

Exploiting Coloured Hearing for Research on Acoustic Perception

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Coloured Hearing

- Synaesthesia: “Stimulation of one sensory or cognitive pathway leads to automatic, involuntary experiences in a second sensory or cognitive pathway” – Wikipedia
- Coloured Hearing: Acoustic stimulation leads to visual experiences
- Genuine form
 - Origins very early in life (“congenital”)
 - Does not change over time
 - Not “acquired” (i.e. not trained)
 - Not “induced” (e.g. by chemicals)

Research Idea

- Seek many individuals with coloured hearing
- Find aural-visual correlations common to many individuals
- Assumption: correlation represents congenital acoustic recognition skill given to many individuals
 - learn about border between congenital perception and culturally influenced perception habits
- Knowledge on congenital acoustic recognition skills important for
 - Contemporary composition techniques
 - Synthesizer design
 - AUI design (AUI = Aural User Interface)

Status

- Conducted a preparatory study
 - Developed a set of test sounds
 - Conducted study on *single* coloured hearing individual
 - Learned lessons about suitability of test sounds
 - Learned lessons about way to present test sounds
- To do
 - Develop & conduct revised study on *multiple* coloured hearing individuals

Set of Test Sounds

- Produced CD with 88 audio tracks
- Each track 3-12 seconds
- Tracks grouped in series that change a single or at most two acoustic parameters
- No questionnaire with check boxes or selection options
- Instead, instruction to describe visuals in at most two short sentences per track
- Leave option to alternatively describe difference between two adjacent tracks
- Instruction to use headphones (for stereo effects)

Acoustic Parameters: Frequency (pitch)

- Diatonic & chromatic intervals
- Consonant / dissonant intervals
- Irrational intervals
- Micro-tonal intervals, beats
- Ultrasonic frequencies
- Single pitches
- Sequence of pitches (melody)
- Simultaneous pitches (diatonic chords, disharmonic spectra)
- Different frequencies on left / right ear
- Vibrato

Acoustic Parameters: Sound / Noise

- Sine, square, triangle
- Variation of duty cycle
 - square → pulse
 - triangle → sawtooth
- Additive forms (overtone series) with fading out overtone by overtone (thus ending with sine)
- Different wave forms on left / right ear
- Added noise content
 - Left ear only / right ear only / both ears
- White noise / coloured noise

Acoustic Parameters: Loudness, Balance & Phase

- Increasing / decreasing phase of individual partials of additive sounds on *both* ears
- Increasing / decreasing phase shift between left and right ear
- Loudness difference between left and right ear

Rhythms

- Simple periodic patterns of noises (e.g. clicks) with emphasis on selected noises

Lessons Learned: Sound Media

- Alsa player, Audacity and others: Severe rendering problems on re-sampling (44.1kHz wave file on 48 kHz sound card), while e.g. mplayer is fine
 - can hear beats (difference tone) of ultrasonic pitches!
- Should provide CD + CD player + headphones for controlled & reproducible environment
- Rendering problem could also be an issue of the synthesizer engine that creates the test sounds (e.g. sharp edge of sawtooth at certain frequencies interfering with sample rate)

Lessons Learned: Questionnaire

- No questionnaire with check marks in preparatory study
- Pros
 - Get more information, as not restricted to pre-formulated choices
- Cons
 - Had to ask for more information in second round, as provided answers sometimes were not essential

Lessons Learned: Order of Sounds

- Grouped into series of sounds that vary single or two acoustic parameters
- Pros:
 - Get clearer answers about changes between adjacent sounds
- Cons:
 - In cyclic series (i.e. first sound = last sound), last sound was described differently; direct comparison: no more difference

Lessons Learned: Loudness of Sounds

- Major differences in loudness due to construction of test sounds
- Results partially vague, as loudness influenced brightness / saturation for tested person
- When compiling test CD, ensure loudness varies within small range (except where explicitly testing impact of loudness)

Lessons Learned: Need More Test Sounds

- For tested individual person, only few correlations could be found
 - Loudness – Brightness / Saturation
 - Wave form – ???
 - Phase / Balance – Geometric properties
- Obviously need more test sounds for evaluation

Conclusion

- Many lessons learned in preparatory study
- Next step: develop & prepare actual study
- Any volunteers interested to join into conducting this study?