A new method for estimating Internal Drift and Just Noticeable Difference in perception of continuous tempo drift.

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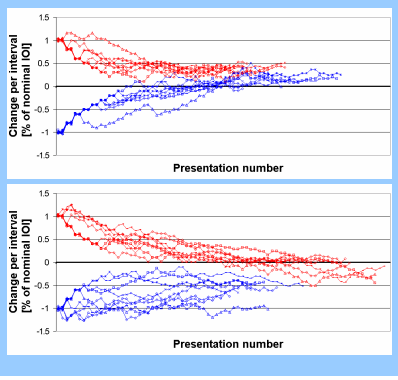
1. AIM

•How small tempo drifts are perceivable?
•Is there such a thing as an internal representation of a "steady tempo"?
•Is this representation itself free from tempo drift?
To investigate this we propose a new method for studying detection of continuous tempo drift.

2. METHOD

The method uses a modification of **Parameter Estimation by Sequential Testing (PEST)**. Two correct responses in a row were required to assume that the response was correct. Thus the tempo drift converged towards **the 75% correct responses level**.
Each session consist of several series running in parallel. **Each series is designated** as either **'increasing'** or **'decreasing'.** Because of the designation, the correct response to **a series designated 'decreasing', is always "decreasing"** – also when the physical drift is increasing. Thus, the physical drift of a series can shift sign and cross the zero-line as **the response curves converge around a *perceived* isochronous tempo.**
The average endpoints across the 'increasing' and 'decreasing' series respectively, give a span of non-discriminable drift. This span was interpreted as twice the **Just Noticeable Difference (JND),** centred around an internal reference; the **internal drift**.



The response series for two subjects:

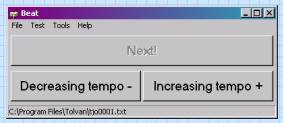
Subject AA (top) has an ID corresponding to a decreasing tempo and a small JND.

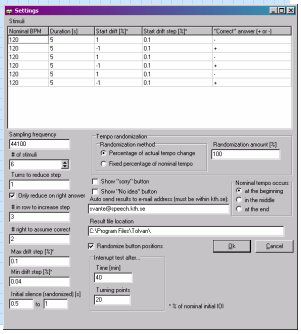
Subject GS (bottom) has an ID corresponding to a increasing tempo and a larger JND.

•**Physical drift:** The actual drift generated by the computer program by adding or subtracting time to each interval.
•**Perceived drift:** The subject's perception of the drift. Neither the amount or direction of this drift need to be the same as the physical drift.

3. EXPERIMENT

Seven subjects each did **three listenening sessions of 40 minutes** each. Each session consisted of six parallel series; **three designated 'increasing'** and **three designated 'decreasing'**. The nominal start tempo had a beat separation of 500 ms (120 beats/minute).

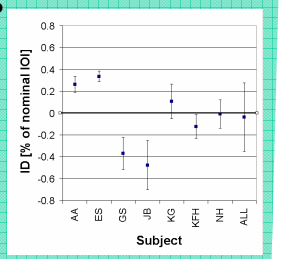




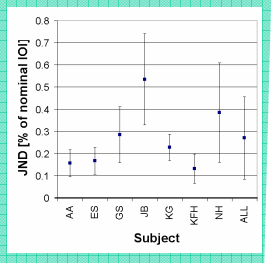
•Maximum amount of change: 0.1 % of initial (nominal) Inter-onset interval.
•Minimum amount of change: 0.04 % of initial (nominal) Inter-onset interval.
•Intial silence with a randomised duration 0.5 to 1 s.
•Number of intervals per presentation: 10 (~5 s).
•Initial tempo slightly randomised.

4. ANALYSIS AND RESULTS

The **internal drift differs significantly between subjects,** but each subject is consistent. There were **no significant differences between sessions** for any of the subjects.



Mean JND across the seven subjects was **0.27 %** of nominal IOI, corresponding to a change of **1.35 ms per interval**.



5. CONCLUSION

The found values for JND are small when comparing to previously reported estimates (e.g. Drake and Botte 1993, Madison 2001). However, our results correspond to measured production data from drummers (Dahl 2000, Madison 2001).
The method appears to be successful in estimating the internal drift (ID). This ID was consistent within subjects, but differed between subjects.

REFERENCES:

•Dahl, S. (2000), The Playing of an Accent – Preliminary Observations from Temporal and Kinematic Analysis of percussionists. *Journal of New Music Research*, 29(3), pp. 225-234.
•Drake, C. and Botte, M-C. (1993), Tempo sensitivity in auditory sequences: Evidence for a multiple-look model. *Perception & Psychophysics*, 54(3), pp. 277-283.
•Madison, G. (2001) Functional Modelling of the Human Timing Mechanism. Published doctoral dissertation, Uppsala University, Sweden.