N400 in Females with High and Low Acceptable Noise Levels

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BACKGROUND

Acceptable Noise Level (ANL)
In 1991, Nabelek, Tucker, and Letowski developed the acceptable noise level (ANL) to measure a listener's ability to accept background noise while listening to speech. ANL is determined by obtaining two behavioral measures: most comfortable level (MCL) for speech and background noise level (BNL). BNL is the maximum level of background noise one is willing to accept while listening to speech. ANL is then calculated by subtracting BNL from MCL. A low ANL score indicates the listener is willing to accept higher levels of noise, while a high ANL score indicates the listener's willingness for lower levels of background noise when listening to speech. ANL scores of new hearing aid users are unrelated to SPIN scores and have high reliability over a three-month period (Nabelek, Tampas, & Burchfield, 2004; Nabelek, Freyaldenhoven, Tampas, Burchfield, & Muenchen, 2006). Factors that do not affect ANL are age, gender, and hearing sensitivity (Nabelek et al., 1991; Rogers et al., 2003).

ANL and Auditory Evoked Potentials
One area of ANL research has focused on evoked electrophysiological differences in groups of listeners with high and low ANLs. Harkrider and Tampas (2006) examined young normal female adults with high and low ANLs using click-evoked otoacoustic emissions (CEOAE) and the auditory brainstem response (ABR). No group differences were found for CEOAEs or ABR waves I and III. However, ABR wave V and Na-Pa of the middle latency response (MLR) did reveal significant amplitude differences between the groups, with the high ANL group showing larger amplitudes. These findings of dissimilar CANS function between the groups was validated with additional research from Tampas and Harkrider (2006). Young females with high and low ANLs were again examined using ABR, MLR, and auditory late latency response (LLR). Differing from the previous research, findings in this experiment showed a lack of significance for ABR wave V amplitude. However, analysis of MLR and LLR amplitudes revealed significant differences between the high and low ANL groups. The high ANL group displayed larger MLR and LLR amplitudes than the low ANL group. Based on findings from both experiments, the authors hypothesized that the dissimilar electrophysiologic responses of the groups represent different levels of responsiveness of the CANS. Specifically, individuals with low ANLs have less responsive afferent CANS function and/or enhanced cortical inhibition strength allowing them to accept higher levels of background noise.

Auditory N400 Response
The N400 is an endogenous response manifested as a negative deflection occurring between 350-600 msec poststimulus and is usually elicited when stimulus context is incongruent. It has often been analyzed in language comprehension research. The N400 represents cognitive processing of visual or auditory stimuli. N400 electrophysiologic data is consistent with neuroimaging data revealing that it represents a variety of higher level processing areas within the brain such as the inferotemporal cortex, superior temporal sulcus, medial temporal lobe, hippocampus, and ventrolateral prefrontal cortex. Thus, the N400 represents activity in areas of the brain responsible for the processing of numerous modalities.

PURPOSE

1. Examine the auditory N400 response in listeners with high and low ANLs in an attempt to provide new information regarding processing of speech beyond the level of the SOC in a group of young adult females.
2. Examine auditory LLR components (P1, N1, and P2) in listeners with high and low ANLs in a similar manner to previous research (Tampas & Harkrider, 2006).

MATERIALS AND METHOD

Participants
Eighteen normal hearing adult females between the ages of 19-31 years participated in this study. Participants provided pertinent medical information to exclude those with significant history of tinnitus, middle ear disease, use of medication, neurological disorder, brain trauma, speech/language disorder, auditory processing disorder (APD), or attention deficit hyperactivity disorder (ADHD). All participants were right-handed and passed an otoscopic examination, hearing screening, and APD screening (Dichotic Digits). Participants were placed in one of two groups according to their ANL scores (high or low) with a total of 9 per group.

ANL Procedure
Participants were provided verbal and written instructions prior to ANL testing. The primary (speech) stimulus was male running discourse (Arizona Travelogue, Cosmos, Inc.), as used in previous ANL studies. The secondary (noise) stimulus was twelve-talker babble (Revised SPIN, Cosmos, Inc; Bilger et al., 1984). Stimuli for the ANL task were presented via CD player routed through an two-channel audiometer and loudspeaker. Participants were seated 1.5 meters from the loudspeaker at 0 degrees azimuth and instructed to signal intensity adjustments of the primary and secondary stimuli. Intensity adjustments were signaled by participants using thumbs-up (increase in intensity), thumbs-down (decrease in intensity), and flat palm (stop adjustment) gestures. The MCL and BNL levels were used to calculate ANL (ANL = MCL - BNL).

Electrophysiologic Testing
EEG recordings were conducted with the Intelligent Hearing System (IHS) SmartEP evoked potential system. EEG activity was recorded using gold-plated electrodes at Fz, Cz, and Pz, referenced to linked mastoids. Electrode impedance was maintained at or below 7 kohms. The EEG was analog filtered (1-30 Hz, -6 dB/octave slope), artifact rejected (± 50 microvolts), and digitized with an A/D rate of 1250 Hz.

For N400 acquisition, two experimental conditions (quiet vs. noise) were presented to each participant. Stimuli were SPIN sentences and twelve-talker babble (presented in the noise condition only). Half of the sentences in a list were high predictability (e.g., The boy gave the football a *kick*) and the other half low predictability (e.g., Betty had considered the *bark*). Each SPIN list was kept in their original sequence, however sentence timing was manipulated and twelve-talker babble added using Adobe Audition software. Lists were saved to a compact disc and presented via CD player routed through an audiometer. Stimuli were presented monaurally via insert earphones. Two SPIN lists totaling 100 sentences were presented for each condition. For both conditions speech was presented monaurally at 60 dBHL with a sentence onset asynchrony of 12 seconds. For the noise condition twelve-talker babble was presented to the test ear at a +8 dB signal-to-noise ratio. An acoustic click on the second channel of the CD recording occurred simultaneously with the onset of each target final word to trigger EEG sampling. Peak amplitude and latency of the N400 was recorded as the most negative point occurring between 300 and 600 msec post final word onset.

For LLR acquisition, four experimental conditions (2 frequencies x 2 intensities) were presented to each participant. Stimuli were 500 and 3000 Hz Blackman-gated tone bursts presented binaurally at 35 and 70 dBnHL. Stimuli rate was 1.1/s and a total of 250 sweeps were collected for each condition. Peak-to-peak amplitudes were calculated for P1-N1 and N1-P2. Absolute latencies were measured for waves P1, N1, and P2.

Table: ANL descriptive statistics

Group	Mean	Standard Deviation	Range	Individual ANLs
High (n=9)	12.33	1.41	11 - 15	15, 14, 13, 12, 12, 12, 11, 11, 11
Low (n=9)	1.22	2.64	-3 – 6	-3, -1, 0, 0, 1, 2, 3, 3, 6

RESULTS & CONCLUSIONS

N400
For the purposes of this poster, only analysis of the quiet condition is presented. Two separate repeated measures ANOVAs were used to analyze N400 peak amplitude and latency. The variables of interest were ANL group (high vs. low), final word predictability (high vs. low), and electrode site (Cz vs. Pz).

- N400 peak amplitude was significantly larger (i.e., greater negativity) (p<0.001) for the final words with low predictability as compared to those with high predictability.
- No main effects or interactions (p>0.05) were found for ANL group or electrode site.

LLR
Five separate repeated measures ANOVAs were used to analyze LLR peak-to-peak amplitude (P1-N1 and N1-P2) and latency (P1, N1, and P2). The variables of interest were ANL group (high vs. low), stimulus frequency (500 vs. 3000 Hz), and stimulus intensity (35 vs. 70 dBnHL), and electrode site (Fz vs. Cz vs. Pz).

- Both LLR peak-to-peak amplitudes were significantly larger for the lower stimulus frequency (i.e., 500 Hz) (p<0.001), as well as for the higher intensity (i.e., 70 dBnHL) (p=0.003).
- Both N1 (p=0.014) and P2 (p=0.021) peak latency was significantly shorter for the higher stimulus intensity (i.e., 70 dBnHL).
- No main effects or interactions (p>0.05) were found for ANL group or electrode site.

Conclusions
There were no differences found between high and low ANL groups for the auditory N400 response. Significant findings for the LLR were due to stimulus frequency and intensity only, with no differences found between the high and low ANL groups. These findings do not suggest variability in the responsiveness of the CANS for these two groups as previous research has suggested. The reasons for different findings in the current study compared to those of Tampas and Harkrider (2006) could be due to a smaller number of participants and lower ANL scores within the high group. Data collection for the current study is still in progress.

Figure 1. Evoked potential component amplitudes as a function of ANL group

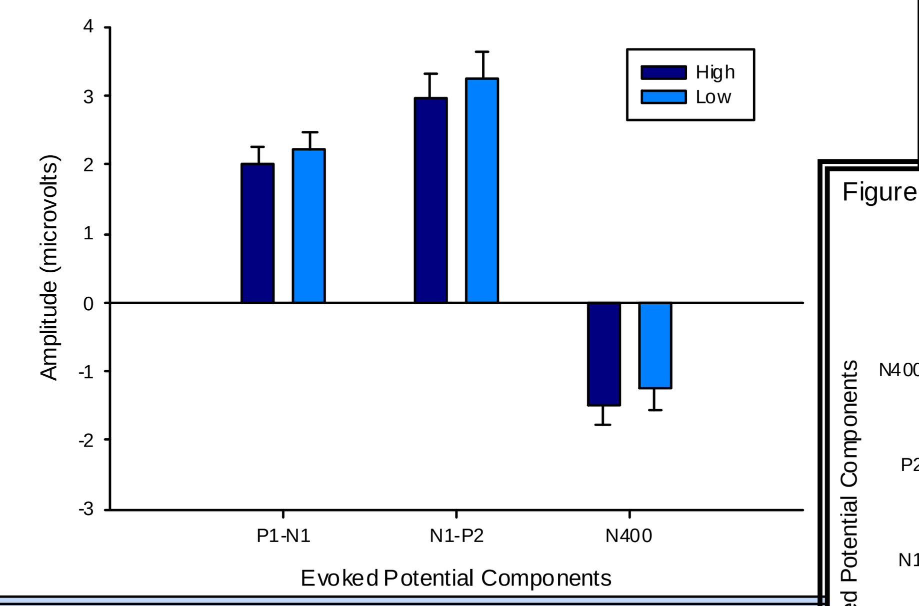

Figure 2. Evoked potential component latencies as a function of ANL group