APCAM 2017

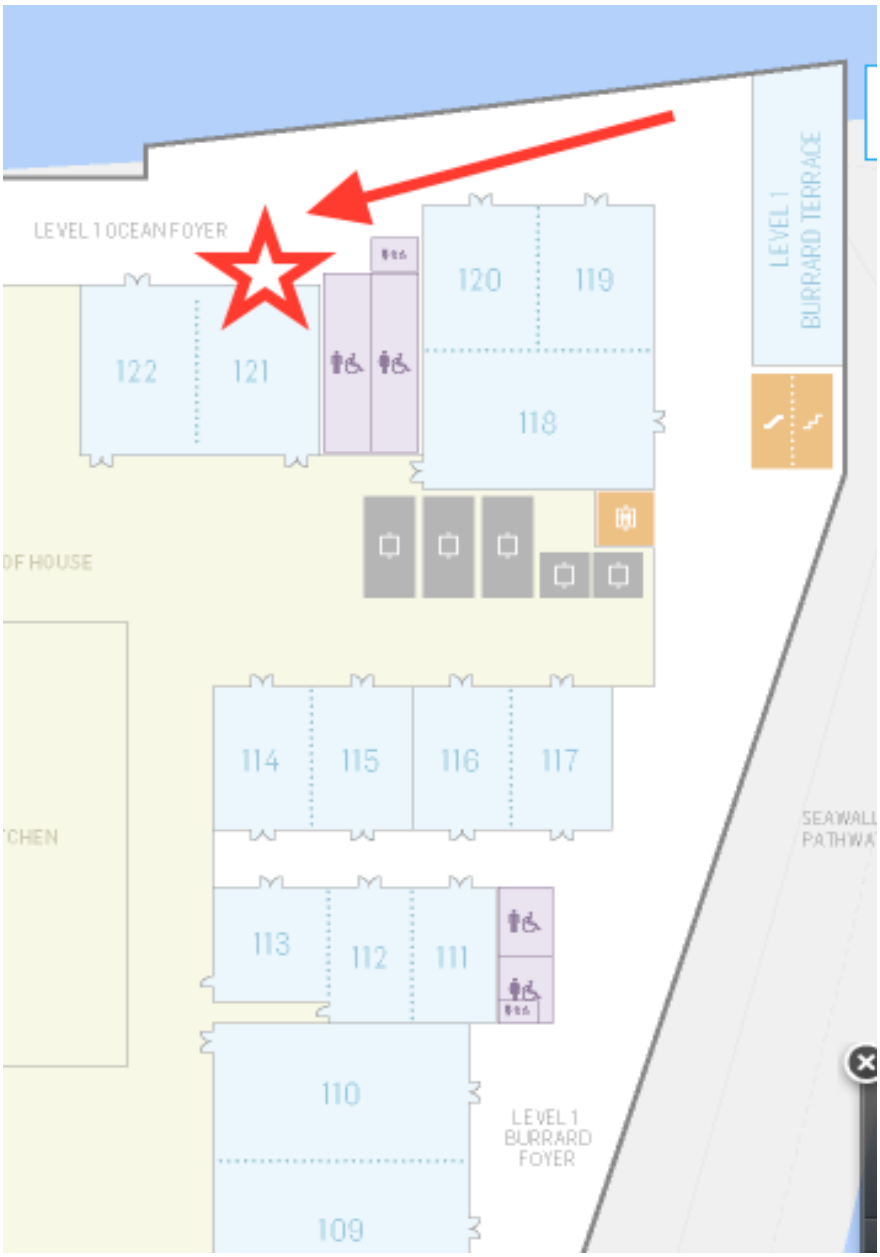
16th Annual Auditory Perception, Cognition, and Action Meeting

Thursday, November 9th

Vancouver Convention Centre West
Meeting Room 121, Level 1
Vancouver, British Columbia

Program sponsored by

WASHBURN UNIVERSITY



The meeting room is on *Level 1* (Burrard Terrace, 1 level up from the ground floor) of the Vancouver Convention Centre *West*.

Room 121 is on the *right side of Level 1*, facing the Vancouver Harbour.

http://www.vancouverconventioncentre.com/facility/floor-plans-and-specs#west-meeting-room-121

Welcome to APCAM 2017

Meeting (APCAM 2017). Now in its sixteenth year, APCAM continues to be unique in its mission ". . . to bring together researchers from various theoretical perspectives to present focused research on auditory cognition, perception, and aurally guided action". It likewise continues to be unique in collecting such work, which spans across levels of processing, basic v. applied research interests, and distinct theoretical perspectives, all within a single session/day of conference activity. We firmly believe this kind of varied and friendly exchange of ideas to be critical to propelling our field(s) forward (e.g., increasing the possibility of revolutionary approaches to solve identified problems). This belief is evident in our continued pursuit of an accompanying APCAM-themed journal this past year.

Given that APCAM is a satellite meeting, it has remained relatively compact in size. While this makes for a more intimate context for sharing science, it also means that the meeting depends upon support from its attendees to make it successful. There are several areas where we are asking for your support. For example, over the years, APCAM has depended largely on word of mouth to encourage first-time attendance, and in many instances, those first-time attendees become regular contributors to APCAM's program. We need your help to expand our conference-related community of researchers. If you like what you see at the meeting, then bring a colleague with you next year. Suggest the same procedure to that colleague. This will ensure that APCAM continues to grow, while also ensuring new and varied discussion each year.

Another request we are making of you is to give us your input or feedback in several areas.
One of these concerns our conference website (www.apcam.us), which now contains contact information for committee members. Also, for the first time, we have shared online a subset of posters from the meeting. We would like to continue this practice, and therefore ask poster presenters this year to consider sending us a single-page PowerPoint or .pdf copy of their posters immediately following the meeting. This way, we'll be able to not only guarantee that their work can be received by interest attendees, but also that others who couldn't make it to the meeting this year can still learn from it. Poster presenters on the lookout for a brief message requesting such a submission shortly after the meeting concludes.
Furthermore, last year we launched a page that provides links to laboratory sites of APCAM attendees. However, since its inception, only a relatively few researchers have included their information on the site. Only a brief paragraph is needed, and the provided links could potentially direct interested students to their future research mentors. Please help us to turn this page into a more effective information resource by including your lab's information as well. You will see that the existing site descriptions all reflect a single-paragraph format that includes the same kinds of information in a fixed order. This means that you can use the information provided by most laboratories on the site as a template/guide to quickly easily generate corresponding information for your lab. When it is complete, simply send it to Mike Russell at mike.russell@washburn.edu. These additional sources of information should continue to help make the conference site more useful. We also would welcome any other suggestions that you have regarding information that you would consider to be desirable for inclusion on the site.

Last year, we were able to stream oral presentations live from the meeting for the first time. Views of those presentations exceeded the number of people in attendance, indicating that APCAM was reaching a wider audience with that online presence. We hope to be able to continue to offer the opportunity to view presentations online, and would be grateful for your input about the likelihood that you would use this option for any meeting that you would not be able to attend, as well as whether you would like to see presentations archived in some way for later access by other researchers.

Finally, we want to hear from you if you desire to get more involved in helping to deliver APCAM as one of its organizers. **We are interested in bringing in new people into the organizing team**. This will serve to further strengthen that team while infusing it with fresh ideas to further improve the meeting and accompanying information.

APCAM has traditionally been dependent upon certain groups for support so that we could bring you the meeting free of charge. For example, the Psychonomic Society has covered all expenses associated with satellite meeting rooms, A/V equipment, and poster displays for the past several years. For a

considerably longer period, the committee's Mike Russell and Washburn University have assumed all responsibilities (i.e., time and costs) associated with formatting and producing printed programs for the meeting. Please be sure to share your gratitude with Mike and Psychonomic Society officers for their tremendous support that has made this meeting possible. The organizing committee also would like to thank Jenny Roche (from Kent State University) for her valued assistance with the review of abstracts for this year's program.

Special thanks are reserved for all the contributing authors who collectively have helped make this year's program a strong one. We appreciate you choosing to share your work with us today, and sincerely hope that you will be regular APCAM contributors for years to come. An overview of abstracts reveals concentration in several topic areas, including speech and language, music perception and cognition, and temporal processing, among others. We are confident that each attendee will find something in sessions today that they consider interesting and thought-provoking. As always, if there are issues that arise during the meeting, or you have thoughts for further enhancing future meetings, then do not hesitate to share those thoughts with any committee member. For now, we wish you a pleasant and productive day at APCAM.

Sincerely,
The APCAM 2017 Organizing Committee

Michael D. Hall (Chair)
Devin McAuley
John Neuhoff (Founder)
Kristopher (Jake) Patten
Peter Q. Pfordresher
Mike Russell (Assistant Chair)

8:00	**Registration**	
8:30	**Business Meeting: *Essential* you attend**	
9:10	**Break (10 mins)**	
	Music (abstracts pages 9 – 10)	
9:20	Waxing lyrical (and waning instrumental): The role of lyrics in involuntary musical imagery (earworms)	**C. Philip Beaman**
9:40	Using pupillometry as a tool to investigate pitch perception and identification by music students with varying degrees of absolute pitch	**Patricia Vanzella Guilherme Delmolin Oliveira Francisco Fraga João Sato**
10:00	Toward a more usable form of additive synthesis	**Michael D. Hall**
10:20	**Break & Poster Setup (20 mins)**	
	General (abstracts page 10 – 11)	
10:40	Some methodological considerations in studies of auditory imagery	**Timothy L. Hubbard**
11:00	Deafness to spatial and identity change in auditory scenes: An event-related potential study	**Natalie Ball Matthew Wisniewski Nandini Iyer Brian Simpson**
11:20	Pairing near-threshold tones with an irrelevant visual task produces improvement in tone discrimination	**Steven R. Holloway José E. Náñez Sr. Gurjot Kaur**
	Poster Session (12 noon – 1:20 pm) West Ballroom BCD (located on Level 1 of the Vancouver Convention Centre West) Abstracts located on pages 18 –24	

Lunch (1:20 – 2:00 pm)		
Invited Address (abstract page 13)		
2:00	***Multisensory influences on infant speech perception***	***Janet F. Werker***
Speech & Language (abstracts pages 14 – 15)		
2:30	The relationship between working memory and second language speech reception thresholds in sequential bilingual children	**Douglas MacCutcheon Florian Pausch Janina Fels Robert Ljung**
2:50	Individual differences in perceptual adaptation to phonetic categories: Categorization gradiency and cognitive abilities	**Donghyun Kim Meghan Clayards Eun Jong Kong**
3:10	What am I saying? Exploring the perception-production loop in children's speech	**Sarah C. Creel**
3:30	The perception of operational sex ratios by voice	**John Neuhoff**
3:50	**Break (20 mins)**	
Temporal Processing (abstracts pages 16 – 17)		
4:10	The influence of grouping and tempo on subjective metricization	**Ève Poudrier**
4:30	Central and peripheral processing of spectral temporal order judgment	**Leah Fostick Noam Madmon Tamar Ishay Harvey Babkoff**
4:45	Spectral temporal order judgment (TOJ) thresholds along the frequency spectrum	**Leah Fostick Ortal Burda Hadar Hassid Harvey Babkoff**
5:00	**Updates & Closing Remarks**	

Posters (abstracts located on pages 18 – 24)		
1	Perception of approaching and retreating sounds in a two-dimensional space	**Holly Johnston** **Mike Russell**
2	Motion in a 2-dimensional space: Do we really only live in and perceive a 1-dimensional world?	**Mike Russell** **Holly Johnston** **Stephanie Brown**
3	Perception of gap passability: Is our perception of the world based on vision or audition?	**Stephanie Brown** **Mike Russell**
4	Semantic activation by auditory distractor speech	**Jan Phillip Röer** **Ulrike Körner** **Axel Buchner** **Raoul Bell**
5	Measuring listening effort: Convergent validity, sensitivity, and links with cognitive and personality measures	**Julia F. Strand** **Violet A. Brown** **Madeleine Merchant** **Hunter Brown** **Julia Smith**
6	Acoustic differences in native/non-native affective speech production for Chinese learners of English	**Mengjiao Wu** **Ke-Jui Yen** **Jennifer Roche**
7	Encoding acoustic cues in speech: Electrophysiological measurements	**Agnes Yang Gao** **Joseph Toscano**
8	Crossmodal effect of irrelevant auditory stimuli on saccadic eye movement behavior	**Cailey Salagovic** **Carly J. Leonard**
9	Post-categorical auditory distraction in serial short-term memory: Insights from increased task load and task type	**John E. Marsh** **Jingqi Yang** **Pamela Qualter** **Cassandra Richardson** **Nick Perham** **François Vachon** **Rob Hughes**
10	Schematic and veridical information in the detection of wrong notes in melodies	**W. Jay Dowling** **Rachna Raman**

11	Intonation error perception and correction in a cello performance context	**Sally Norris**
12	Three models of sound localization	**Justin MacDonald**
13	Healthy hearing attitudes and behaviors among college students	**Chris Koch** **Julia Ristau**
14	Perceptual interference in the localization of simulated sounds of small arms fire	**Jeremy Gaston** **Kelly Dickerson** **Brandon Perelman** **Ashley Foots** **Tim Mermagen** **Christopher Stachowiak**

Oral Presentations

9:20

Waxing lyrical (and waning instrumental): The role of lyrics in involuntary musical imagery (earworms)

C. Philip Beaman* *University of Reading*

The involuntary recollection of a piece of music is a common experience: when the experience is unwanted it is usually referred to as an "earworm". Specifically musical characteristics of earworms have proven difficult to identify, but one common feature is that earworms reported most often have some form of lyrical content. Using the procedure developed by Beaman et al. (2015), the potency of instrumental and non-instrumental versions of the same song to act as earworms was investigated. Results show parallel effects of a concurrent interference task designed to reduce involuntary imagery on involuntarily thinking of a song and "hearing" the song. There were more reports of "hearing" the song than thinking of the song in all conditions, Additionally, the version with lyrics both intruded more (there were more reports of both "thinking" and "hearing" the song) and showed larger interference effects from the concurrent task. "Hearing" the song in a control condition was also significantly correlated with scores on the Bucknell Auditory Imagery Scale.

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9:40

Using pupillometry as a tool to investigate pitch perception and identification by music students with varying degrees of absolute pitch

Patricia Vanzella* *Federal University of ABC*
Guilherme Delmolin Oliveira *Federal University of ABC*
Francisco Fraga *Federal University of ABC*
João Sato *Federal University of ABC*

Absolute Pitch (AP) is usually described as the ability to effortlessly identify or sing pitches without reference. It has been shown, however, that pitches in certain timbres pose more difficulty for AP possessors to identify (i.e. piano tones being easier than sung tones). Recently, several studies have shown that pupillary responses are a reliable and sensitive index of the extent of central nervous system processing allocated to a task. In this study, we look at the pitch identification performance on piano and vocal timbres by analyzing hit rates, reaction times and pupillary responses of 19 undergraduate and graduate music students with varying degrees of AP. We used a pitch identification task while recording their pupillary responses with an eye tracker. The task was designed in a block paradigm. Each block consisted of six 1-second-duration tones, with an inter onset interval of 5 seconds between them. There were twelve blocks in all, six for the vocal timbre and six for the piano timbre. Each block was separated by an interval of silence of 30 seconds. The tones presented included all pitches of the chromatic scale between A3 and Gsharp5. The reaction time was measured as the elapsed time between the onset of the played tone and the onset of the participant's vocal response using a Voice Activity Detection algorithm. Hit rates were measured by recognizing each trial response. Pupillary responses were matched with each participant reaction time in the task. Behavioral results reveal significant longer reaction times for the vocal tones compared to the piano tones. Also, preliminary results suggest greater pupil dilation for vocal tones, which could indicate more cognitive effort in recognizing sung tones.

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10:00

Toward a more usable form of additive synthesis

Michael D. Hall* *James Madison University*

Various methods have been used to attain controlled stimulus generation in auditory research. Additive synthesis approaches produce particularly natural results, but traditionally are computationally expensive and contain too many independent pieces of information to permit straightforward manipulation. Furthermore, commercial alternatives shift the spectrum with changes in fundamental frequency or use static banks of harmonics as oscillators. It has been suggested that hybrid forms of additive synthesis afford significant data reduction (e.g., see Serra & Smith, 1990), and initial implementations were instrumental in establishing critical dimensions of musical instrument timbre (e.g., see Grey, 1977). The current project was motivated by an interest in making additive synthesis more usable to eventually assess how much spectro-temporal variation can be simplified without impacting source recognition. A hybrid method, interpolated additive synthesis, was developed by eliminating parameters that do not compromise perception. This method specifies amplitudes of harmonics at four breakpoints that reflect critical changes in the spectral envelope, and interpolates between adjacent values for each harmonic. Interpolation also determines harmonic amplitudes for each fundamental frequency using acoustic measurements from a single sample, thereby maintaining spectral envelope shape/position. A MIDI-controlled instrument was programmed within MaxforLive as proof-of-concept. Phase was ignored given its relatively small impact on timbre (Plomp & Steeneken, 2005), as was harmonic mistuning, which is only needed for some sources. Amplitude envelope was conveyed by harmonic amplitudes except for brief ramps at onset and offset. Perceptual results with various timbres and voiced syllables are promising, producing sounds that are easily identified, and with only slightly decreased naturalness. Remaining challenges include reducing CPU demands with many harmonics and rapid changes in fundamental frequency, as well as simplified modeling of stochastic components to capture residual noise. The completed product and other tools will be made available through the author's laboratory site (see www.apcam.us for links).

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10:20	**Break & Poster Setup (20 mins)**

10:40

Some methodological considerations in studies of auditory imagery

Timothy L. Hubbard* *Arizona State University*

The past few years have seen an increase of interest in auditory imagery. Consistent with the growth in the amount of research on auditory imagery has been a growth in the types and number of methods and instruments used to study auditory imagery. Three major types of methods and instruments that have been used involve questionnaires (e.g., SVQ, VISQ, DES, BAIS), behavioral measures (e.g., priming, interference, discrimination, detection), and assessment of physiological differences (e.g., brain damage, PET, fMRI, ERP), and the costs and benefits associated with each of these methods and instruments are briefly described. Related issues such as inconsistencies and contradictions in terminology (e.g., involving speech imagery, inner hearing, subvocal rehearsal, etc.) observed across papers are noted, and potential distinctions (a) within different types of speech imagery, (b) between the inner ear and inner voice, (c) between auditory information and nonauditory information within auditory imagery, (d) between voluntary (deliberately created) and involuntary (spontaneous) auditory imagery, and (e) between vividness, clarity, and controllability of auditory imagery are considered. Common methodological problems observed across papers are noted (e.g., many brain imaging papers appear to assume that giving an experimental participant instructions to form an image is sufficient to guarantee an image is formed and that any differences in brain activation patterns between the imagery group and a non-imagery group are due to imagery), and recommendations for future studies (e.g., use of converging multiple measures, provision of clearer evidence that imagery [rather than other forms of mental representation] is being assessed, consideration of contributions and relationships of nonauditory information or nonauditory imagery to auditory imagery) are given.

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11:00

Deafness to spatial and identity change in auditory scenes: An event-related potential study

Natalie Ball* *University at Buffalo*
Matthew Wisniewski *U.S. Air Force Research Laboratory, Wright-Patterson Air Force Base, OH*
Nandini Iyer *U.S. Air Force Research Laboratory, Wright-Patterson Air Force Base, OH*
Brian Simpson *U.S. Air Force Research Laboratory, Wright-Patterson Air Force Base, OH*

Change deafness has been found to occur with alterations to object identities and the location of objects within an auditory scene. Electrophysiological correlates of change deafness for object identity exist in the auditory ERP. We aimed to test whether there were ERP differences between: 1) types of scene changes (ID vs. Space change), and 2) levels of accuracy (correct change was detected, vs. incorrect change (subject indicated a change, but incorrectly labeled change type), vs. change deaf (subject did not detect any change)). Within a trial, listeners were presented with two consecutive auditory scenes. Each was composed of four common environmental sounds played simultaneously at separate azimuths of -45°, -10°, 10°, and 45°. The second scene was either identical to the first (same), had one sound replaced with another (ID change), or contained the same sounds but at different locations (Space change). Accuracy was similar for ID and Space change trials (~60% correct). In the ERP, P3 amplitudes locked to the onset of the second scene were larger for correct trials than incorrect trials when a change was present. This was the case for both ID and Space change trials. Further, after breaking up trials into different response categories, it was found that P3 amplitude decreased from correct change, to incorrect change, to change deaf trials. These data indicate that P3 amplitude is a reliable indicator of successful change detection across different types of scene changes. Further, it reflects degrees of change detection accuracy.

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11:20

Pairing near-threshold tones with an irrelevant visual task produces improvement in tone discrimination

Steven R. Holloway *Arizona State University*
José E. Náñez Sr. *Arizona State University*
Gurjot Kaur *Arizona State University*

Previous research shows that pairing a near-threshold dot-motion stimulus with an irrelevant visual task improves the ability to detect dot-motion. The current theory is that when participants are actively concentrating, neuromodulators flood the brain strengthening neurons that are active at that time of the concentration even though they are not related to the task at hand. Currently, this paradigm pairs visual stimuli with a visual training task. Here we show that an auditory signal paired with the visual training task also subtends learning. Twelve participants were pretested to establish initial ability in motion detection and tone discrimination. All participants engaged in eight days of training in which they reported if a specific pair of shapes repeated within a serial presentation of eight distractor pairs of shapes. Six participants were assigned to a tone training condition and had a baseline tone (400Hz) paired with distractor shape pairs and a target tone (402Hz) paired with the pair of shapes that matched the target pair. The other six participants were assigned to a motion training condition and had three directions of motion randomly paired with the distractor shapes with only one direction of motion consistently paired with the target pair of shapes. After the training period, participants were post-tested on their ability for motion detection and tone discrimination. Participants who were trained in the motion condition exhibited improvement in motion detection, $F(9,140)=22.93$, $p<.001$, $\eta 2=0.59$, but not in tone discrimination. Moreover, participants who were trained in the tone condition improved in their ability to discriminate between tones, $F(4, 30)=3.35$, $p<.05$, $\eta 2=.22$, but showed no improvement in motion detection. These findings demonstrate that a visual task irrelevant training paradigm can extend learning beyond the visual sensory system.

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Poster Session (12 noon – 1:20 PM)
West Ballroom BCD (located on Level 1 of the Vancouver Convention Centre West)
Abstracts located on pages 18 –24

Authors of odd-numbered posters are expected to be available from 12:00-12:40pm.
Authors of even-numbered posters are expected to be available from 12:40-1:20pm.

Lunch (1:20 – 2:00 PM)

Invited Address

2:00

Multisensory influences on infant speech perception

Janet F. Werker *The University of British Columbia*

Infants are born with perceptual sensitivities that facilitate processing of speech. These become rapidly attuned during the first months of life as infants become 'experts' at perceiving their native language. With this as background, I will present and discuss recent research examining the extent to which speech perception and its development are influenced by the contribution of perceptual information from different modalities – including visual information in talking faces, sensori-motor information from infants' own oral-motor movements, and even the aero-tactile information that might be felt by infants in close interaction with their caregivers. Questions this research raises for theories of speech perception, and for studying atypical populations will be considered.

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2:30

The relationship between working memory and second language speech reception thresholds in sequential bilingual children

Douglas MacCutcheon* *Högskolan i Gävle*
Florian Pausch *RWTH Aachen University*
Janina Fels *RWTH Aachen University*
Robert Ljung *Högskolan i Gävle*

This study considers whether or not bilingual school children listening and learning in a second language are among those on which higher perceptual processing and cognitive demands are placed when classroom noise is present. Empirical substantiation for this theory would include elevated speech reception thresholds (SRTs) for second language speech in noise, and native or second language-specific correlations between SRTs and cognitive measures such as working memory (WM) or factors such as the age at which the second language was acquired (age of second language acquisition). Forty-four Swedish sequential bilingual children with no sensory or learning deficits took part in this study. Working memory and vocabulary assessments were conducted and language background data were collected. SRTs at 50 % intelligibility were obtained using an adaptive procedure under Language, Spatial and Noise conditions. The target sentence was presented in simulated room acoustics in Swedish and English, masked by either 8-talker babble or speech shaped noise (SSN) with identical long-term average speech spectra, and noise maskers were positioned either directly in front of the listener or spatially separated from the target at 90° azimuth to either side. Main effects in the Spatial and Noise conditions indicated that spatial release from masking favoured spatially separated conditions and a noise release from masking advantage for SSN conditions, indicated by significantly lower thresholds for those conditions. There were no significant interactions with Language. The age of second language acquisition did not significantly predict second language SRTs and was excluded from the regression model. However, WM significantly predicted 21% of the variance in the second language SRTs, and 9% of the variance in native language SRTs. WM predicted more of the variance in second language SRTs than first language SRTs, suggesting that cognition plays more of a role in second language perceptual processes than native language ones.

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2:50

Individual differences in perceptual adaptation to phonetic categories: Categorization gradiency and cognitive abilities

Donghyun Kim* *McGill University*
Meghan Clayards *McGill University*
Eun Jong Kong *Korea Aerospace University*

The present study examines whether listeners flexibly adapt to unfamiliar speech patterns such as those encountered in foreign-accented English vowels. In these cases, the relative informativity of acoustic dimensions (spectral quality vs. duration) can be changed such that the most informative dimension (spectral quality) is no longer informative, but the role of the secondary cue (duration) is enhanced. This study further tests whether listeners' adaptive strategies are related to individual differences in utilizations of secondary cues (measured by phoneme categorization gradiency) and cognitive abilities. Native English listeners (N=36) listened to continuum of vowels /ɛ/ and /æ/ (as in head and had) varying spectral and duration values to complete a perceptual adaptation task, a visual analogue scaling (VAS) task, and were given cognitive ability tasks measuring inhibitory control, working memory, cognitive flexibility, and sustained attention. Our results showed that listeners mostly used spectral quality (primary cue) to signal vowel category at baseline. However, they rapidly adapted to unfamiliar speech by up-weighting reliance on duration (secondary cue) when spectral quality was no longer informative. The VAS task showed substantial individual differences in categorization gradiency with more gradient listeners using a secondary cue more, but categorization gradiency was not linked to degree of adaptation. Finally, results of cognitive ability tasks revealed that individual differences in inhibitory control, but not the other cognitive abilities, correlated with the amount of perceptual adaptation. Our presentation will discuss how these processing strategies are integrated to broaden our understanding of cognitive mechanisms in speech processing and language learning.

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3:10

What am I saying? Exploring the perception-production loop in children's speech

Sarah C. Creel *University of California, San Diego*

Young children know a lot about the sounds of their language by the preschool years. They perceive speech sound categories globally similarly to adult speakers, and can detect minute mispronunciations of familiar words. Yet they also make numerous speech errors, e.g. saying rabbit more like "wabbit" or block like "bock." This presents a puzzle: If children know what sounds are correct, why can't they produce them? One possibility is that children must work for several years to develop the motor patterns to match their auditory representations. Another possibility is that, in addition to producing motor errors, they begin to learn their own erroneous productions as additional perceptual representations, which then supervise motor pattern learning. I describe a new experimental paradigm that allows sensitive examination of children's comprehension of their own productions. Each child (N=17, ages 3-5 years) and a control adult named a series of familiar pictures. Then we rapidly edited sound files to crop out silences and equate loudness. Finally, children viewed four pictures at a time as they heard a recorded label (theirs or the adult's), and attempted to choose the named picture. We tracked eye movements to pictures as a measure of comprehension speed, and points to pictures as a measure of accuracy. Recognition speed was significantly slower for self-speech than adult speech (p=.009), consistent with children producing words with greater motor error than adults. Still, children were only slightly less accurate at comprehending themselves (94% accuracy) than adult speakers (98% accuracy, p=.07), despite some substantial misarticulations. This high accuracy level is consistent with maintenance of self-speech (or child-speech) representations, though further work is needed to draw strong conclusions. Findings have implications for theories of speech production and perception-production interactions, as well as for child speech sound disorders.

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3:30

The perception of operational sex ratios by voice

John Neuhoff* *The College of Wooster*

Adult sex ratios (the ratio of males to female) are linked to a wide variety of reproductive behaviors in humans and other animals. When sex ratios are biased, the more numerous sex faces increased competition for mates and is more likely to yield to the sociosexual preferences of the less numerous sex. Despite widespread evidence of the relationship between sex ratios and behavior, we know little about whether or how sex ratios are encoded and perceived. In two experiments men and women showed perceived sex ratios that correlated with actual sex ratios after 1500 ms exposures to groups of simultaneous voices. However, men perceived more female voices than women did, and women perceived more male voices than men did. Women showed better accuracy than men, but only when sex ratios departed markedly from 50%. Increasing the number of simultaneous voices reduced accuracy, but only at extreme sex ratios. Talker age also significantly affected perceived sex ratios, suggesting that perceived operational sex ratios are adaptively linked to the reproductive viability of the local population. The results suggest that listeners automatically encode vocal sex ratio information and that perceived sex ratios are influenced by characteristics of the local population and characteristics of the listener.

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3:50	**Break (20 mins)**

4:10

The influence of grouping and tempo on subjective metricization

Ève Poudrier* *University of British Columbia*

The parsing of sequences of undifferentiated auditory signals in a wide range of tempi in groups of 2, 3, or 4 qualitatively distinct elements is one of the earliest phenomenon to have been investigated experimentally (e.g., Bolton 1894, Harrell 1937, Woodrow 1909). The present study aimed to replicate and extend these findings through online experimentation using a spontaneous grouping paradigm. The specific design was motivated by limitations of earlier studies, including response biases created by demand characteristics. Three variables were tested: Rate (interonset intervals = 200, 550, or 950 ms), Grouping (none, duple, triple), and Accent (intensity, duration, pitch). Grouping Response (GR) was defined as 1 to 12 elements per group. In undifferentiated sequences, participants' grouping percepts (N = 4,194) were asymmetrical and tempo-dependent, with GR 1 (no grouping) and GR 4 being most frequent at the slowest and fastest rate, respectively. Linear mixed-effects modeling of group length data with participant (N = 140) treated as random effect factor showed that when every second or third element was differentiated, slower rates, triple grouping and intensity accents resulted in the largest increases in group length. Most interestingly, while duple and triple grouping generally yielded responses consistent with metric types that were purely duple (GR 2, 4 and 8) or triple (GR 3 and 9), triple grouping yielded responses consistent with mixed metric types (GR 6, 10 and 12) more frequently than duple grouping. Multinomial logistic regression modeling of metric type data confirmed that when the grouping is changed from duple to triple, the probability of observing mixed metric types increases, especially at the fastest rate. This finding suggests that lower-level triple grouping gives rise to binary preference at higher levels (3 x 2 and 3 x 4), an interpretation that is consistent with the observed low frequency of GR 9.

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4:30

Central and peripheral processing of spectral temporal order judgment

Leah Fostick* *Ariel University*
Noam Madmon *Ariel University*
Tamar Ishay *Ariel University*
Harvey Babkoff *Bar-Ilan University*

Auditory spectral and spatial TOJ are both considered measures of temporal order judgment (TOJ), in which the individual is required to report the order of two short tones, presented rapidly. In spectral TOJ, the tones differ by frequency ("high" and "low") and are delivered either to one ear or to both ears, synchronously. In spatial TOJ, two equal frequency tones are delivered asynchronously to the two ears ("left" and "right"). This difference in presentation might trigger different mechanisms of processing. Indeed, meta-analysis of over 20 studies has shown a large difference in threshold distribution between spectral and spatial TOJ. A large number of participants (49% of 190 participants) were able to judge the order of the tones in the spectral TOJ paradigm with a very short (<20msec) stimulus-onset-asynchrony (SOA), while only few (4% of 222 participants) were able to do so in the spatial TOJ paradigm. In the current study, spectral and spatial TOJ were presented in the same manner: asynchronous presentation to different ears of two tones that differ in frequency. For the spectral TOJ, participants were asked to judge the order of frequencies and ignore the ear receiving the tones. For spatial TOJ, participants were asked to judge the order of the ears receiving the tones and ignore their frequencies. Thirty participants were tested in a within-subjects design. As hypothesized, the asynchronous presentation of spectral TOJ resulted in a much-reduced number of participants (20% of 30 participants) capable of discriminating the order of the two tones with SOA<20msec. The threshold distribution of spatial TOJ with different frequencies did not change. These results suggest that spectral and spatial TOJ reflect different mechanisms of temporal order judgment. Spectral TOJ that involves synchronous presentation might allow for interactions at the periphery which provide additional cues for the judgment of order.

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4:45

Spectral temporal order judgment (TOJ) thresholds along the frequency spectrum

Harvey Babkoff *Bar-Ilan University*
Ortal Burda *Ariel University*
Hadar Hassid *Ariel University*
Leah Fostick* *Ariel University*

Spectral temporal order judgment (TOJ) is a widely used test for measuring auditory temporal processing and usually involves the judgment of the order of two tones of different frequencies. In a meta-analysis of 13 spectral TOJ studies, we reported that 49% of the participants had very short TOJ thresholds (stimulus-onset-asynchrony (SOA) shorter than 20 msec). These results implied that participants were able to use other cues based on the differences in frequency between the two tones in addition to directly judging the temporal order of the two tones. The current study was designed to test this hypothesis by manipulating the location of the two tones along the frequency spectrum. The study included 11 groups of 25 participants each, who judged spectral temporal order of pairs of tones, one-octave apart. Each group judged the spectral temporal order of two tones at different locations along the frequency spectrum. The midpoints of the 11 frequency pairs were: 283, 424, 566, 707, 1061, 1414, 2121, 2828, 3536, 3889, and 4243 Hz. When the percent of participants able to succeed in judging temporal order with SOA<20msec is plotted against the midpoint of the tone-pairs, the emerging curve appears to be cosine, increasing with frequency from 283Hz to a max at 1414Hz and decreasing to a min at 4243Hz. Apparently, it is easiest to judge the temporal order of two tones, differing by one octave, (even when SOA<20Msec), when their midpoint is between 1000-2000Hz. The relevance of these results to an identification of the cues available when performing spectral TOJ will be discussed.

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5:00 **Updates & Closing Remarks**

Poster session (12 noon – 1:20 PM)
West Ballroom BCD (located on Level 1)

Authors of odd-numbered posters are expected to be available from 12:00-12:40pm.
Authors of even-numbered posters are expected to be available from 12:40-1:20pm.

1

Perception of approaching and retreating sounds in a two-dimensional space

Holly Johnston* *Washburn University*
Mike Russell *Washburn University*

Generally speaking, individuals are highly capable of using sound to judge whether an object is in motion. Research involving auditory motion has also focused on the ability of individuals to determine whether a sound is approaching or retreating. That research has revealed that individuals are better able to recognize approaching (looming) sounds. The current theory explaining such findings is that it is more important to our safety to be able to recognize approaching sounds than retreating sounds. It has also been determined that participant sex is a significant factor, in that women showed significantly greater underestimation of time of arrival. While previous research has examined perception of motion across a single dimension, sound-producing objects obviously can move across multiple dimensions simultaneously. The present study examined the ability of individuals to judge the direction of motion across two dimensions. In addition to assessing whether a sound is approaching or retreating, participants were also required to determine if a sound-producing object was moving up or down. The sounds were footsteps on stairs. The first experiment assessed the ability of participants to determine motion direction: towards/ away and up/down. The second experiment assessed the extent to which perceptual accuracy differed between men and women. Discussion will be given to the overall ability of participants to correctly judge motion direction, differences in perceptual accuracy across dimensions, as well as to sex difference in perceiving motion using sound. Consideration will also be given to the extent to which information about motion in one dimension enhances our ability to perceive motion in another dimension.

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2

Motion in a 2-dimensional space: Do we really only live in and perceive a 1-dimensional world?

Mike Russell *Washburn University*
Holly Johnston* *Washburn University*
Stephanie Brown *Washburn University*

Research has repeatedly shown that individuals can use sound to perceive motion. It has also been shown that individuals are able to correctly determine the direction of sound source motion (approaching or withdrawing), though evidence suggests a greater sensitivity to approaching sounds. As would be expected, individuals make use of the change in the signal intensity to determine motion direction (e.g., increasing intensity specifies approach). Empirical evidence also suggests that judgments of motion and motion direction are influenced by acoustic factors such as sound reverberation, overall signal intensity, and the change in signal frequency. One limitation of previous research is that sound source motion was restricted to a single dimension. In natural settings, sound-producing objects can, and often do, move simultaneously across multiple dimensions. The possibility exists (and the argument will be made) that the information influencing judgments of motion in one direction also influences the perceived motion of direction in a second dimension. The present study sought to determine the degree to which various acoustic factors affect reports of motion direction, when a sound-producing object varied in distance and altitude (elevation) in relation to a point of observation. Given the preponderance of evidence suggesting auditory motion perception is intimately tied to signal intensity, the impact of overall signal intensity, rate of signal intensity change, and degree of intensity change were independently examined. The impact of each manipulation and the weight of each factor were determined. Discussion will be given to the extent to which a change in signal acoustics shown to affect judgments of motion in the anterior-posterior plane equally influence judgments of motion in the vertical plane.

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3

Perception of gap passability: Is our perception of the world based on vision or audition?

Stephanie Brown* *Washburn University*
Mike Russell *Washburn University*

Previous research has examined the ability of individuals to visually judge whether a vertical gap affords passage and whether judgments of passability are body-scaled (i.e., based on the relevant dimensions of the perceiver). Interesting enough, recent results suggest that visual judgments of passage are correlated more with perceived body height than actual body height. If we eliminate vision and judgments are based on audition alone, would perception change? The present study was primarily focused on comparing visual and auditory judgments on eye/ear height, total body height, and minimal gap size for passage. Participants used vision or audition to judge target position and participants completed each of three tasks six times in random order for a total of 18 trials. Neither feedback nor practice was provided. Using the data collected, we will determine if individual's visual and auditory perceptions of gap passage can be better understood as a function of actual or perceived eye (vision)/ear (audition) height or total body height. The findings are discussed in relation to the Gibsonian, ecological approach argument that perception is body-scaled and the eye/ear as being the point from which individuals perceive the world.

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4

Semantic activation by auditory distractor speech

Jan Phillip Röer *Heinrich Heine University Düsseldorf*
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Auditory distractor speech disrupts serial recall performance relative to a quiet control condition. In most studies, the semantic content of the auditory distractors had no effect on disruption, one's own name being one of the few exceptions. Two explanations for this finding are possible: (1) Semantic features are usually not processed, except for highly relevant auditory distractor words, or (2) semantic features are routinely processed, but this processing usually does not interfere with serial recall. To test these explanations, we presented auditory distractor words drawn from different categories while participants memorized visual targets for serial recall. Afterwards, we asked the participants to take part in what they believed to be an unrelated norming study, in which they had to spontaneously produce words from the categories from which the auditory distractor words were drawn. Previously ignored words were produced with a higher probability than words from a parallel, nonpresented set, which is evidence for semantic activation by auditory distractor speech. We conclude that distractor features that do not interfere with serial recall performance may nevertheless be processed and this processing may affect subsequent behavior.

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***NOTE: For poster #4, the authors will be unavailable for discussion.

5

Measuring listening effort: Convergent validity, sensitivity, and links with cognitive and personality measures

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Madeleine Merchant *Carleton College*
Hunter Brown *Carleton College*
Julia Smith *Carleton College*

Listening effort (LE) describes the attentional or cognitive requirements for successful speech understanding. Despite substantial theoretical and clinical interest in LE, there has been little psychometric work evaluating the multiple measures that are used to assess LE. The aims of this large-scale validation study were to evaluate the convergent validity and sensitivity of seven LE measures and assess how performance on LE tasks relates to five tests of cognitive ability, two personality traits measuring sensory processing sensitivity, and one audiological measure. Scores on some behavioral LE tasks were moderately intercorrelated, but were generally not correlated with subjective and physiological measures of LE, suggesting that these tasks may not be tapping into the same underlying construct. Measures of LE differed in their sensitivity to changes in signal-to-noise ratio and in the extent to which they correlated with cognitive and personality variables. Taken together, results suggest that people with high cognitive ability can use their resources more efficiently, thereby reducing processing load.

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6

Acoustic differences in native/non-native affective speech production for Chinese learners of English

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Pragmatics are often not explicitly taught in an ESL (English as a Second Language) context and it has been suggested that bilinguals are more affectively expressive in their native language (L1; Anooshin & Hertel, 1994). Extant literature focuses on how learners acquire a second language (L2), but less on understanding how L2 learners produce extra-linguistic cues. The current study adds to a growing body of literature evaluating the interaction between emotion and language (e.g., Pavlenko, 2005). In the current study, we sought to evaluate how Chinese ESL learners (n = 17), residing in the United States, expressed vocal prosody in both their L1 and L2. Fluent and non-fluent ESL learners were asked to affectively produce emotionally valenced words (positive v. negative) in both their native and non-native languages. A MANOVA was used to evaluate acoustic differences in f0, amplitude, and duration as a function of language fluency (fluent vs. non-fluent), spoken language (Chinese vs. English), and vocal affective prosody (positive vs. negative). The results indicated that each of the acoustic variables differed on at least one level of language fluency, language spoken, or vocal affect (duration: $F(7, 791) = 3.696$, $p < .001$, $R2 = .03$; amplitude: $F(7, 791) = 8.951$, $p < .001$, $R2 = .07$; and f0: $F(7, 791) = 14.240$, $p < .001$, $R2 = .11$). Though the effect sizes are small, likely due to other factors contributing to the acoustic variation accounted for here, there were significant main effects and interactions. Further evaluation of these effects indicated that non-fluent ESL learners may have dampened their affective cues, relative to fluent speakers (e.g., producing shorter speaking durations, lower amplitudes, and lower average f0, all ps < .05, at least). This suggests that non-fluent speakers may not as easily represent pragmatic information in the vocal channel in a second language.

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7

Encoding acoustic cues in speech: Electrophysiological measurements

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Early studies of speech perception argued that fine-grained differences between phonetic cues were discarded by the perceptual system, but recent evidence has refuted this claim. Behavioral work shows that listeners are sensitive to within-category phonetic differences, and that listeners activate graded lexical representations as a function of differences in fine-grained acoustic cues. Moreover, ERP findings examining consonant voicing have shown that differences along a specific acoustic dimension (voice onset time; VOT) are tracked by the auditory N1 ERP component, suggesting that the N1 provides a measure of how listeners encode this cue. The present study aims to determine whether the N1 can serve as a more general index of cue encoding, providing a tool for measuring listeners' perception of fine-grained acoustic differences. Specifically, we examined ERP responses to a wide range of phonetic contrasts, focusing particularly on voicing and place of articulation distinctions for different classes of speech sounds. Listeners were presented with naturally-produced speech sounds spanning 18 consonants (/b,ʧ,d,f,g,ʤ,k,l,m,n,p,r,s,ʃ,t,v,w,z/). Results show larger N1 responses for voiced consonants than voiceless consonants, replicating and extending previous ERP findings. Thus, N1 may be indexing the degree of low-frequency voicing energy that occurs consistently cross consonants with different manners of articulation. Moreover, we found that the N1 also varies as a function of place of articulation, which is signaled by different acoustic cues. In particular, differences in stop consonant place suggest an encoding based on acoustic differences in burst frequency (/p/ → /k/ → /t/) rather than articulatory features. Together, these results suggest that the N1 can serve as a general index of cue encoding at early stages of auditory perception across a wide range of speech distinctions.

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8

Crossmodal effect of irrelevant auditory stimuli on saccadic eye movement behavior

Cailey Salagovic* *University of Colorado Denver*
Carly J. Leonard *University of Colorado Denver*

While it is well-established that current goals and visually salient events direct eye movements, the role that auditory stimuli play in the guidance of visual attention is less understood. The present study examined this crossmodal attentional behavior by tracking eye movements as participants complete a dynamic search task. Specifically, we further examined the "pip-and-pop" effect, a phenomenon wherein an uninformative sound that is synchronized with a target color change event leads participants to locate the target faster than when no sound accompanies the color change (Van der Burg, Olivers, Bronkhorst & Theeuwes, 2008). Zou, Muller & Shi (2017) suggested that these non-spatial sounds may speed target acquisition by triggering a pause in eye movements, allowing for extended information sampling. Our current study investigates how the nature of the auditory stimulus may modify this crossmodal effect, and also further examines the changes in eye movement patterns. Overall, the results indicate both faster reaction time and fewer fixations in search trials with sound events than trials with no sound. No significant difference in these measures was found between a simple, pure tone auditory stimulus and a more complex, frequency modulated auditory stimulus. This finding may suggest that the general presence of non-spatial sound in an environment affects the deployment of visual attention but that sound complexity does not further modulate this effect. Additional study is planned to evaluate how other qualities of auditory stimuli, such as sound novelty, affect visual attention. Such inquiry is important for building an understanding of how attentional behavior functions in response to the multisensory environments of the natural world.

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9

Post-categorical auditory distraction in serial short-term memory: Insights from increased task load and task type

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Pamela Qualter *University of Manchester*
Cassandra Richardson *University of Central Lancashire*
Nick Perham *Cardiff Metropolitan University*
François Vachon *Universitie Laval*
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Task-irrelevant speech disrupts short-term serial recall of visual items appreciably. According to the interference-by-process account, the processing of pre-categorical (physical) changes in sound (e.g., speech) gives rise to order cues that conflict with the serial rehearsal process used to perform the serial recall task. Therefore, on this view, post-categorical properties (e.g., phonology, meaning) should be impotent in their capacity to disrupt short-term memory. This study reassessed the implications of recent demonstrations of auditory post-categorical distraction in serial recall that have been taken as support for an alternative, attentional-diversion, account of the irrelevant speech effect. Focusing on the disruptive effect of emotionally valent compared to neutral words on serial recall, it is shown that the distracter-valence effect is eliminated under conditions—high task-encoding load—thought to shield against attentional diversion (Experiment 1). Furthermore, the distracter-valence effect generalizes to a task that does not require the processing of serial order—the missing-item task (Experiment 2). The implication of the study is that post-categorical auditory distraction phenomena in serial short-term memory are incidental: they are observable in such a setting but, unlike the acoustically driven irrelevant speech effect, are not integral to it. As such, the findings support a duplex-mechanism account over a unitary view of auditory distraction.

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10

Schematic and veridical information in the detection of wrong notes in melodies

W. Jay Dowling* *The University of Texas at Dallas*
Rachna Raman *The University of Texas at Dallas*

Both schematic and veridical knowledge must be involved in detecting wrong notes in familiar melodies. Dowling (1976) proposed that veridical knowledge of melodic contour is combined with schematic knowledge of the tonal scale (tonal hierarchy) in forming a memory representation which can serve in recognition or recall. Previous studies found that deviations from the scale are recognized quickly and accurately as wrong notes. Here we varied familiarity of the melodies, varying the accessibility of veridical information, whereas schematic information (the scale) remained constant. We presented listeners with 8 highly familiar melodies (the most familiar of a set of 32 that were rated familiar), 24 moderately familiar melodies (that remained from the 32), and 32 completely unfamiliar melodies, all European folksongs. Listeners were musically untrained, minimally trained (1-4 yr music lessons), or moderately trained (>5 yr), and served in one of two groups: One group heard highly and moderately familiar melodies, and the other heard the unfamiliar. Each session had 64 trials, in which each melody appeared twice, with different wrong notes. The wrong notes were either 1 or 2 ST from the original pitch, and in-key or not. We measured the proportion of correct detections and response times. More experienced listeners detected wrong notes better in the familiar melodies, and their responses were faster. Out-of-key wrong notes were detected faster and more accurately, as were alterations moved 2 ST, and out-of-key notes at 2 ST were detected fastest and most accurately of all, with the opposite effect for in-key notes 1 ST from the target. That result was even more pronounced with highly familiar melodies. Detection was much harder with unfamiliar melodies, where veridical information was eliminated. But there key membership determined speed and accuracy, and listeners were again particularly successful with out-of-key notes 2 ST from targets.

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Intonation error perception and correction in a cello performance context

Sally Norris* *Western University*

Participation in and experience of music involves a complex interaction of the auditory and motor systems. While a musician's production and fluency relies on congruency between expected and actual auditory feedback (Pfordresher, 2006), few studies address the extent to which musicians correct, or recover, from unexpected pitch errors in a realistic performance context. The extent to which auditory-motor integration gives a perceptual advantage compared to listening-only conditions can also be investigated in this context. String instruments are useful for studying corrections in the pitch domain because they make use of continuous rather than discrete tuning systems. To this end, expert cello players, defined through self-report and the Ollen Musical Sophistication Index (Ollen, 2006), heard pitch-perturbed feedback (PPF) while performing or listening to typical scalar passages. During performance trials, PPF was heard either unaccompanied or with a pitch-accurate play-a-long track. Motor adjustments to correct errors heard in PPF were extracted by frequency-tracking the (unperturbed) played sound. Correction latency and magnitude were determined by fitting a piece-wise linear regression to the recorded frequency. During listening trials, cellists heard similarly pitch-perturbed scalar passages unaccompanied or with a pitch-accurate accompaniment. They were asked to indicate a perceived pitch-error by a toggle switch toward "sharp" (error was higher than the expected pitch) or "flat" (error was lower than the expected pitch). Results suggest that sensitivity to errors in auditory feedback is higher in conditions with active auditory motor integration compared to listening-only conditions. Motor responses in performance trials were differentiated in magnitude corresponding to the size and direction of the perturbation within 400ms. Error detection in listening-only conditions where dependent on the onset of the subsequent pitches and did not accurately reflect the direction of the perturbation.

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12

Three models of sound localization

Justin MacDonald* *New Mexico State University*

In this poster I present three predictive models of single source sound localization that vary in the plausibility of their assumptions. Model performance in this task was evaluated using binaural recordings of directional stimuli embedded in background noise. The first model corresponds to the idealized situation in which the listener is familiar with both the to-be-localized (TBL) sound as well as the acoustic properties of their head, pinnae, and torso. The model was given noise-free nondirectional templates of the to-be-localized (TBL) stimuli, as well as exact knowledge of the Head-Related Transfer Functions (HRTFs) of the acoustic dummy used to record the TBL sounds. This comprehensive knowledge effectively allows the model access to near-perfect templates of all TBL sounds spatialized in all potential locations. The second model corresponds to the situation in which the listener is trying to localize an unfamiliar sound but is still familiar with their own head, pinnae, and torso effects. In this case, the model was given no information about the TBL stimuli, but was given exact knowledge of the HRTFs of the acoustic dummy used to record the TBL sounds. Finally, the third model corresponds to the situation in which the listener is localizing unfamiliar sounds using imperfect knowledge of the HRTFs used to spatialize the stimuli. This situation occurs when trying to localize sounds while wearing a helmet, or when using a spatial audio interface based on generalized HRTFs. The third model localized stimuli using a set of HRTFs that are not those of the acoustic dummy used to record the TBL stimuli. The models were compared to human data to assess their ability to predict well-established patterns of localization performance.

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Healthy hearing attitudes and behaviors among college students

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Julia Ristau *George Fox University*

Approximately 15% of adults aged 18 or older experience some trouble hearing (Blackwell, Lucas, and Clarke, 2012). Although the likelihood of hearing loss increases with age, the NIDCD reports that 1 in 2 young adults listen to music or audio too loudly and 2 in 5 are exposed to harmfully loud noises. Furthermore, an estimated 10% of adults have experienced at least five minutes of tinnitus within the last year. Unfortunately knowledge about hearing loss does not necessarily lead to behavior change. Marron et al. (2015) found that 1 in 4 college students listened to music at levels exceeding 80 dB despite having knowledge about the risks associated with such volume levels. Since hearing damage is irreversible, it is important to examine the attitudes and behaviors of young adults toward hearing to determine the role health psychology may play in preventing hearing loss. The present study explored attitudes and behaviors toward hearing health among college students. Nearly 75% of students reported attending concerts, 89% reported attending sporting events, 98% watched movies in theaters, with 9% doing so weekly, and 60% worked with loud machines or tools. Twenty-eight percent reported feeling that they had hearing loss and 38% indicated that a family member or friend felt that they (respondents) have hearing loss. Over 66% experienced some degree of tinnitus within the last year. Nevertheless, 92% of respondents reported that they did not try to reduce their exposure to noise over the last six months. The majority did not wear hearing protection even when working with loud tools. However, they were slightly more likely to limit their length of exposure to load noises or increase their distance from the source. Respondents also indicated that they were more concerned about hearing loss from entertainment venues than from work environments.

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Perceptual interference in the localization of simulated sounds of small arms fire

Jeremy Gaston *US Army Research Laboratory*
Kelly Dickerson *US Army Research Laboratory*
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Tim Mermagen *US Army Research Laboratory*
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In real-world sound environments, integration of events distributed across space and time can lead to significant interference in perceptual decisions. Small-arms fire is a complex real-world sound source that produces two distinct impulse sounds: (1) the muzzle blast produced by escaping hot gases from the weapon's barrel, and (2) a ballistic shockwave shed by the supersonic bullet in flight. Based on the relative positions of the shooter and an observer there can be significant spatial-temporal variance in the resulting acoustical relationships. In the present study, a physical model of gunfire propagation is implemented to create sets of simulated small-arms impulse stimuli that mimic these relationships. These stimulus sets are used to examine potential perceptual interference between competing impulse events as a function of temporal delay, spatial offset and relative amplitude offset. Using a 180 loudspeaker array in a hemi-anechoic chamber, target impulse sounds were presented at positions ranging from +/- 60° in the presence of an impulse sound competitor; listeners were instructed to localize to the target and ignore the competitor. The results showed significant increases in localization error as a function of the spatial offset and temporal delay between impulse events. The amplitude manipulation resulted in the least amount of error. These results indicate significant perceptual interference; bias in the localization decision towards the competitor sound suggests integration of the competing impulse events.

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