Continuous sound feedback in tracking tasks

E. O. Boyer[1,2], L. Colin Malagon[1], F. Bevilacqua[1], P. Susini[1] and S. Hanneton[2]

[1]*STMS Lab IRCAM-CNRS-UPMC, France*

[2]*UMR CNRS 8119, Université Paris Descartes, France*

***Summary*— Auditory feedback can be beneficial to motor control, however the precise mechanisms that enable sound features to influence movements remain poorly understood. We propose an experiment to evaluate whether continuous auditory feedback can improve tracking performance. Different types of sonification were assessed.**

INTRODUCTION

We are currently performing a series of experiments to evaluate audio-motor learning and identify mechanisms that are beneficial to motor control and learning (ANR project LEGOS). Following the recent published results of Rosati and coworkers [1], we propose here an experiment aiming at bringing complementary results on the effect of auditory feedback in a tracking task.

MATERIALS AND METHODS

A two-dimensional tracking task was designed. Thirty participants had to follow a target displayed on a screen using a touch pen on a tablet. The target is shown as a red dot, while the subject's cursor is shown as a green dot of the same size. The target trajectory is a low-pass filtered 2D white noise. Additionally to the vision modality, a continuous auditory feedback is provided to the participants through headphones. The sound is synthesized by applying resonant filters to white noise (using the Max environment for sound processing, by Cycling'74). The frequency of the filter depends on parameters computed from the positions or velocities of the target and cursor.

Four different conditions with only one 3 minutes trial each were considered: 1-no auditory feedback, 2-target-cursor distance (error-related feedback), 3-target velocity, 4-cursor velocity (velocity-related feedbacks).

PRELIMINARY RESULTS

As shown in Figure 1, our current results (N=36) show that the total tracking error is at least 15% less with the auditory feedbacks and an ANOVA exhibited significant effect of the four-level condition repeated measures factor ($F(3,90)=13.5$, $p<0.0001$). Post-hoc Bonferroni test revealed significant differences between auditory and no auditory feedback conditions, but none within audio conditions. The auditory feedback conditions also show similar reduction of spatial dragging errors, computed by the cross-correlation between the target and cursor data (either position or velocity).

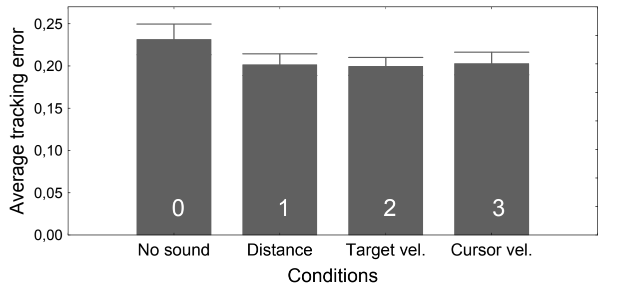

Figure 1 Tracking error averaged for 36 first subjects.

Frequency analysis of the target and cursor data reveals that trajectory and velocity spectra differ between the conditions. As an example, the average power spectral density of the transfer function between cursor and target trajectories is plotted Figure 2. It shows that the auditory feedback conditions present higher magnitude and frequency content than the no auditory feedback condition.

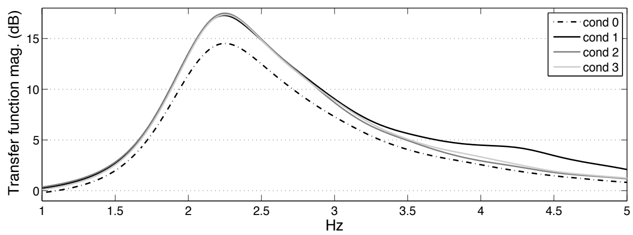

Figure 2 Average trajectory transfer function for each feedback condition.

DISCUSSION AND FUTURE WORKS

The first results tend to confirm that both error-related, target and cursor auditory feedbacks can improve performance in the tracking task we considered. The alteration in the frequency content of subject movements is typical of the visuo-motor system in a tracking task [2]. We are currently evaluating the differences observed in the spectra between each feedback condition.

Further experiments and analysis are also currently conducted to better assess the learning process occurring during this task, and to discriminate between the efficiency of the different sonification feedbacks.

REFERENCES

[1] G. Rosati, F. Oscari, S. Spagnol, F. Avanzini, and S. Masiero, "Effect of task-related continuous auditory feedback during learning of tracking motion exercises", Journal of Neuroengineering and Rehabilitation, vol. 9, no. 1, p. 79, Jan. 2012.

[2] S. Hanneton, A. Berthoz, J. Droulez, and J. J. E. Slotine, "Does the brain use sliding variables for the control of movements?", Biological Cybernetics, vol. 77, no. 6, pp. 381–393, Dec. 1997.