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► To cite this version:

K Bouillet, S Lemonnier, F Clanche, G Gauchard. Human working in interaction with a cobot: what do its gesture, posture and gaze tell us?. Association des Chercheurs en Activités Physiques et Sportives, Oct 2021, Montpellier, France. hal-04123527

HAL Id: hal-04123527

<https://hal.science/hal-04123527>

Submitted on 9 Jun 2023

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Human working in interaction with a cobot: what do its gesture, posture and gaze tell us?

K. Bouillet^{1,2}, S. Lemonnier², F. Clanche¹, G. Gauchard¹

Cobots:
 Robots intended to **interact physically** with humans, in a **shared workplace**, with a **common goal**. (Terveen, 1995)

Human-Robot Interaction:
 Interaction between human and cobot are mainly a **collaboration**: same workplace in order to accomplish common task with potential contacts. (Hentout et al., 2019)



Musculoskeletal disorders (L'Assurance Maladie, 2020):

- Main issue for industries: almost 90% of professional diseases in 2019.
- Causes: stress, psychosocial factors, work organisation, **biomechanical load**. (Uguen et al., 2018)
- Most affected areas: **upper limbs and back**.
- Evaluation of risk of MSDs with RULA: score and level action from joint positions.



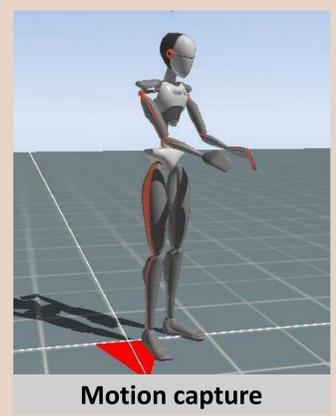
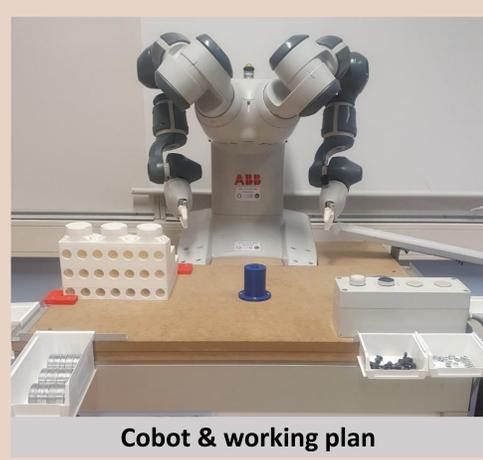
34 participants
 22,1±2,0 years old
 13♀ & 21♂
 Not familiar with robots

Collaborative task:
 Manufacture maximum of products in four minutes in collaboration either...

...with a cobot (COB)
 YuMi cobot

...with a human (HUM)
 Always the same human

Auditive task:
 Second task in parallel, with two levels of difficulty



Measures:

Collaborative task performance:

- Number of products manufactured

Fluidity interaction:

- Cobot/human actions: inactivity, activity
- Participant actions: inactivity, activity

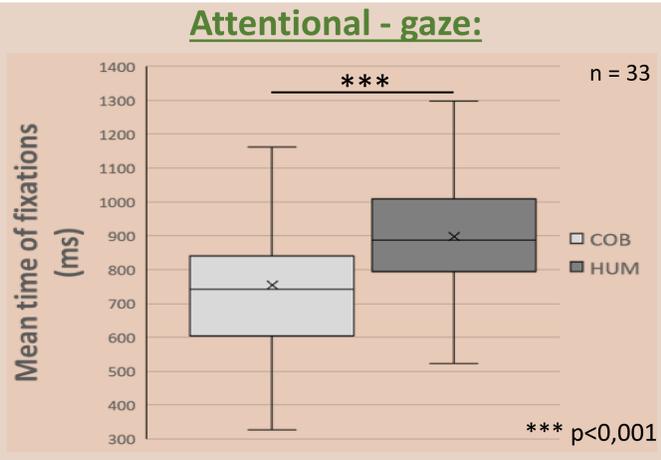
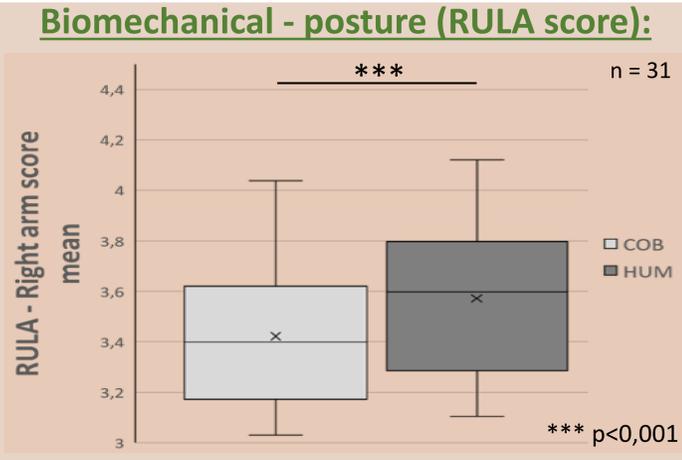
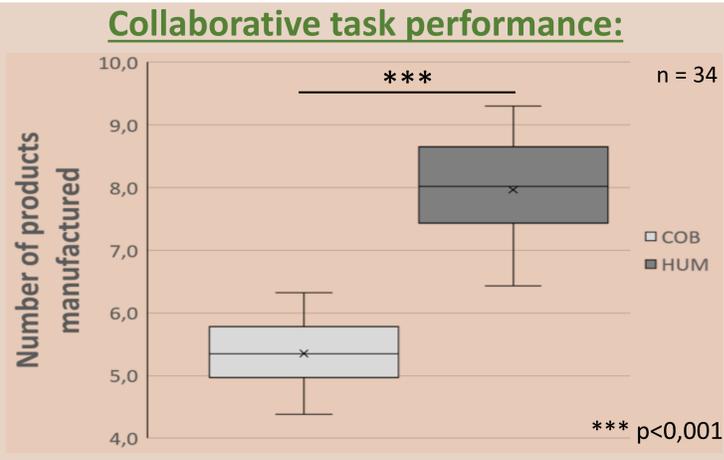
•Concurrent actions: collaboration

Biomechanical:

- Posture: RULA, trunk flexion, ...
- Gesture: hand speed, fluidity, ...

Attentional:

- Fixations: number, time
- Saccades: length
- Pupillary diameter



Production: **Collaboration with human > cobot.**

Mean RULA score: **Collaboration with human > cobot.**

Time spent in risk 3: **Collaboration with human > cobot.**

Fixations: **Longer but less face a human than a cobot.**

Pupillary diameter: **Collaboration with cobot > human.**

Conclusion:

Collaboration between a human and a cobot compared to a collaboration between two humans	Cadence of production less important
	Less risks of developing MSDs
	More intense visual exploration?
	Higher cognitive load
	Other results are in progress

Future work: Evaluate the impact of the autonomy of the cobot (cadence of production led by the operator or by the cobot with three different speeds) on **motor behaviour & physiological measures** of operators & **fluidity interaction**.

Title:

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Keywords: Cobot, Industry 4.0, Motion capture, Eye-tracking.

R sum :

Introduction

Industry is currently subjected to a new revolution, moving from Industry 3.0 to Industry 4.0. Industry 4.0 is more digital, more ecological, more economical and more flexible. Its production is relied on the digital revolution and artificial intelligence [1]. Collaborative robots, or cobots, are a pillar of this new industry [2] and are characterised by the possibility to interact directly with a human [3,4].

With this work we want to study the nature of the interaction with a cobot. The collaboration between the human and the cobot is analysed during an activity such as the assembly of several products requiring co-manipulation of the product. This new form of collaboration requires an adaptation of the operator, since the introduction of the cobot transforms the relationship between his task and him, but also his motor activity, his work performance as well as potentially his health (in addition to the risks of traumas, musculoskeletal disorders can occur or move due to the adaptation of the operator to the cobot [5]) and his safety. The objective of this work is therefore to analyse the characteristics of human motor performance, through multimodal measurements, of the introduction of the cobot into the collaborative work situation in comparison with the same performance when faced with a human.

To this end, we have constructed an experiment in which participants are asked to put together several components in order to constitute a series of semi-finished products, either with a cobot or with a person. We hypothesize that the presence of the cobot shifts the participant's motor (posture and gesture) and oculomotor (gaze areas) behaviours, compared to the presence of a human.

Methods

A population of forty people, aged between 18 and 40 years, participated in the experiment. The participants were equipped with seventeen wireless inertial motion sensors (Xsens), which, with the help of a biomechanical model integrated into the software, estimate the joint angles, position, speed and acceleration of the participants' body segments. These data allow the study of biomechanical behaviour. The participants are also equipped with an eye tracker (Tobii) which records the position of the gaze, as well as the dilation of the pupils. The sessions are recorded and then analysed with the Captiv software in order to study the activity and inactivity time of the cobot and the human. The different measurement tools are synchronized with a Matlab program.

The motor task of the participant, standing in front of the working plan, consists in manufacturing a maximum of products in four minutes, in collaboration either with a YuMi cobot (ABB Group, Zurich, Switzerland) or with another human.

Results and Discussion

Currently, the experiments are ongoing (20 participants have passed). The experiments will continue over the next few weeks. Results will be presented at the ACAPS'2021 conference.

Conclusion

The introduction of cobots in industries modifies the relations between the operator and his task, as well as his performance, health and safety. With this study, we hope to gather information that will allow us to better characterise these new relationships, which are still little studied in the literature, and thus to distinguish, upstream of the introduction of the cobot, the situations at risk from those that will benefit from it. A demonstrator is also being designed and our data will be used to enrich it.

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