

IS THE PLAYER MORE INFLUENCED BY THE AUDITORY THAN THE TACTILE FEEDBACK FROM THE INSTRUMENT?

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ABSTRACT

What sensory feedback, tactile or auditory, is the more important for a musician when playing? In an attempt to answer this question, subjects were asked to play along with a metronome while the auditory feedback from their playing was manipulated. The preliminary results showed a tendency for matching sound with sound, i.e. players initiated strokes earlier as the delay increased. Increase in timing errors indicate a possible breakpoint around 55 ms. As the feedback was delayed even more subjects showed increased difficulties in maintaining a steady rhythm.

1. INTRODUCTION

It is well known that the visual information to the brain is ranked so high that we are sometimes fooled to discard other sensory information. How does the tactile and auditory information relate to each other and to vision?

When playing on electronic drum pads and synthesized drums the drummer is able to change the acoustical properties of the instrument with a flick of a switch. For the acoustical drumset changing the characteristics of the sound would correspond to a change in the tactile feedback from the instrument. This, in turn, should prompt a modification of the performance for an untrained player and possibly also for a skilled performer. Keeping the same tactile feedback and changing only the characteristics of the sound, or delaying it, should cause the player to modify his/her performance according to one or the other sensory feedback. As it is possible that the different feedbacks will contradict each other an interesting question is which sensory feedback the player will adjust to.

Finney [1] reported large errors in performance for pianists subjected to delayed auditory feedback during playing. In his study the delayed feedback caused more discrepancies in interhand coordination compared to the condition with combined delay and pitch modulation of the feedback to the player. These issues are specifically important when aiming towards control of sound models [2]. A physical model of an instrument supplies a sound source that responds naturally to gestures during playing. Such a model, however, may introduce some delay in the response. It is therefore important to know to what extent such a perturbation can be tolerated.

The hypothesis for this investigation was that if the player has to synchronize with another audio source, i.e. other musicians, then he/she would try to match sound with sound for as long as

possible. There should, however, be a certain point when the time delay is so large that the player no longer can disregard the discrepancies. The player will have to make an active choice and this should cause a change in the temporal errors produced.

In the following we will present two pilot experiments with subjects playing on electronic percussion instruments with delayed audio feedback.

2. PILOT EXPERIMENT 1: RADIO BATON

2.1. Method and subjects

In a first investigation the Max Mathews radio-baton [3] was used as a percussion instrument. The radio-baton was connected via MIDI to a personal computer. The vertical position of one of the two sticks of the radio-baton was used as a trigger for each stroke. When the level of the radio plate surface was reached this was used to generate a MIDI note. This was done with a patch in PD [4]. A synthesizer (Roland JV10-10) generated a percussive sound and the player listened through a pair of closed headphones that blocked out the direct audio feedback from the playing. The PD patch also supplied a metronome to the player through the headphones and the player was asked to synchronize with the clicks. Through the patch the experimenter was able to control the tempo of the metronome and the delay of the auditory feedback to the player in real time. These parameters could be changed by writing the new value directly in the patch, or by moving the sliders associated with them. Each hit triggered by the baton and all changes to tempo and delay were logged in a text file by the patch.

There were four subjects participating in the pilot experiment, all musically trained. A recording session started with the onset of the metronome and the player playing along with the preferred hand. The player was placed with the back towards the experimenter, so that no movements when controlling the session could be seen by the player. After the player had adjusted to the tempo (120 beats per minute, onset interval 500 ms) a delay of the auditory feedback was introduced gradually with 1 or 2 ms steps. The delay, Δt , could vary from 1 to 127 ms. Each step was maintained for about 15 seconds.

2.2. Analysis

The output files were analyzed with respect to the time difference between the onset of the baton stroke and the metronome. The spread in inter-onset intervals were also studied. In Figure 1 the

results from one of the subjects is seen. The figure shows the time difference between the hits of the baton versus the introduced delay. It's clearly seen how the player compensates for the delay by initiating the strokes earlier. A linear regression on the 1098 data points collected produced an R-value of -0.684 with a standard deviation of 33.49 . The subject playing in Figure 1 (subject S1) was the only one able to play throughout the whole range of delay available, most players however gave up at about half the range.

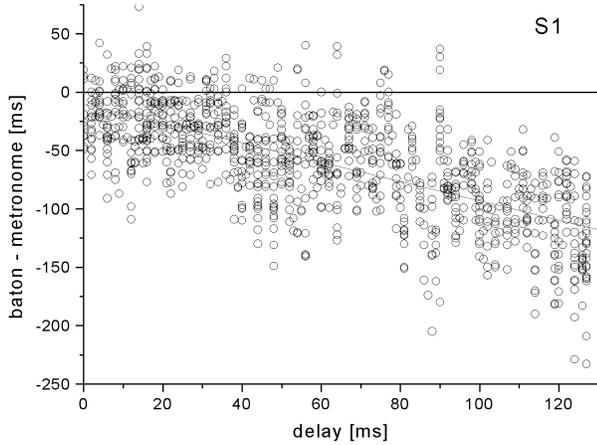


Figure 1. Time difference between radio-baton stick hits and metronome versus introduced delay for one of the subjects in the pilot experiment.

3. PILOT EXPERTIMENT 2: DRUM PAD

3.1. Method and subjects

To further explore the importance of the auditory versus the tactile feedback the radio baton was exchanged for a commercial drum pad (Clavia ddrum) [5]. This was considered to give a more defined tactile feedback to the player, and also correspond closer to a normal playing situation where delay effects could occur. The set-up for the experiment remained the same with the exception of the sound generation, which now was handled by the ddrum system. A PD patch, similar to that of experiment 1, was developed (Figure 2).

The day after the pilot experiment 1 was performed, two of the four subjects (subject S1 and S2) performed four sessions of drumming, synchronizing with the metronome clicktrack at a tempo of 120 beats per minute (onset interval 500 ms). This time the delay was introduced in steps from 0 to Δt and then back to 0. Each step in Δt was maintained for about 11 to 15 strokes so that the player was not prepared for a tempo change. After each step in Δt there would be a period (of about the same length) with $\Delta t=0$, before introducing a new Δt . Two of the sessions started with a Δt of 10 ms, which was then increased by 5 ms each time the delay returned until the player failed to continue playing. In the two remaining sessions the delay started at a value little above where the subjects stopped playing in the previous session and Δt was reduced for each occurrence until the zero-level was reached.

An example of how the changes in auditory feedback were introduced to the player is shown in Figure 3

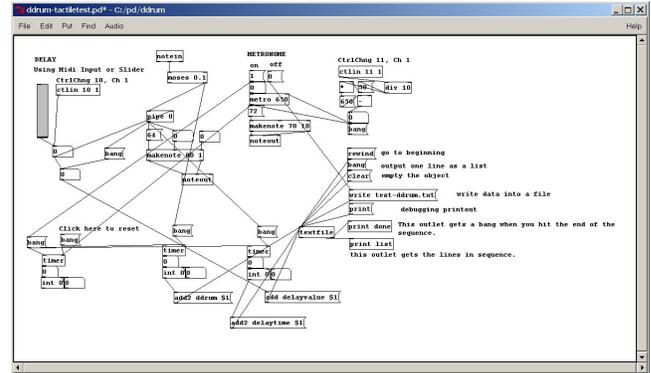


Figure 2. PD patch used in the pilot experiment 2 for delaying audio feedback to ddrum players.

3.2. Analysis

The analysis was concentrated to the spread in inter-onset intervals. The last eleven inter-onset intervals produced before each change in Δt were pooled together and the spread of data was calculated as the standard deviation.

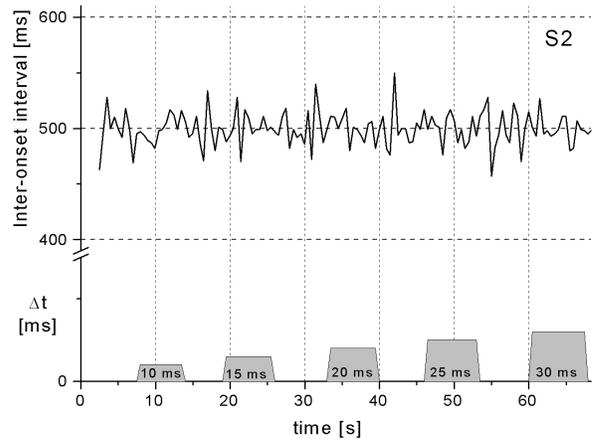


Figure 3. An example of the player's response to the different Δt s introduced. The lower panel of the figure shows the steps in Δt as they were introduced to the player in the "increasing" session. In the upper panel the inter-onset intervals in sequence can be seen. Note that the larger differences in between adjacent inter-onset intervals may occur in between changes in Δt .

4. PRELIMINAR RESULTS

The mean inter-onset intervals and the standard deviation versus the different Δt for the two players can be seen in Figure 4. As expected there are no changes in the mean tempo since they were skilled to follow the metronome. On the other hand both players

display changes in the standard deviation as Δt increases. A visual inspection of the spread in data determined that there was a possible break where playing became increasingly difficult. For subject S1 (upper panel, Figure 3) this point was considered to be $\Delta t=55$ ms, whereas subject S2 (lower panel) show more spread in data around $\Delta t=40$ ms.

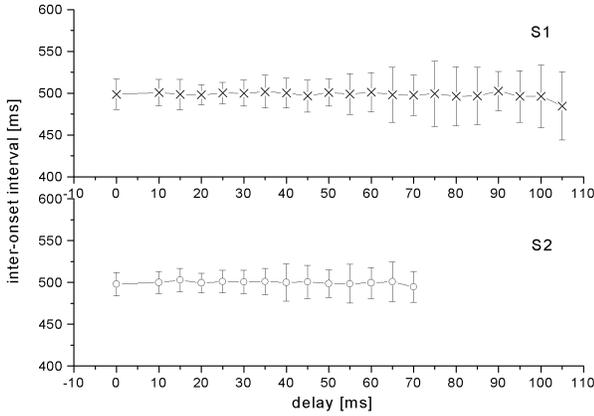


Figure 3. Mean inter-onset intervals for different amount of delay for the two players participating in the second experiment. The vertical bars indicate the standard deviations for each mean value.

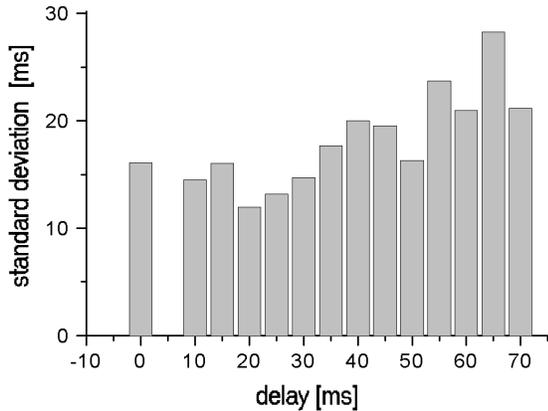


Figure 4. Mean standard deviation for subjects S1 and S2 participating in the second pilot experiment. The standard deviation increases with increasing auditory delay.

5. CONCLUSIONS AND DISCUSSION

The main result from the two pilot experiments is the tendency to match a gradually delayed auditory feedback with the sound of the metronome. When the delay was introduced slowly and gradually, subjects adjusted their playing without always realizing that changes occurred. However, when the auditory delay exceeded a certain point subjects began to show difficulties keeping a steady rhythm. This confirmed our hypothesis that there will be a point where the conflict between movement (the tactile feedback from the drum pad) and the sound (the delayed

auditory feedback) begin to make playing increasingly difficult. A preliminary analysis shows that a possible break-point could be sought in a range between 40 and 55 ms. It seems reasonable to assume that, as Δt increase even more, the player has to deal with the incoming sensory information according to other strategies in order to continue playing. The abrupt, stepwise, changes introduced in the second experiment also forced the players to choose a strategy with which to keep the tempo. One drastic example could be to simply ignore the confusing sounds and concentrate on the internal representation of the tempo. In Finney's investigation [1] subjects performances were not impaired when they received no auditory feedback. In view of this it is possible that a player could be aided by discarding the auditory information as non-relevant.

The preliminary results show that individual subjects have varying ability for coping with contradictory sensory feedback. Of the four subjects participating in the first pilot experiment two were not able to continue playing past approximately half the delay range (about 60 ms). The two players that were recorded in the second experiment had experience from two diametrically opposed musical contexts. The player in Figure 1, subject S1, plays the violin in symphony orchestras. In an interview after the experiments, this player brought forward the necessity of adjusting to the orchestral tempo as an explanation for his ability to adjust to large delays in auditory feedback. The other player, subject S2, plays the drumset in smaller ensembles and was not able to cope with larger delays. A possible explanation is that percussionists are trained to keep the tempo in ensembles and might thus be more sensible to time delays affecting their own performance than most other musicians. In addition to the subjects different musical backgrounds it should also be mentioned that playing along with a metronome could be difficult in itself [6]. Playing to a clicktrack is common in recording situations, and often these involve electronic instruments. It is important that these aspects are kept in mind when developing new instruments, such as synthesizers and electronic drums.

In the near future, experiments with a larger number of subjects and professional percussionists are planned for a further investigation of the preliminary results presented in this paper. Also, physics-based sound modules will be used as audio feedback.

6. ACKNOWLEDGMENTS

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