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SENSITIVITY OF A MEDIOLATERAL BALANCE ASSESSMENT TOOL TO SENSORY MANIPULATIONS.

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SUMMARY
The effect of sensory manipulations on mediolateral balance control was explored using a visual tracking task (VTT). This VTT uses the centre of pressure (CoP) as feedback on performance. A previous study has shown this method to give insights into the physical capabilities and visuomotor delays of the balance control system in the mediolateral direction. In this study we aimed to study its sensitivity to small changes in different types of sensory information. We manipulated vestibular and feet somatososensory information using a galvanic stimulator (GVS) and a transcutaneal nerve stimulator (TENS), respectively. Eight healthy young subjects participated in the experiment. Each performed a series of VTT using a predictable and an unpredictable target. The frequency of the target increased from 0.1 to 2.0 Hz. The predictable target used single sines, whereas the unpredictable used multisines with a bandwidth of 0.6 Hz, increasing in frequency in steps of 0.1 Hz. Compared to no-stimulation trials, no significant effects of sensory manipulations on phase shift and gain as well as bandwidth at which performance dropped below 75% of its maximum were found. An interaction of target by condition was found for average gain, with a lower gain (worse performance) with GVS than in the other two conditions on the predictable task. These results indicate a low overall sensitivity of the method to the sensory manipulations, possibly due to the predictable nature of the manipulations (fixed frequencies for GVS and TENS), but possibly also due to the subjects' ability to re-weight sensory inputs.

INTRODUCTION
It has been proposed that decreased performance in daily-life activities, especially in the elderly, is related to detriments of balance control in the mediolateral direction [1,2]. To assess mediolateral balance control, we have developed a zero-order visual tracking task, using the centre of pressure (CoP) as feedback on performance in tracking a predictable and an unpredictable target with a frequency content ranging from 0.1 to 2.0 Hz [3]. This method was shown to be reliable in determining frequencies at which phase shift and gain between the target and the CoP dropped below plateau values. As the sensory systems can be affected by age, we aimed to explore the sensitivity of our method to small changes in different types of sensory information.

METHODS
Manipulations of the vestibular system using a galvanic stimulator (GVS: 1 Hz at 1 mA) and the foot sole somatosensory system using a transcutaneous nerve stimulator (TENS - 100 Hz at 18 mA, varying between feet at 0.17 Hz) were applied to 8 healthy young subjects, while performing a visual tracking task. Each participant performed 3 trials for each target under three conditions: no-sensory manipulation, GVS and TENS. D-flow software 3.10.0 (Motek Medical, The Netherlands) was used to record raw data from a Kistler-9281B force plate (Kistler Instruments AG, Switzerland) in order to calculate CoP, produce targets and display visual feedback on performance at 60 Hz. Four descriptors for PS and G were calculated to quantify performance: PSX and GX which are the cutoff frequencies (bandwidth) at which performance dropped below 75% of the plateau value (average of three highest values) and PSY and GY which are the average of the G and PS values within the bandwidth.

RESULTS AND DISCUSSION
Descriptive statistics and repeated measures ANOVAs for the measures of PS and G are summarized in table 1 whereas figure 1 depicts PS and G average performance under no-stimulus, GVS and TENS conditions. Repeated measures ANOVAs showed significant ($p<0.01$) main effects of target for average phase and gain overall and within the bandwidth (PSY and GY, respectively). No main effects of condition were found. An interaction of target by condition was found for average gain, with a lower gain (worse performance) with GVS than in the other two conditions on the predictable task.

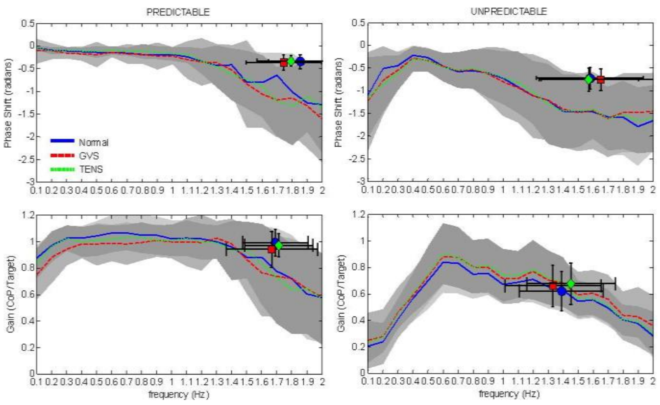

Figure 1: Averaged curves (± sd) for PS (top panel), G (bottom panel) measures using both, predictable target (left column) and unpredictable (right column) during no stimulus (blue line), GVS (red dashed line) and TENS (green dotted line) conditions. Crosses inserted in the plots indicate means (± sd) for performance descriptors for the no stimulus (blue circular markers), GVS (red squared markers) and TENS (green diamond markers).

CONCLUSIONS

These preliminary results appear to indicate a low overall sensitivity of the method, possibly due to the predictable nature of the sensory manipulations (fixed frequencies for GVS and TENS), but possibly also due to the subjects' ability to re-weight sensory inputs. Further investigations should explore whether these sensory manipulations affect the balance performance more in the elderly, especially in those at risk of falling.

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Table 1: Descriptive statistics for phase shift, gain and performance descriptors (PSX, PSY, GX and GY) for the predictable and unpredictable targets under the three conditions tested (no stimulation, GVS or TENS). Right part of the table summarizes the p-values of the repeated measures ANOVAs for the main factors target (unpredictable and predictable) and conditions (no sensory manipulation, GVS and TENS) and the interaction effect. Statistically significant p-values are presented in bold.

	UNPREDICTABLE						PREDICTABLE						Target	Condition	Target * Condition
	No-Stim		GVS		TENS		No-Stim		GVS		TENS				
	m	**sd**	**m**	**sd**	**m**	**sd**	**m**	**sd**	**m**	**sd**	**m**	**sd**			
Phase Shift	-0.99	0.06	-0.99	0.06	-1.00	0.05	-0.43	0.04	-0.52	0.05	-0.47	0.04	**<0.01**	0.07	0.14
PSX	1.58	0.12	1.65	0.12	1.58	0.09	1.85	0.07	1.75	0.05	1.79	0.06	0.03	0.68	0.33
PSY	-0.72	0.12	-0.76	0.12	-0.76	0.09	-0.34	0.07	-0.36	0.05	-0.33	0.06	**<0.01**	0.68	0.57
Gain	0.56	0.02	0.61	0.02	0.60	0.02	0.93	0.02	0.89	0.02	0.91	0.02	**<0.01**	0.15	**<0.01**
GX	1.39	0.06	1.34	0.11	1.45	0.08	1.69	0.04	1.66	0.06	1.71	0.06	0.02	0.36	0.90
GY	0.62	0.05	0.66	0.05	0.67	0.06	0.99	0.03	0.94	0.03	0.97	0.03	**<0.01**	0.17	0.15