The HealthPAC project received its funding from the EU 7th Framework Programme Marie-Curie FP7-PEOPLE-2013-ITN under IDP Grant agreement nr. 604063

Name ESR and number in HP: Alessia Longo –ESR14
Nationality: Italian
Research work-package (select): WP 6
WP3 (HEAR), WP4 (FEEL), WP 5 (SEE), WP 6 (ACT)
Starting date ESR: 01/04/2014
Supervisor and co-supervisor: Ruud Meulenbroek
Host-institution - Department: Donders Centre for Cognition

RESEARCH

RESEARCH PROJECTS AND RESULTS FROM **01/04/2014** UNTIL **31/12/2017**

Project 1

Title:**Precision-dependent changes in motor variability during sustained bimanual reaching (D21)**

Movement variability of the upper limb was investigated using a bimanual Fitts' task. Participants tapped rhythmically between pairs of targets of different Index of Difficulties (IDs) for three intervals of 20 min each. We studied the effects of IDs and time-on-task on movement time, end-point variability, approximate entropy and standard deviation of relative phase. Lower IDs and time-on-task caused decreasing movement time and increasing end-point variability. Moreover, standard deviation of relative phase and approximate entropy moderately increased. By looking into the long-term effects of a sustained bimanual Fitts' task, this is the first time such movement variability increase is demonstrated in multiple variability indices. The findings are relevant for future studies on work-related musculoskeletal disorders.

Project 2

Title:**Postural reconfiguration and cycle-to-cycle variability in patients with work-related musculoskeletal disorders compared to healthy controls and in relation to pain emerging during a repetitive movement task**

The aim of the current study was to investigate, first, differences in movement behavior between volunteers with and without work-related pain and, second, the influence of emerging pain on movement variability. Upper-body 3D kinematics were collected as 22 subjects with musculoskeletal disorders and 19 healthy volunteers performed a bimanual repetitive tapping task with a self-chosen and a given rhythm. Three subgroups were formed within the patient group according to the level of pain the participants experienced during the task. Principal component analysis was applied to 30 joint angle coordinates to characterize in a combined analysis the movement variability associated with reconfigurations of the volunteers' postures and the cycle-to-cycle variability that occurred during the execution of the task. Patients with no task-related pain showed lower cycle-to-cycle variability compared to healthy controls. Findings also indicated an increase in movement variability as pain emerged, manifesting both as frequent postural changes and large cycle-to-cycle variability. The findings suggested a relationship between work-related musculoskeletal disorders and movement variability but further investigation is needed on this issue. Additionally, the findings provided clear evidence that pain increased motor variability. Postural reconfigurations and cycle-to-cycle variability should be considered jointly when investigating movement variability and musculoskeletal disorders.

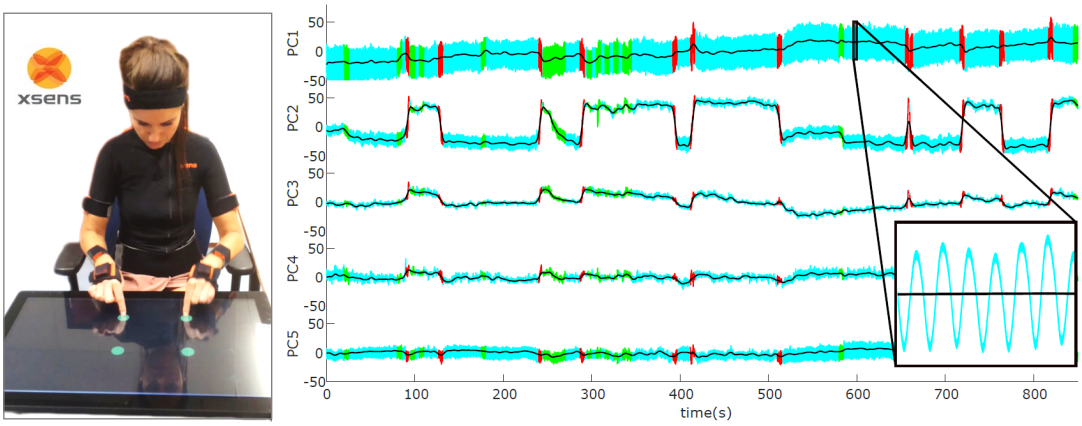

Fig.1 *Left: experimental set-up. Right: Dataset of a 15-min trial of one volunteer: the first 5 PCs are shown. The tapping movement is printed as a colored line, the black line represent the low-pass filter underlying trend. Quasi-stationary phases were colored in cyan,*

phases of gradual changes in green and transitions in red. The enlargement of a 5 seconds section of PC1 shows the cyclical tapping movement.

Project 3:

Title: **A cognitive dual task on sustained repetitive arm movements increases temporal variability and local dynamic instability but reduces postural reconfigurations**

Here we explored the effects of a secondary cognitive task on distinct types of variability in sustained repetitive arm movements. To this end, thirteen healthy volunteers participated in the experiment consisting of two phases. First, participants performed a repetitive bimanual tapping task between two target pairs. Second, they performed the same motor task concurrently with a secondary task of counting aloud backwards in multiples of three. Upper-body 3D kinematics was collected and postural reconfigurations were determined through a principal component analysis-based procedure. Further, cycle-to-cycle variability was characterized via cycle duration, temporal and spatial variability, and the Lyapunov exponent. In addition, end-point variability was assessed as a control measure. The findings show an overall increase of temporal variability and dynamic instability, a marginal decrease of end-point variability, and a substantial reduction of postural reconfigurations in the dual-task conditions. The findings may have important implications for the prevention of work-related musculoskeletal disorders.

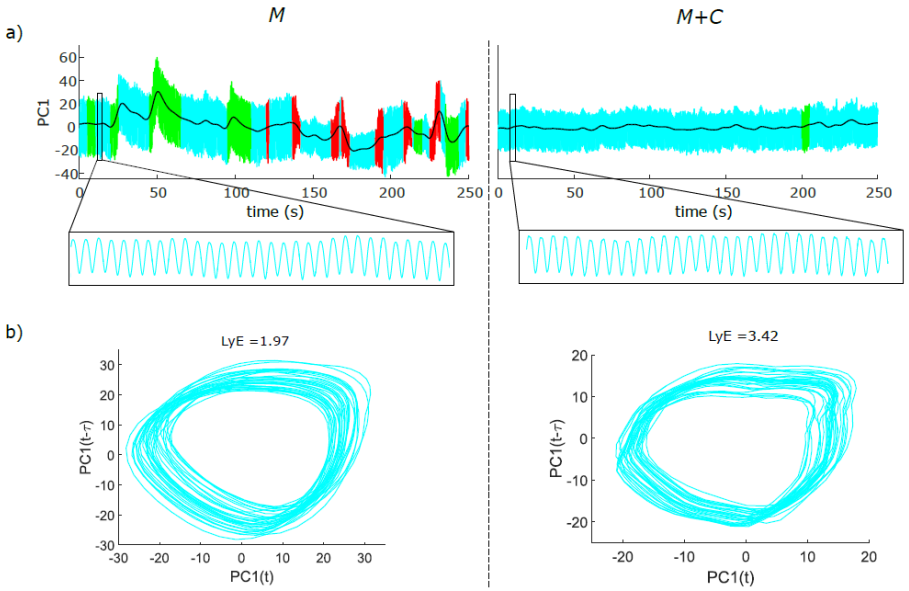

Fig.2 *a) Representation of PC1 of the Motor (M) and the Motor + Cognitive (M +C) trial of one subject. The enlargement shows 30 cycles selected in the quasi-stationary phases for the analysis of cycle-to-cycle variability. b) State space representation of 30-cycles of the same subject for the analysis of the Lyapunov Exponent*

Project 4

Title: **Biomechanics in a PCA-based posture space using Xsens inertial sensors**

The main aim of the current study was to demonstrate mathematically that kinematics in posture space can be used in the same way as kinematics in normal space. Nineteen healthy volunteers performed a bimanual repetitive task. Upper-body 3D positions were collected and submitted to a principal component analysis (PCA). The findings demonstrated that accelerations can be computed out of principal accelerations in the same way that the input data can be computed out of principal positions. Further, we explored possible applications of principal accelerations, investigating their relationship with the Lyapunov exponent (LyE). The results showed a high correlation between the standard deviation among cycles of the first principal acceleration and the LyE of the first principal position. The findings are promising since principal accelerations are easier to understand in comparison to LyE and other non-linear measure which are used for the analysis of stability or predictability of time series. Moreover, applying PCA on acceleration vectors might have a great potential in the contexts of inertial sensors. The analysis of principal accelerations could be a new and powerful way of studying the control of movement.

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OUTREACH ACTIVITIES

OUTREACH ACTIVITIES FROM 01/04/2014 UNTIL 31/12/2017

Publications

Longo, A., & Meulenbroek, R. (2017). Precision-Dependent Changes in Motor Variability During Sustained Bimanual Reaching. *Motor Control*, 1–17. https://doi.org/10.1123/mc.2016-0013.

Longo, A., Meulenbroek, R., Haid T., & Federolf P. Postural reconfiguration and cycle-to-cycle variability in patients with work-related musculoskeletal disorders compared to healthy controls and in relation to pain emerging during a repetitive movement task. *Clinical Biomechanics* (resubmitted)

Longo, A., Federolf P., Haid T., & Meulenbroek, R. A cognitive dual task on sustained repetitive arm movements increases temporal variability and local dynamic instability but reduces postural reconfigurations. *Experimental Brain Research* (resubmission)

Longo, A., Meulenbroek, R., Haid T., & Federolf P. Biomechanics in a PCA-based posture space using Xsens inertial sensors. *Journal of Biomechanics*(to be submitted soon)

Presentations

Longo, A., Meulenbroek, R., Haid T., & Federolf P. (2017). Postural variability in cyclic, work-related reaching movements. *OSG – Section Biomechanics Conference for young scientists*. December 2017, Obergurgl,Tirol, Austria.

Longo, A., Meulenbroek, R., Haid T., & Federolf P. (2017). Variability in postural configuration assessed in the context of work-related musculoskeletal disorders. *23th congress of the European Society of Biomechanics*, July 2017, Seville, Spain.

Longo, A., Meulenbroek, R., (2016). The beneficial role of movement variability in repetitive tasks: A preliminary study. *25th European Society for Movement Analysis in Adults and Children (ESMAC) annual meeting*, September 2016, Seville, Spain. Abstract published in *Gait & Posture , Volume 49 , 265.*

Longo, A., Meulenbroek, R., (2016). Task-precision and time-dependent changes in motor variability during a sustained bimanual reaching task. *9th International Scientific Conference on the Prevention of Work-Related Musculoskeletal Disorders*, Toronto, Canada (2016)

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TRAINING ACTIVITIES

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Training Activities Training modules at the Donders institute:

Motor Control (6 ECTS; 2014)
Introduction to Dutch A1 (Radboud into Languages, 2014)
Introduction to Dutch A2 (Radboud into Languages, 2015)
Optimizing Cognitive Function (3 ECTS; 2015)
Advanced conversation English (2015)
Art of presenting science (2016)
Writing Scientific English (2016)
Statistics for behavioral science (2016)

Coaching or mentoring activity at the Donders institute:

Supervision four bachelor students in a 6-months research project (OP3;2015)
Supervision of research assistant conducting data acquisition (2015)
Supervision four bachelor students in a 6-months research project (OP3;2016)
Matlab course (2018-planned)

Summer and winter schools:

Winter School HealthPAC (Jan 2015, Nijmegen)
Summer School in Computational Sensory-Motor Neuroscience COSMO (July 2015, Groesbeek)

Visits to associated partners of HealthPAC:

Xsens (Apr 2015, Enschede)
Philips (Jun 2015, Eindhoven)
SintMaartienskliniek (Sept 2015, Nijmegen)
UCL (Dec 2015,London)

Secondments:

Two months (May-Jun 2015) secondment at Xsens(Enschede, the Netherlands)
The aim was to learn how to use state-of-the-art accelerometers for full-body motion recording. Further, the collaboration with Xsens has continued, since we used their device to record the data for the second, third and fourth project.
Twelve months (Dec 2016- Dec 2017) secondment at Sport Science Institute (Innsbruck, Austria)
The aim was to be trained in advanced data analysis methods based on principal component analysis and non-linear data analysis. Further, to use these techniques to complete the data analysis for the second, third and fourth project.

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CONFERENCES
CONFERENCES, WORKSHOPS FROM 01/04/2014 UNTIL 31/12/2017
Neurovation (Oct 2014, Utrecht) Donders Discussion (Nov 2014, Nijmegen) Progress in Motor control X (July 2015, Budapest) International Conference on System Level Approaches to Neural Engineering (Sep 2015, Barcelona) International Scientific Conference on the Prevention of Work-Related Musculoskeletal Disorders PREMUS (June 2016, Toronto) 25th European Society for Movement analysis in Adults and Children annual meeting, ESMAC (Sept 2016, Seville) ESMAC gait course (Sept 2016, Seville) Business school (April 2017, Nijmegen) European Society of Biomechanics (July 2017, Seville) Section Biomechanics conference for young scientists, OSG (Dec 2017, Austria)

FUTURE CAREER PLANS
Describe your future career plan(s), after the end of the project.
Future plan(s) - Revision of the third paper for resubmission to peer-review journal - Submit the fourth paper to peer-review journal - Finish-up and submit PhD thesis within April 2018 Future plan(s) after obtaining PhD - applying for a job in a healthcare company in the Netherlands, Switzerland, Austria or Italy - writing a grant to obtain funding of a post-doc, HealthPAC-relevant research project at a Dutch, Spanish, Italian or Austrian university or research institute - networking in Horizon 2020 projects to find a relevant R&D position which extends my HealthPAC experience and expertise