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**ASSESSMENT OF ATTENTION DEMAND FOR  
BALANCE CONTROL USING A SMARTPHONE:  
IMPLEMENTATION AND EVALUATION**

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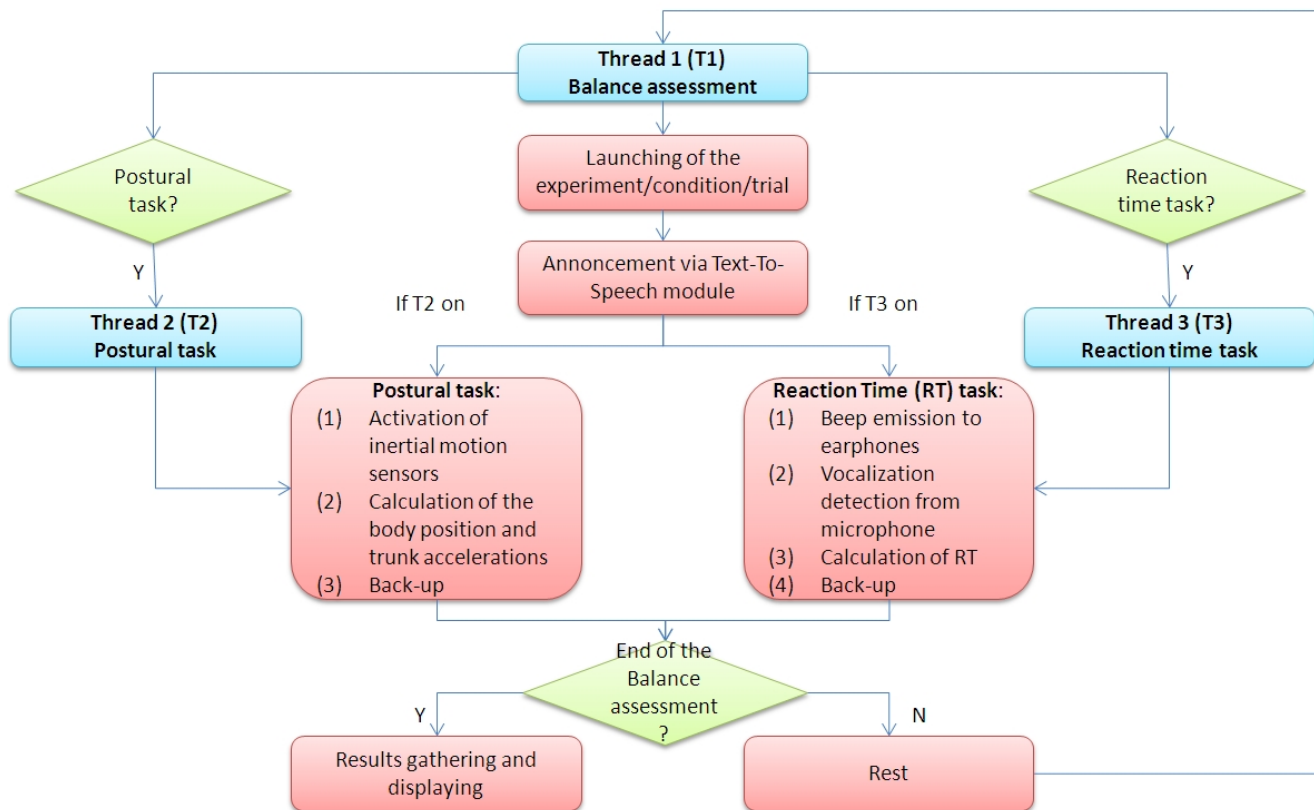


Postural control and stability of a person is a very strong information on his/her autonomy and his/her wellbeing

- ▶ Control of balance involves the integration of sensory information from various sources including visual, somatosensory and vestibular systems
- ▶ Growing interest in whether and how cognitive factors could play a role.
- ▶ Balance control, mainly performed at an unconscious level but fully automatic process.
  - Even the control of a bipedal stance requires attention resources
- ▶ Estimation of the capacities of the person → **could give information on the fall risk of a person? (lower control capacities → higher fall risk?)**

To estimate the part of automaticity in the control of the posture, dual task paradigm can be used.

- ▶ A procedure in experimental (neuro)psychology that requires a participant to execute two tasks simultaneously
  - First task is a postural control task (the main one)
  - Second task is a cognitively demanding task (for instance reaction to an unpredictable stimulus, performing math operation, describing a visual stimulus, etc.).
- ▶ Nervous system has a limited central capacity. Performing a task requires a given portion of this capacity → if two tasks performed simultaneously the performance of one or both tasks will be affected negatively.
- ▶ **Measuring how much a postural control task is affected could give us information on the level of automaticity of this task**
- ▶ **For now, measurement with an external device on a computer generally.**



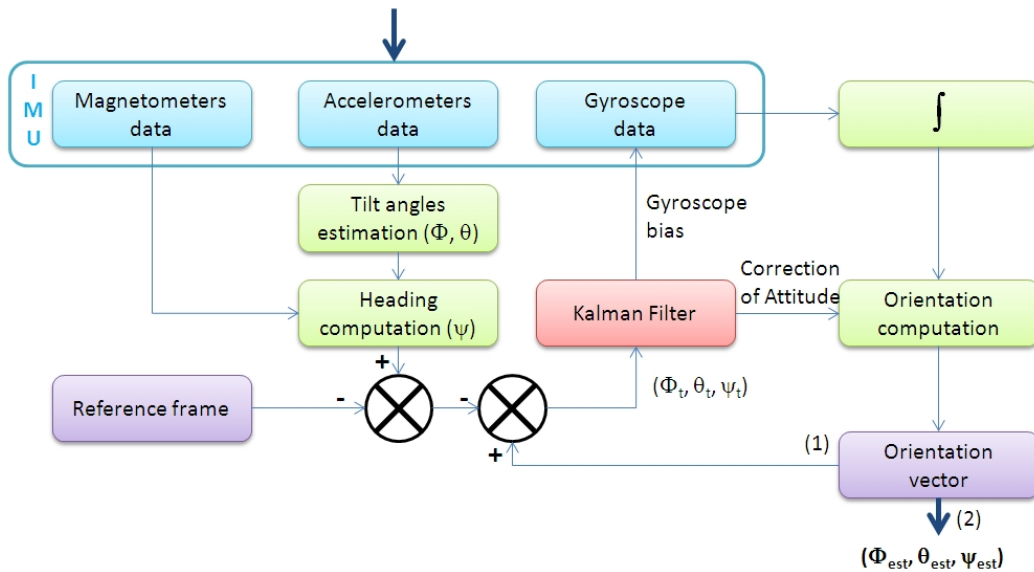
► Fully automated test (to be able to use it on his/her own at home).

- Pre-program of several conditions for postural control (several positions, position of arm, eyes closed or not etc.) by for instance a medical staff member
- All the conditions are announced along with the resting etc. and the program manages the session with or without double task.

## 2: MATERIALS AND METHOD

### 2.2 Postural control task and reaction task measurement

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- ▶ Postural stability is estimated from the sensors of the smartphone measuring the deviation from the initial position.
- ▶ The reference frame is a mean position of the smartphone in the first second of the first experimentation (as the person will put it by himself/herself).

- ▶ Reaction task: respond to a sound solicitation by a word emission as quickly as possible.
- ▶ Microphone is used for that:
  - Sampling at 100Hz,
  - Power of signal evaluation at each sample
  - If the new value is over 15% of the former, detection of a sound.
- ▶ → Assume that the noise is relatively constant or slowly varies during the experimentation.

Several data are extracted from both IMU and microphone data.

▶ Two postural parameters are computed:

- (1) the root mean square of trunk tilt in the ML (Medial-lateral) and AP (Antero-Posterior) directions (RMS in degree) as a measure of sway;
- (2) the mean power frequency of trunk tilt in the ML and AP directions (MPF in Hz) calculated from the power spectral density of trunk tilt

▶ And one “cognitive one”

- (3) Reaction Time (RT) score that is defined as the temporal interval between the beginning of the presentation of the auditory stimulus (“beep”) and the onset of the participant’s verbal responses (“top”).

A proof-of-concept experiment have been performed.

Participants:

- ▶ Eight young healthy adults (age:  $29 \pm 3$  years; height:  $174 \pm 9$  cm; weight:  $66 \pm 15$  kg, mean  $\pm$  SD)
- ▶ Volunteers, without any history of sensory and/or motor problems, neurological diseases or disorder

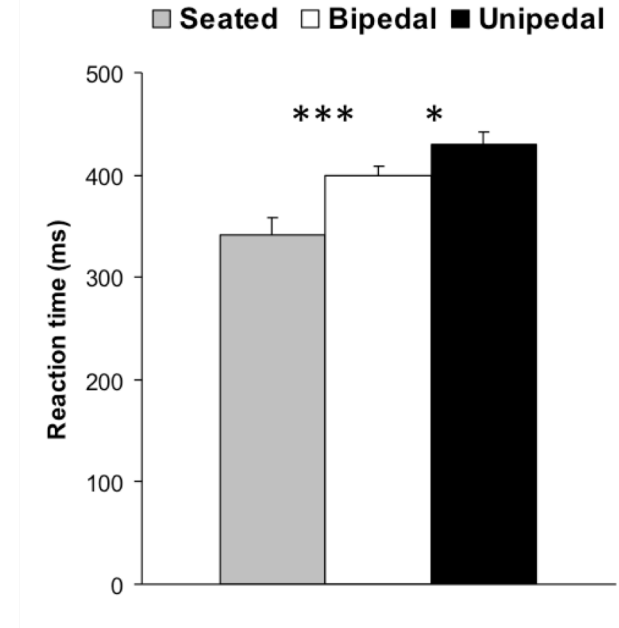
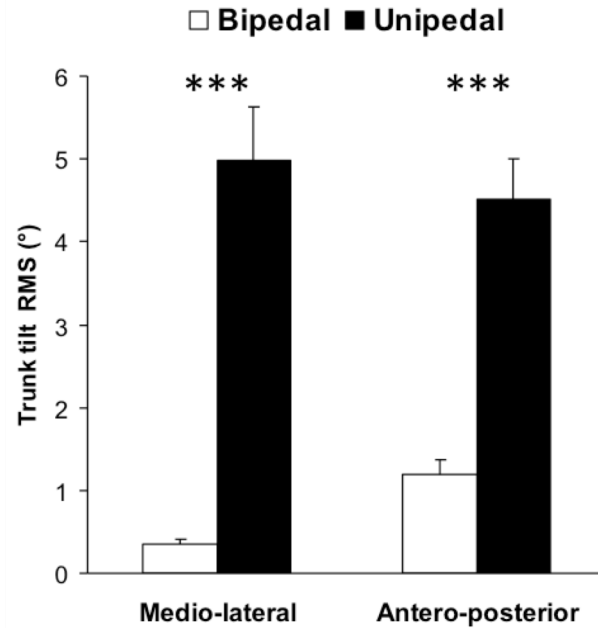
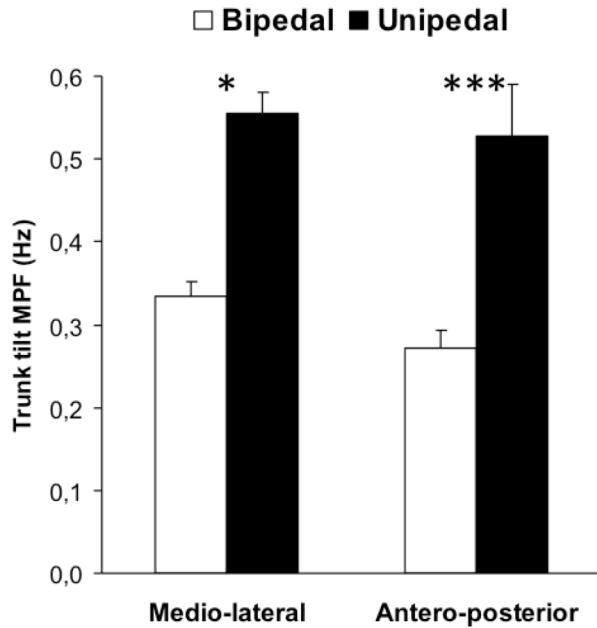
Material:

- ▶ Smartphone mounted in a belt on the posterior low back at the level of L5 vertebra
- ▶ A pair of earphones throughout the experiment (a hands-free kit made of earphones with a piezoelectric microphone included).

Task:

- ▶ Control their balance in two upright postures of increasing difficulty: (1) bipedal standing feet parallel 10 cm apart (Bipedal posture) and (2) unipedal standing on their dominant leg (Unipedal posture). In the Bipedal and Unipedal postures, participants were standing with eyes closed, barefoot, arms close to the trunk, and were asked to sway as little as possible.
- ▶ Secondary is a reaction-time task. Required to verbally respond with “top” to an unpredictable auditory stimulus (50 ms, 440 Hz) (word used because unrelated to the task and one syllable). 5 auditory stimulus randomly positioned but at least 2.5s apart.





► First we checked that in healthy patients, the secondary task does not perturbate significantly the primary.

► A one way repeated-measure ANOVA was used for statistical evaluation of the results:

- As expected, it shows that in more challenging postures the reaction time was higher → the postural task, depending on the posture required, is more or less demanding.

### Conclusions:

- ▶ This work presents a way to measure attention demand using a double task paradigm with the following:
  - Everything is integrated on a smartphone, largely available to everyone
  - The user interface guides the patient to perform the exercises, telling him/her what to do and when) and performs a set of exercises automatically to evaluate the performances with and without double task following a protocol entered by the staff.
  - Present results in terms of several features extracted to evaluate the automaticity of a person to maintain a given posture.
  
- It showed that we can effectively measure, and without any other device, the reaction time and the difference of reaction times due to changes in exercises conditions.
  
- ▶ Future works include to:
  - Check the results on different and wider population
  - Determine precisely depending on the population if there are normal/abnormal values for the different features → classification and clustering.