (or detecting a target among interferers).



- Affected by:
    - Hearing loss
    - Signal degradation (background noise, poor quality)
- Increases with:
    - Foreign Language
    - Speaker accent
    - Phone call w/ a bad connection
- Associated with allocation of intentional and cognitive resources, and contributes to mental fatigue and distress.
    - Age-related decline in attention and memory capacity

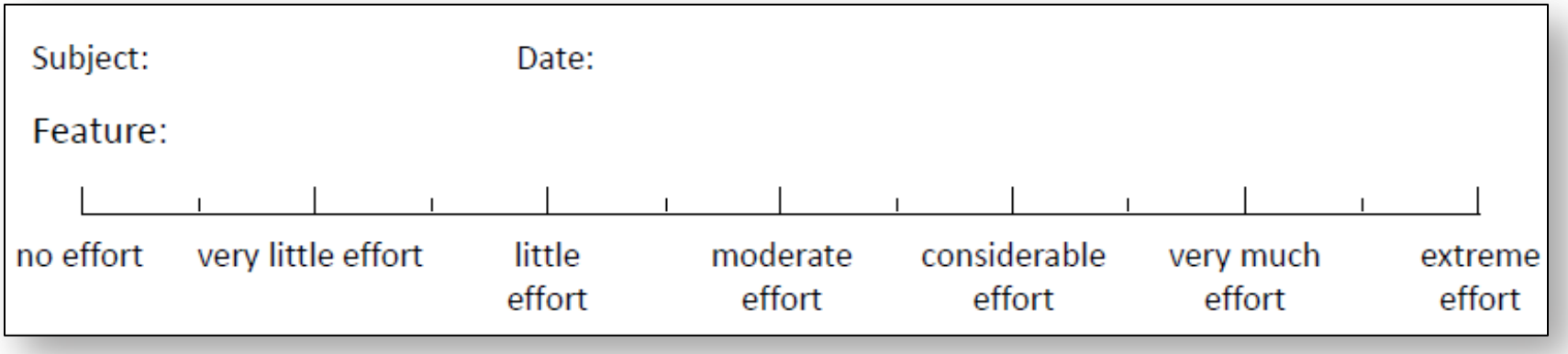


Hearing Systems
SIEMENS

Subjective Measurement of Listening Effort

signia
Life sounds brilliant.

- Mostly done via subjective measurements
  - Questionnaires, rating scales, self-reports
- Sensitive to individual's (confounding factors)
  - Awareness of her/his performance on task
  - Understanding of the situation
  - Numerous indicators of body and mental states
- Result in
  - High risks of intera-rater variability
  - High risks of inter-rater variability



Objective Measurement of Listening Effort

Life sounds brilliant.

- Dual Task Paradigms
  - Two tasks at the same time (e.g. listening to speech & a visual memory activity)
  - Complex method easily influenced factors such as motivation, task strategy, & participant cooperation
  - Results difficult to compare to other studies w/ different methods

- Evaluating pupil dilatation (pupillometry)
- Psychophysiological measures
  - Heart rate, skin conductance, skin temperature, and electromyographic activity
- Drawbacks and limitations:
  - Not measuring the effort of auditory processing in itself, but the response of the body to the activities in the auditory system
  - We can listen w/ our eyes closed
  - Individuals have different bodily responses to the same listening experience

Oscillatory Electroencephalography (EEG)

Life sounds brilliant.

- Objective method used to evaluate effect of primax features on listening effort
  - Developed & optimized in collaboration with neuroscientists over the last five years
  - Noninvasive recording of electrical activity of the brain

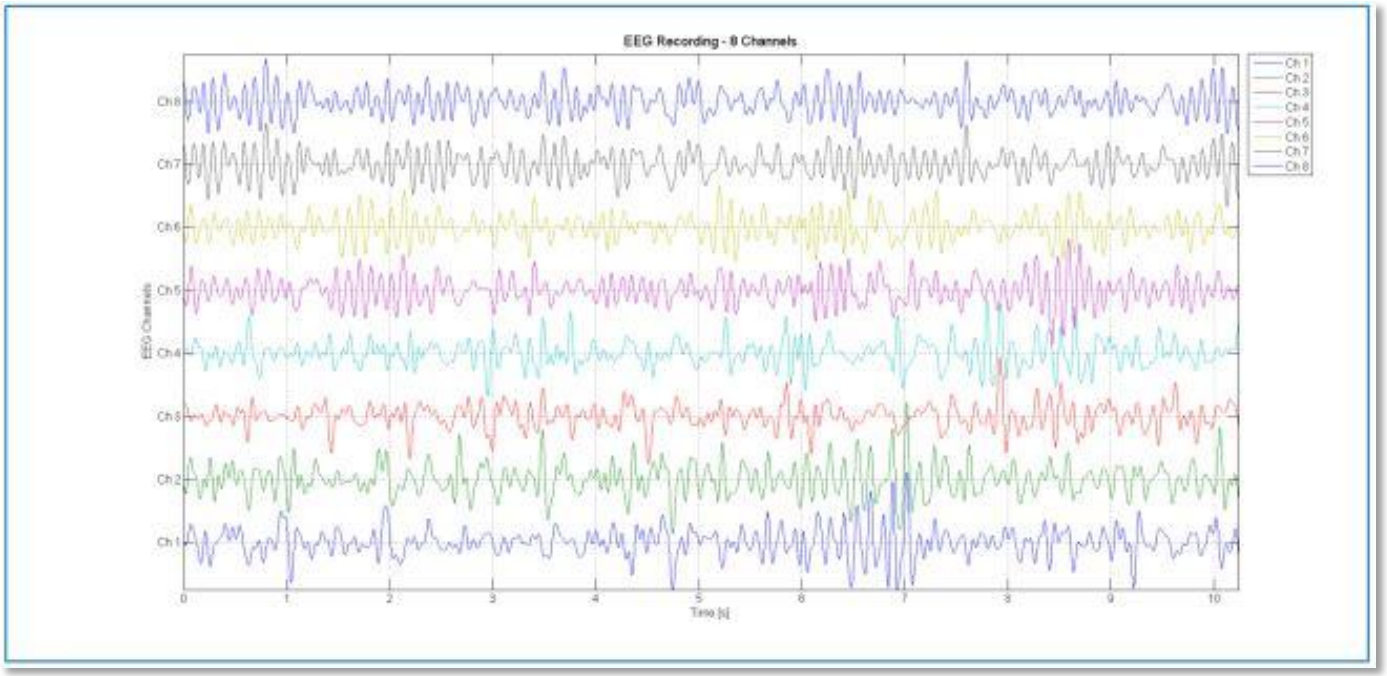
- Voltage fluctuations from neuronal communication within the brain

- Diagnostic applications generally focus on the type of neural oscillation that can be observed in the EEG signal

EEG recordings

Life sounds brilliant.

- e.g. the auditory brainstem response (ABR) evaluates electrophysiological events of the brainstem using evoked potentials
- We used EEGs from higher processing states of the neural pathway which are oscillatory or ongoing EEGs for the purpose of evaluating listening effort
    - Advantages include the ability to analyze longer listening periods and not restricted to short repetitive stimuli
    - Measuring listening effort in realtime while speech recognition tasks are being conducted



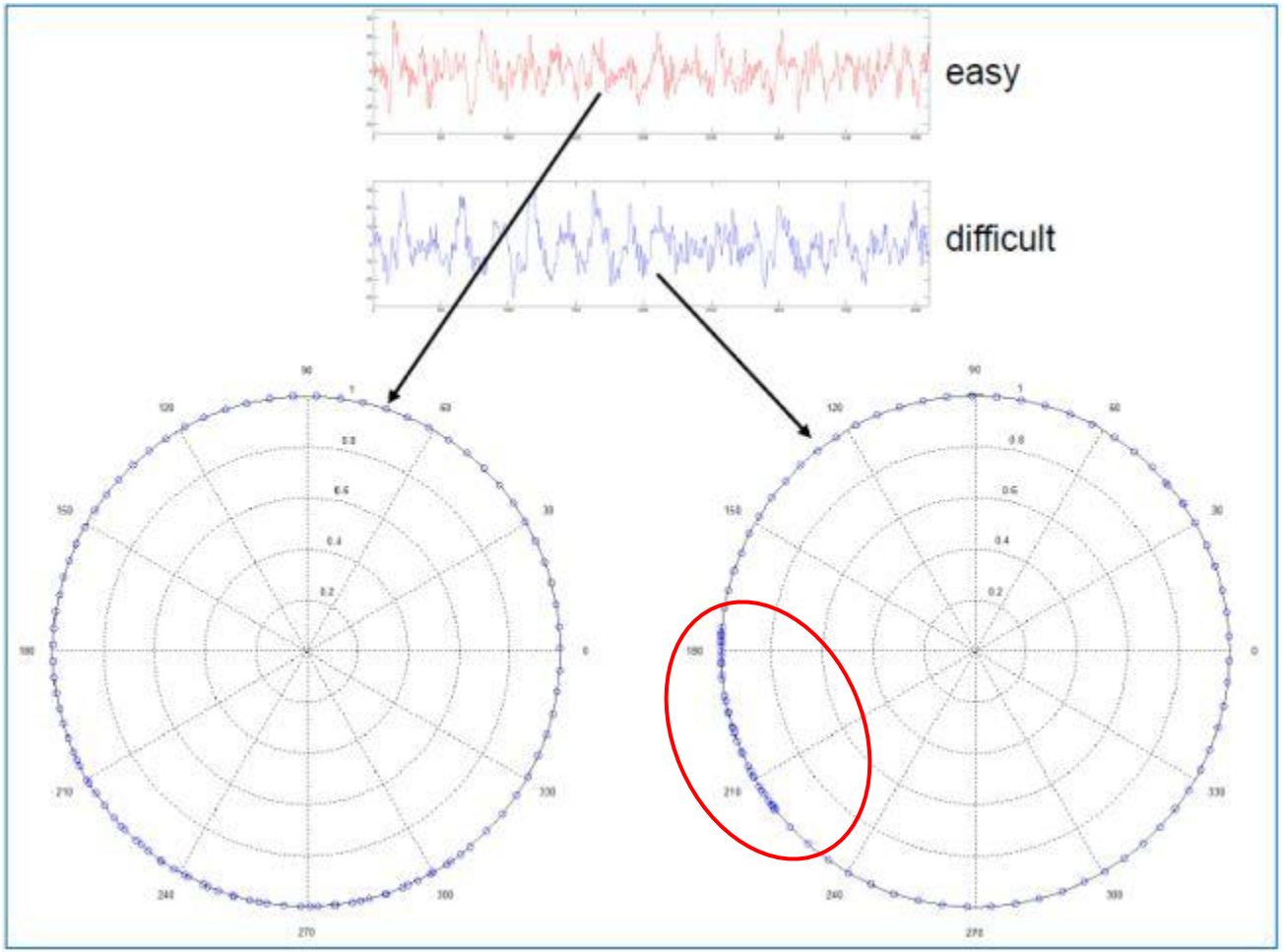
Measuring Listening Effort by Analyzing EEG

Life sounds brilliant.

- ABRs
  - are analyzed in the delayed amplitude of the averaged waveforms in response to repeated stimuli
- Ongoing EEGs (our studies)
  - not evoked by repeating the same stimuli; waveforms cannot be simply averaged
  - we rely on special time-frequency transforms of waveforms while participants perform speech recognition task and evaluate the instantaneous phase of the resulting signal
    - Frequency-specific instantaneous phase characteristics of the EEG waveforms
      - Phase is measured as an angle (i.e. degrees) and is plotted on a so-called unit circle

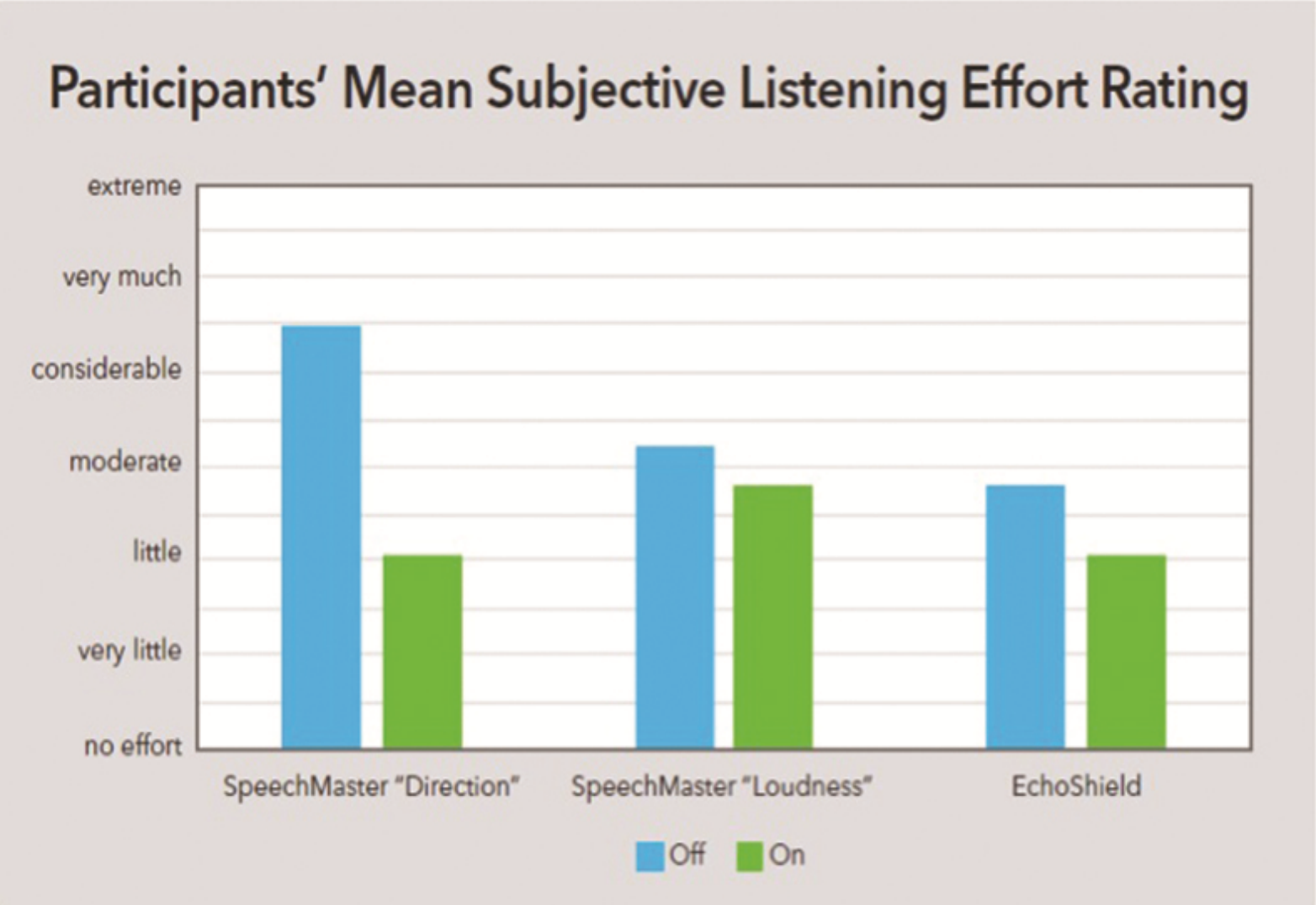
Plotting Phase Around the Unit Circle

Life sounds brilliant.



Clinical results
New features significantly reduce listening effort

Life sounds brilliant.



An independent clinical study in the US has shown that primax provided a significant improvement in ease of listening in demanding listening environments. A methodology using objective brain behavior measures with electroencephalographic data, showed a significant reduction in listening effort for mild to moderate hearing impaired subjects using primax hearing instruments, when applying advanced features SpeechMaster and EchoShield.

signia

Life sounds brilliant.

Hearing
Systems

SIEMENS

2016 Expert Series

signia
Life sounds brilliant.

signia
Life sounds brilliant.

2016 Expert Series.

Join us all summer long in a series of free online seminars.
All sessions are recorded and will be available at AudiologyOnline.com.

To register for these courses and many more,
visit http://www.audiologyonline.com/ce/signia-siemens

CEUs Available

June 2, 2016 at 12 PM ET

Managing tinnitus in pediatric patients, can we apply adult strategies?

Presented by Catherine Palmer, Ph.D.

Pediatric patients may present with bothersome or debilitating tinnitus for a number of reasons. Common causes will be reviewed as well as management strategies. Management strategies will be discussed in the context of the adult evidence base and protocols and how these may (or may not) be applied to a pediatric population. Several case studies will be discussed in order to highlight the challenges of managing tinnitus in a variety of pediatric patients.

June 15, 2016 at 12 PM ET

Holistic approach to tinnitus management

Presented by Christopher Spankovich, Au.D., Ph.D., M.P.H.

In this lecture we will discuss approaches to tinnitus management with emphasis on sound based therapy using amplification as a delivery platform. The lecture will provide step-by-step recommendations for clinical application.

June 27, 2016 at 12 PM ET

Driving a Hearing Aid on Highway 80

Presented by Yu-Hsiang Wu, MD. Ph.D.

It is important to know whether new interventions, such as hearing aid technologies or fitting strategies, deliver greater benefit to listeners with hearing impairment than older interventions. Measuring the intervention benefits - or the outcomes - is not as straightforward because many factors, such as the acoustic characteristics of listening environments, can affect the outcomes. In this talk, a series of studies will be presented to illustrate the effect of hearing aid directional microphone technology on speech understanding and listening effort in a laboratory setting and in an automobile. The use of dual-task paradigms to measure listening effort will also be discussed.

July 8, 2016 at 12 PM ET

Speech-in-noise testing for selection and fitting of hearing aids: Worth the effort?

Presented by H. Gustav Mueller, Ph.D.

Hearing aid fitting protocols must be efficient, and some have questioned if there is value in including speech-in-noise testing. In this course, we'll review evidence showing that indeed, the findings from this testing can be used for the selection and adjustment of special features, selection of accessories, and most importantly, patient counseling. We'll also discuss what specific speech tests easily can be implemented into a busy schedule.

July 26, 2016 at 12 PM ET

Impact of auditory access on speech and language development

Presented by Merry Spratford, Au.D.

Recent results from the Outcomes of Children with Hearing Loss (OCHL) study indicate that auditory access - aided audibility levels (i.e., speech intelligibility index) and amount and duration of hearing aid use - contributes to speech and language development for children who are hard of hearing. Longitudinal trends in audibility and hearing aid use show some children to be at consistent risk for decreased auditory access, thus also at risk for speech and language delays. Auditory access profiles for individual children will be discussed relative to speech and language outcomes and recommendations for audiological/ amplification management.

Hearing Systems

SIEMENS

References

Life sounds brilliant.

1. Strauss, D. J., Corona-Strauss, F. I., & Froehlich, M. (2008). Objective Estimation of the Listening Effort: Towards a Neuropsychological and Neurophysical Model. *Conf Proc IEEE Eng Med Biol Soc,1777-1780.*

2. Strauss, D. J., Corona-Strauss, F. I., Trenado, C., Bernarding, C., Reith, W., Latzel, M., & Froehlich, M. (2010). Electrophysiological correlates of listening effort: neurodynamical modeling and measurement. *Cogn Neurodyn, 4,* 119-131.

3. Bernarding, C., Strauss, D. J., Latzel, M., Hannemann, R., Chalupper, J., & Corona-Strauss, F. I. (2011). Simulations of hearing loss and hearing aid: effects on electrophysiological correlates of listening effort. *Conf Proc IEEE Eng Med Biol Soc, 2319-2322.*

4. Bernarding, C., Strauss, D., J., Hannemann, R., Seidler, H., & Corona-Strauss, F. I. (2013). Neural Correlates of Listening Effort Related Factors: Influence of Age and Hearing Impairment. *Brain Res Bull. 91, 21-30.*

5. Bernarding, C., Hannemann, R., Herrmann, D.,Strauss, D. J., & Corona-Strauss, F. I. (2013). Extraction of listening effort correlates in the oscillatory EEG activity: Investigation of different hearing aid configurations. *Neu- ral Engineering (NER), 2013 6th International IEEE/EMBS Conference, 1258-1261.*

6. Schafer, P. J., Serman, M., Arnold, M., Corona-Strauss, F. I., Strauss, D. J., Seidler-Fallbohmer, B., Seidler, H. (2015). Evaluation of an objective listening effort measure in a selective, multi–speaker listening task using different hearing aid settings. *Conf Proc IEEE Eng Med Biol Soc, 4647-50.*

7. Wisniewski, M. G., Thompson, E. R., Iyer, N., Estepp, J. R., Goder-Reiser, M. N., Sullivan, S. C. (2015). Frontal midline θ power as an index of listening effort. *Neurore- port, 26(2), 94-9.*

8. Bruneau, N, Roux, S., Guérin, P., Garreau, B., Lelord, G. (1993). Auditory stimulus intensity responses and frontal midline theta rhythm. *Electroencephalogr Clin Neurophysiol, 86(3), 213-6.*

9. J Am Acad Audiol. 2016 Jan;27(1):29-41. doi: 10.3766/jaaa.15030.The Effects of Hearing Aid Directional Microphone and Noise Reduction Processing on Listening Effort in Older Adults with Hearing Loss. Desjardins JL1.

10. Ng, E. H., et al. (2013). "Effects of noise and working memory capacity on memory processing of speech for hearing-aid users." Int J Audiol 52(7): 433-441.

11. Conf Proc IEEE Eng Med Biol Soc. 2012;2012:4615-8. doi: 10.1109/EMBC.2012.6346995. Quantification of listening effort correlates in the oscillatory EEG activity: a feasibility study. Bernarding C1, Strauss DJ, Hannemann R, Corona-Strauss FI.

signia

Life sounds brilliant.

primax

Redefining the ease of listening

Thank you!

Hearing Systems

SIEMENS