# THE EFFECTS OF NOISE MASKING ON THE CORTICAL AUDITORY EVENT-RELATED POTENTIALS TO SPEECH SOUNDS /BA/ AND /DA/.*

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Introduction. Cortical event-related potentials (ERPs) provide measures of the timing, sequence, and anatomical location of brain processing reflecting the detection and discrimination of sounds. Cortical ERP N1 occurs about 80-150 ms following stimulus onset, and reflects an obligatory response of the brain to stimulus onset or offset. Its major generators lie in the primary auditory cortex bilaterally. The mismatch negativity (MMN) begins during N1 and can lost longer than N1. This response, generated in the primary auditory cortex bilaterally, is a preconscious response elicited by the mismatch or physical difference between stimuli presented in an oddball paradigm. In the oddball paradigm (e.g., /ba, ba, ba, ba, ba, **da**, ba/, etc.), infrequently occurring "deviant" stimuli (e.g., /da/) are embedded in a series of frequently occurring "standard" stimuli (e.g., /ba/). MMN increases in amplitude and decreases in latency the greater the physical difference between the standard and deviant stimuli. ERP wave N2 (or N2b) occurs approximately 200 ms following the beginning of stimulus deviance, is usually present only in an attend condition, requires unpredictable stimulus presentation, and is seen for auditory and visual modalities (all in contrast to the MMN). Active attend and passive ignore conditions are employed to separate MMN from N2. ERP wave P3 (or P3b) occurs approximately 300-500 ms following the beginning of stimulus deviance. Like the N2, it requires unpredictable stimuli which are attended. N2 and P3 intracranial generators are multiple and not fully determined, but both reflect later processing of stimuli. N2 occurs when a stimulus mismatch has been consciously noted. P3 latency has been suggested to reflect stimulus evaluation time, or post-decision evaluation of the deviant stimuli. Thus, these ERP measures provide, in humans, measures of the timing (reflected by latencies), strength (reflected by response amplitude), and location (reflected by generators of the waves) of brain processing at different stages in the auditory system. The recordings are even more informative when recorded together with, and constrained by, behavioural measures, such as reaction time (RT) and discriminability (e.g., d' from %correct and false alarm data).

Many behavioural studies have investigated the effects of hearing loss, real or simulated by stimulus filtering or masking, on perception of speech. Little is known of changes in human brain processing of auditory stimuli occurring with hearing loss. In the present studies, we investigated the effects of decreased audibility, caused by either broadband (BBN) or by high-pass (HPN) noise masking, on cortical ERP and behavioural measures of detection and discrimination of the consonant-vowel syllables /ba/ and /da/. The /ba/ - /da/ stimuli were presented at 65 (Studies 1,2 & 3) and 80 (Studies 1 & 2) dB peak-to-peak equivalent (ppe) SPL.

Results/Discussion. In *study 1*, we investigated the effects of BBN maskers on cortical ERPs recorded in an active attend condition (N1, N2 and P3), as well as behavioural measures. BBN masking noise was presented at 50, 60 and 70 dB SPL for 65 dB stimuli, and at 60, 70 and 80 dB SPL for 80 dB stimuli. These maskers produced "flat" behavioural threshold elevations of 18, 25, 35 and 48 dB, respectively. The BBN maskers produced significant decreases (relative to a QUIET condition) in ERP amplitudes and behavioural discriminability. These decreases did not occur, however, until the noise masker intensity (in dB SPL) was equal to or greater than the speech stimulus intensity (in dB ppe SPL), that is, until speech-to-noise ratios were ≤ 0 dB. N1 remained present even after N2, P3, and behavioural discriminability were absent. In contrast to amplitudes, ERP and behavioural latencies showed significant decreases at higher (better) speech-to-noise ratios. Significant latency increases occurred when the noise maskers were within 10-20 dB of the stimuli. At these levels, *amplitudes* showed no change. Latency increases occurred with less masking for N1 than for P3 or behavioural reaction time.

*Study 2* investigated the effects of HPN masking on the cortical ERPs recorded in an active attend condition (N1, N2 and P3), as well as behavioural measures. The HPN maskers resulted in sloping high-frequency losses, with pure-tone behavioural threshold elevations of 38 dB at the high-pass cutoff, and 50 dB one octave above the cutoff frequency. ERP results show that as the HPN cutoff frequency is lowered, ERP latencies increased and amplitudes decreased. The cutoff frequency where the changes first occurred and the rate of change differed for N1 compared to N2, P3 and the behavioural measures. N1 showed small and systematic changes. N2, P3 and RT/d' showed marked changes only when the HPN cutoff was below 2000 Hz.

*Study 3* investigated the effects of HPN masking on the cortical ERPs recorded in a passive ignore condition (N1, MMN). Results for N1 are similar to those seen in Study 2. MMN and behavioural results showed a similar pattern to those seen for N2 and P3 in Study 2: marked changes (increased latency and decreased amplitude) only when the HPN cutoff was below 2000 Hz (i.e., at 1000 Hz). The marked changes in latency and amplitude of ERP waves MMN, N2, and P3 (and behavioural RT and d') occur when the HPN masker cutoff was lowered from 2000 to 1000 Hz. This is the region of the second formant frequency transition differentiating /ba/ from /da/. N1 changes with HPN masking were systematic, and lacked this marked change at a specific cutoff.

Conclusions. Several general conclusions are reached from these studies: (i) ERP and behavioural latencies are more sensitive to the effects of masking than are amplitude (or %correct) measures; (ii) Latencies increase and amplitudes (or %correct) decrease with masking. To the extent that the audibility changes with masking are similar to those of hearing loss, then hearing loss might be expected to produce similar changes. (We are currently assessing this in subjects with SNHL.) (iii) The effects of masking are different for ERP wave N1 compared to ERP waves MMN, N2 and P3, as well as for behavioural measures, reflecting the different functional significance of N1 compared to these other measures. N1 is an "obligatory" response, indicating detection by the brain of audible stimulus energy; it does not reflect discrimination of stimuli. MMN, N2, P3, and behavioural measures reflect detection *and* discrimination; (iv) changes in ERP waves MMN, N2, and P3 latency/amplitude with masking are strongly correlated with changes in behavioural measures.

These studies have implications both for basic research into brain processing of auditory stimuli and changes with masking and hearing loss, and for possible applications to clinical populations.

* *The studies presented in this Summary form part of Brett A. Martin's Ph.D. dissertation.*