The Role of Semantic Processing in the Allocation of Auditory Attention in Competitive Acoustic Scenarios

John McGee  
*Technological University Dublin*, johnnyboymcgee@gmail.com

Charlie Cullen  
*Technological University Dublin*, charlie.cullen@tudublin.ie

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John McGee
Dublin Institute of Technology, Dublin, Ireland • johnnyboymcgee@gmail.com

Dr. Charlie Cullen
Dublin Institute of Technology, Dublin, Ireland • Charlie.Cullen@dit.com

Overview
Many devices, such as smartphones, rely heavily on audio to get the attention of users, but this can also cause auditory overload in noisy real-world environments. The temptation for users to multi-task can often lead to auditory overload as a result of auditory overload. It is possible to exploit auditory overload as a means of advertising or communicating with users.

Method
Background Task: The background task was the same for all three test conditions. Participants were required to acknowledge a non-speech sound as soon as it was presented. This provided a baseline for response time in the background task as well as for overall cognitive load.

Forefront Speech Task: In the second test condition, participants were required to attend to the foreground task while also attending to a concurrent background speech task. The speech task required participants to listen to a three-minute recording of the BBC shipping forecast and to make note of how many times the word ‘Viking’ was mentioned. The intention in having participants complete this straightforward word-search task was to encourage a more attentive form of listening along with having participants complete this straightforward word-search task. The voice on the recording was that of a male speaker. Participants were allowed to make notes with a pen and paper throughout the task.

Forefront Music Task: In the third test condition, participants were required to attend to the background task while also attending to a concurrent background music task. The music task required participants to listen to a three-minute excerpt of Brian Eno’s Ambient 1 (‘Music for Airports’), and to make note of how many times a specific musical phrase was repeated. Similar to the speech task, the intention with this straightforward musical task was to encourage a more attentive form of listening. An instrumental piece was chosen so as to have a clear distinction between the speech condition and the music condition. Participants were allowed to bring themselves to the target melody prior to beginning the task and to make notes with a pen and paper throughout.

Experimental Design
A crossover repeated-measures design was adopted with an overall sample of 16 participants. The main concern with a repeated-measures study is order effects. In order to balance these effects the overall sample was split into two groups of eight participants randomly assigned to each group. The two groups were then required to complete the speech and music conditions in the opposite order (Fig. 1).

Setting
Participants were placed inside a soundproof isolation booth in a controlled audio laboratory environment in order to keep extraneous noises and visual distractions to a minimum (Fig. 2).

Results
Response Time: As expected, the average overall response time for background sounds was quick in the control condition, with only one sound recording a faster average response time in one of the experimental conditions (the sound of insects chirping). A one-way ANOVA revealed a highly significant difference in average response time between the three test conditions, F(2, 30) = 36.1, p < 0.001. Post-hoc tests using the Bonferroni correction (3) revealed a statistically significant difference between the control condition and the speech condition, t(14) = 0.0000000002, p < 0.017; between the control condition and the music task condition, t(38) = 0.000000000001, p < 0.017; and between the speech task condition and the music task condition, t(30) = 0.000000, p < 0.017 (Fig. 3).

Rural vs. Urban Sounds: One-way ANOVAs were carried out for each individual sound to determine whether or not there was any significant difference in response time across the three test conditions. Results revealed statistically significant differences for 8 of the 10 sounds (only the sound of insects chirping and the sound of a siren showed no significant difference across any of the three test conditions). Post-hoc tests using the Bonferroni correction determined where these statistically significant differences were occurring (Fig. 4). Neither sound set fared any better than the other in any of the three test conditions. Two-tailed dependent t-tests revealed no significant difference in overall response time between rural sounds and urban sounds in the control condition, t(150) = 0.75, p > 0.05; the speech task condition, t(154) = 0.33, p > 0.05; or the music task condition, t(148) = 0.59, p > 0.05.

Cognitive Load: As expected, cognitive load scores were lowest in the control condition, with only one participant reporting this condition to be cognitively more demanding than one of the test conditions. The average overall cognitive load score for the control condition was 23.41%. Scores varied between the speech and music conditions, with the speech condition recording an average overall score of 51.54% compared to just 46.32% in the music condition. A one-way ANOVA followed by post-hoc tests using the Bonferroni correction revealed a statistically significant difference between the control condition and the speech task condition, (30) = 0.0000028, p < 0.017; and between the control condition and the music task condition, (30) = 0.001, p < 0.017 but statistically significant difference between the speech condition and the music condition, (30) = 0.38, p = 0.017 (Fig. 5).

Conclusions
Based on average response times in the background, rural sounds across all three test conditions, it can be concluded that belonging to a particular sound set confers no apparent advantage when it comes to registering auditory attention in a competitive acoustic scenario. Sounds from both sound sets fall varying degrees of success, with no one sound set in particular exhibiting any statistically significant advantage when compared to any of the other in any of the three test conditions. As expected, participants responded significantly faster to background sounds in the control condition, but interestingly they also responded significantly faster to background sounds in the speech task condition compared to the music task condition. The results, despite rewarding faster and more efficiently to background sounds in the speech task condition, participants performed this condition to be slightly more demanding than the music task condition in terms of cognitive load. The results of this study suggest that listening to music is generally considered a leisure activity.

Future work will consider whether or not low-level attributes other than volume, such as frequency bandwidth, can be manipulated in order to regular auditory attention in competitive acoustic scenarios.

References

Fig. 1: Experimental Design
1. Experimental Design: Crossover repeated-measures design with 16 participants divided into two groups of 8
2. Setting: Sounds were recorded in a controlled audio laboratory environment between 9 a.m. and 5 p.m. High-quality audio files (WAV format, 44100 Hz, 16 bits, 2 channels) were processed using commercial Beardown DT-105 headphones. Background sounds were matched for volume based on root-mean-square amplitude with the order and timing of presentation randomized.
3. Response Time: Overall average response times for background sounds. Scores varied between the control and music conditions, with rural, sounds shown in black on urban); Stars indicate statistically significant differences between conditions based on one-way ANOVAs followed by post-hoc tests using Bonferroni correction: * = Control/Music; ** = Speech/Music
4. Rural vs. Urban Sounds: Average response times for individual background sounds (p = 0.017; between rural and urban sounds). Stars indicate statistically significant differences between conditions based on one-way ANOVAs followed by post-hoc tests using Bonferroni correction: = Control/Speech; = = Control/Music; = = Speech/Music
5. Cognitive Load: Average cognitive load scores for each test condition. Stars indicate statistically significant differences between conditions based on one-way ANOVAs followed by post-hoc tests using Bonferroni correction: * = Control/Speech; = = Control/Music; = = Speech/Music

Fig. 2: Setting
1. Soundproof Isolation Booth
2. Sounds were recorded in a controlled audio laboratory environment between 9 a.m. and 5 p.m. High-quality audio files (WAV format, 44100 Hz, 16 bits, 2 channels) were processed using commercial Beardown DT-105 headphones. Background sounds were matched for volume based on root-mean-square amplitude with the order and timing of presentation randomized.

Fig. 3: Results
1. Results: Response Time: Average cognitive load scores for each test condition. Bars indicate standard deviation. Stars indicate statistically significant differences between conditions based on one-way ANOVAs followed by post-hoc tests using Bonferroni correction: = Control/Speech; = = Control/Music; = = Speech/Music