How audio and visual cues combine to discriminate the tempo of swing groove drumming

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Scott Love[1], James M. Hillis[1], Carl Waadeland[2], Davide Rocchesso[3], Federico Avanzini[4], Sofia Dahl[5], Frank E. Pollick[1]

[1]Department of Psychology, University of Glasgow; [2]Department of Music, Norwegian University of Science and Technology; [3]Department of Computer Science, University of Verona; [4]Department of Information Engineering, University of Padova; [5]Cognitive and Systematic Musicology Lab , School of Music , Ohio State University

s.love@psy.gla.ac.uk

http://paco.psy.gla.ac.uk/

Introduction

• Studies show that when multiple sources of sensory information about a single environmental property are available, more precise estimates of that property can be formed by combining the different sources.

• For physical dimensions such as object size (Ernst & Banks, 2002), surface slant (Knill & Saunders, 2003) and object location (Alais & Burr, 2004), studies show that humans integrate different sensory sources in a statistically optimal fashion.

• According to these models, to maximize the precision of the combined estimate, each cue must be weighted in proportion to its reliability.

• **We investigated the integration of auditory and visual cues for a more complex physical property: beat tempo.**

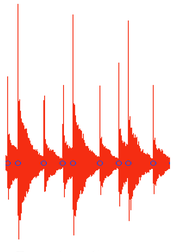
Stimulus Production

• Stimuli were created from 3D motion capture data (240Hz) of a drummer who was asked to perform swing groove drumming at 90BPM.

• This movement data was converted into a visual point-light display (60Hz) with points at the shoulder, elbow, wrist, hand and two drumstick points.

• Sounds were obtained by simulation of the first 25 modes of a circular membrane (Rocchesso & Avanzini, 2004). Parameters for the sound model were the physical parameters of the membrane and the time and impact velocity of a strike taken from the motion capture data.

• To create a standard stimulus a segment containing 9 drum impacts was chosen and found to be 97BPM . Comparison stimuli were created by multiplying the time of impact and total duration to produce 6 tempi above and 6 below the standard in 2BPM increments.



Example audio-wave

References:

Alais, D & Burr, D (2004). The ventriloquist effect results in near-optimal bimodal integration. *Current Biology 14*(3) p257-262.

Ernst, M.O. & Banks, M.S. (2002). Humans integrate visual and haptic information in a statistically optimal fashion. *Nature, 415,* 429-433

Knill, D.C. & Saunders (2003). Do humans optimally integrate stereo and texture information for judgments of surface slant? *Vision Research, 43,* 2539-2558.

Rocchesso, D. & Avanzini, F. (2004) Computation of Nonlinear Filter Networks Containing Delay-Free Paths. *Proceedings of the 7th Int. Conference on Digital Audio Effects (DAFx '04)* 113-118

Methods

• 3 conditions: Audio-alone(A), Visual-alone(V), Audio-Visual(AV).

• 2IFC design with a random trial-by-trial allocation of which interval contained the standard stimulus.

• 7 novices and 1 expert drummer completed 2 one hour sessions on different days. Each session contained 3 blocks, one for each condition with 10 repetitions of each standard/comparison pair (e.g. 97 vs 85BPM).

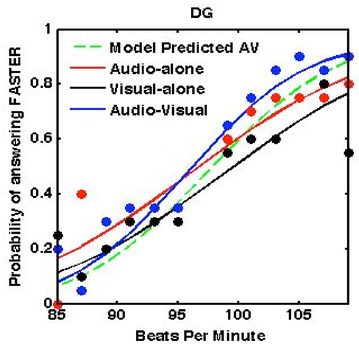
• 240 trials per person, 20 trials per data point.

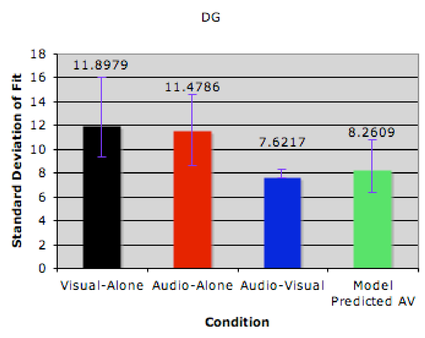
• Participants were asked to indicate which of the two intervals contained the faster drumming tempo.

• The model predicted fits are based on Ernst & Banks (2002).

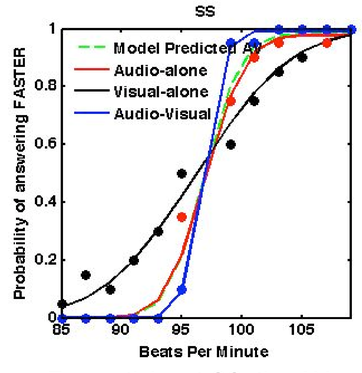
Examples of Novice Results

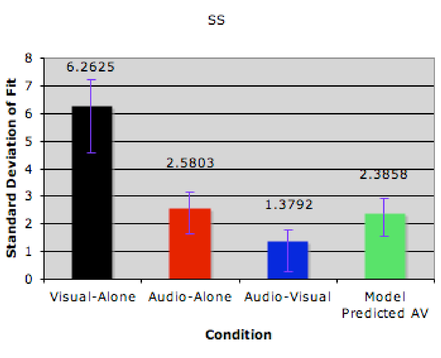
• Standard deviations are taken from the best fitting cumulative gaussian functions, with lower standard deviations indicating better performance.





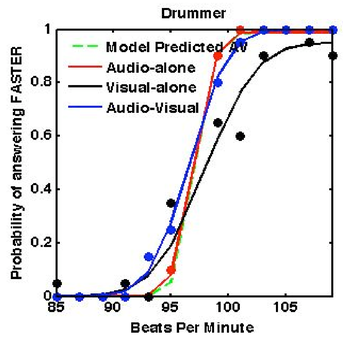
• For participant DG, the AV confidence intervals only overlap with the model predicted confidence intervals.

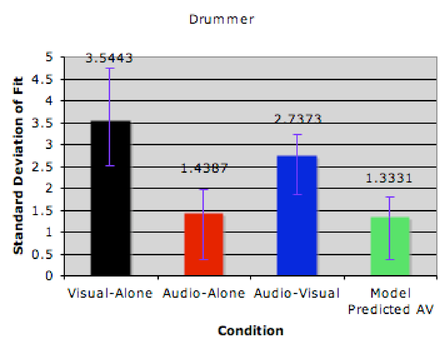




• For participant SS, the AV confidence intervals overlap with both the A and model predicted confidence intervals.

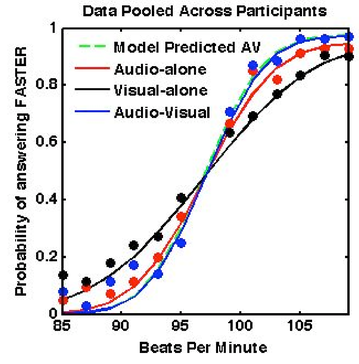
Drummer Results

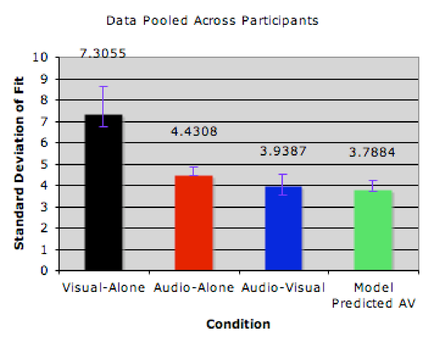




• For the drummer, the AV confidence intervals overlap with both the V and A confidence intervals but not the model predicted confidence intervals.

Average Novice Results





• On average, the AV confidence intervals overlap with both the A and model predicted confidence intervals.

Conclusions

• There are considerable individual differences in performance on each condition of the task and on the relationship between observed and model predicted results on the AV condition.

• On average combined AV standard deviations are within the model predicted standard deviations.

• However, it is not possible to draw strong conclusions as to whether the cues are being combined in a statistically optimal manner because it is still possible that only the most reliable single cue is being utilised.