Validating a Cortisol-Inspired Framework for Human-Robot Interaction with a Replication of the Still Face Paradigm

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Motivation

Humans have individual differences in the way they prefer to interact with others and these depend also on their *attachment style,* which modulates their hormonal dynamics (in particular cortisol) in response to an interaction. Enabling a robot to understand its partner's attachment style could help the machine to adapt its behavior accordingly. In this direction, we develop an *intrinsic motivation system* for the humanoid robot iCub inspired by the cortisol hormone (*R-cortisol*). We validate our framework during human-robot interaction, modeling different robots' attachment styles and evaluating how the R-cortisol dynamic evolves as a function of the partner's style of interaction.

Our long term goal is to allow iCub to infer its partner's attachment style, by monitoring its own R-cortisol during the interaction, in order to personalize its behavior.

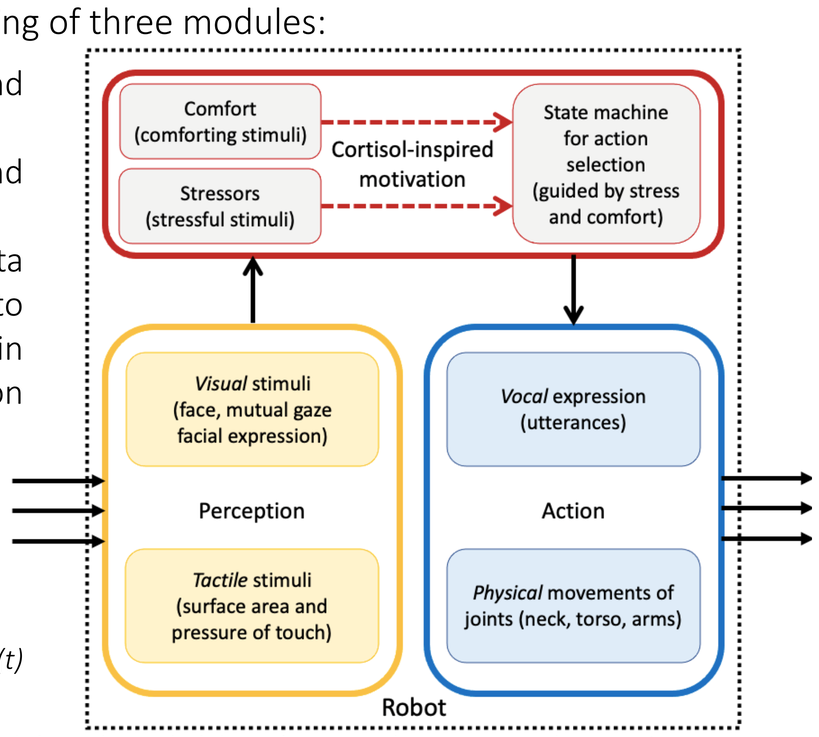
Methodology

❖ Design of a cortisol-inspired framework consisting of three modules:

- Perception module processes the **tactile** and **visual** stimuli received from the person;
- Action module performs a finite set of **actions** and **vocalizations**;
- Motivation module analyzes the received data from the *Perception* module and sorts it into **Comforting** stimuli or **Stressful** stimuli, which in turn influence the **R-cortisol** level in the selection of the action performed by the *Action* module.

$$C(t) = \begin{cases} C(t-1) * \alpha & \text{if } S(t) \leq 0.5 \\ \dfrac{S(t) + C(t-1) * \tau}{\tau + 1} & \text{if } S(t) > 0.5 \end{cases}$$

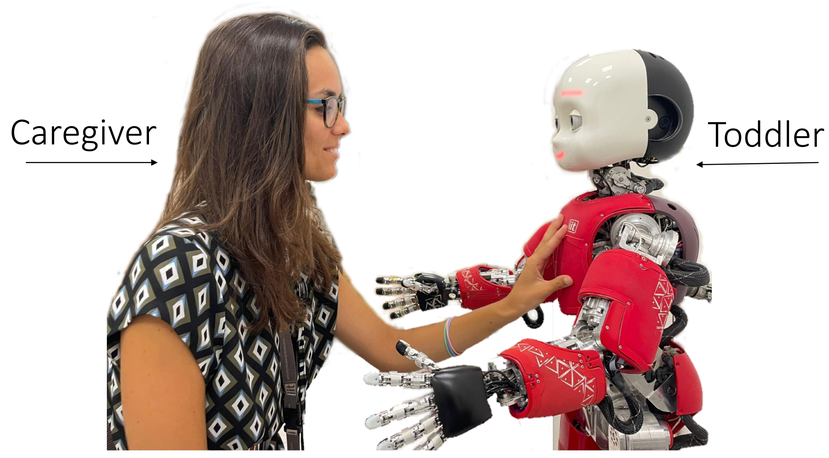
C(t): R-cortisol value at time t; *S(t): stressor* value at time t; τ, α: social variables setting the decay and growth rate of *C(t)* and *S(t)*.



❖ Design of two robot attachment styles inspired by the children's attachment style **anxious** and **avoidant** and their cortisol dynamics [1,2].

Validation Study

Replication of the **Still Face** (SF) and **Still Face + Touch** (SF+T) **Paradigm** [3].

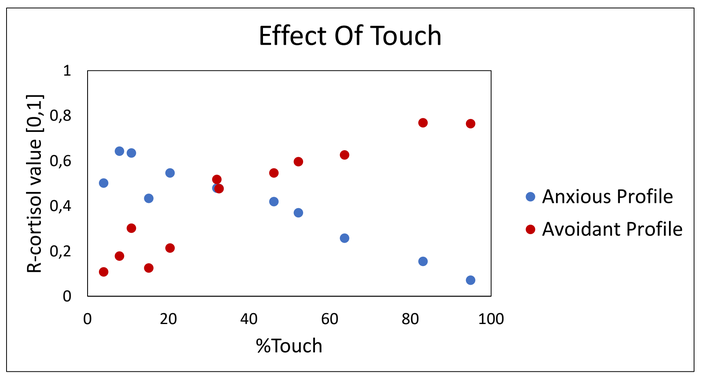


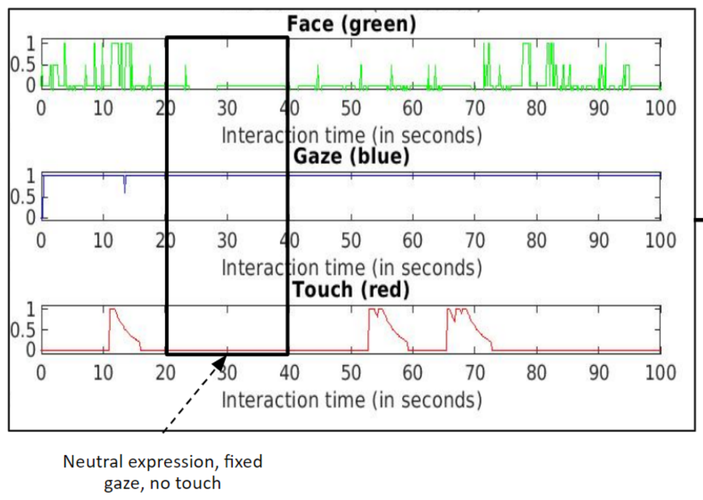
N=6: 3 with "*anxious iCub*", with "*avoidant iCub*".

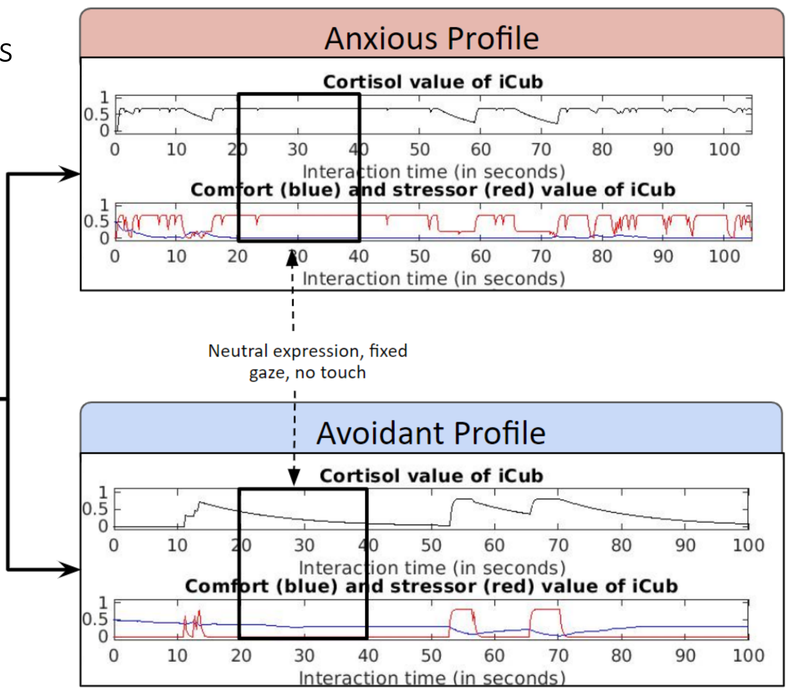
The experimenter narrated to the participants how the robot would have reacted to their current interactive behaviors.

Preliminary Results

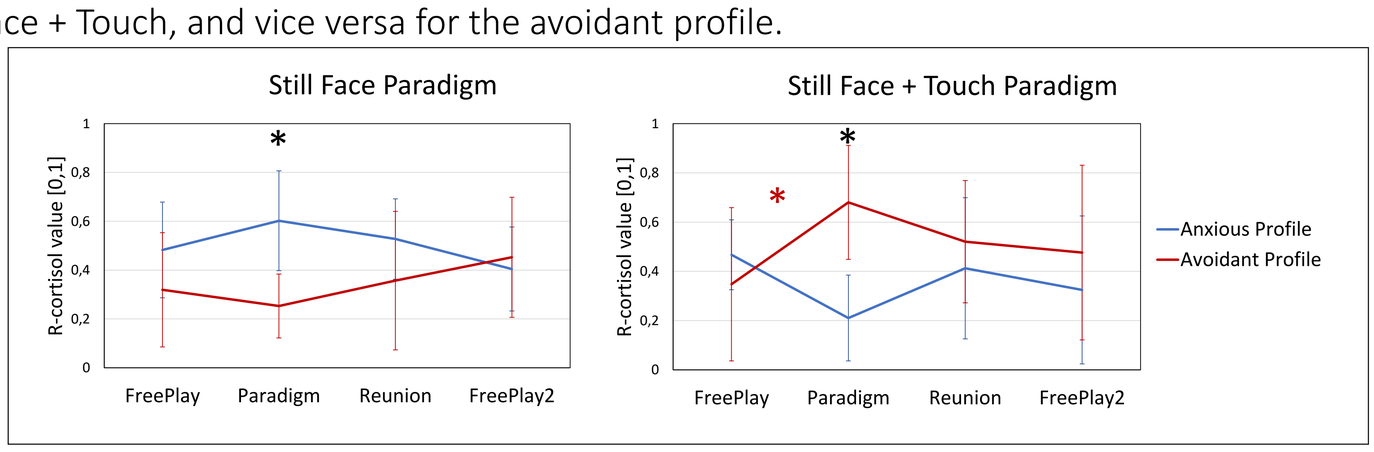
- The two robot attachments styles are characterized by a different *sensitivity to interaction stimuli,* that is reflected by a different stress sensitivity (σ) and cortisol reaction after being exposed to the same stimuli.
- A higher frequency of touches causes higher R-cortisol values in the avoidant profile than in the anxious profile: the former perceives touch as a stressor, while touch is a source of comfort for the latter.







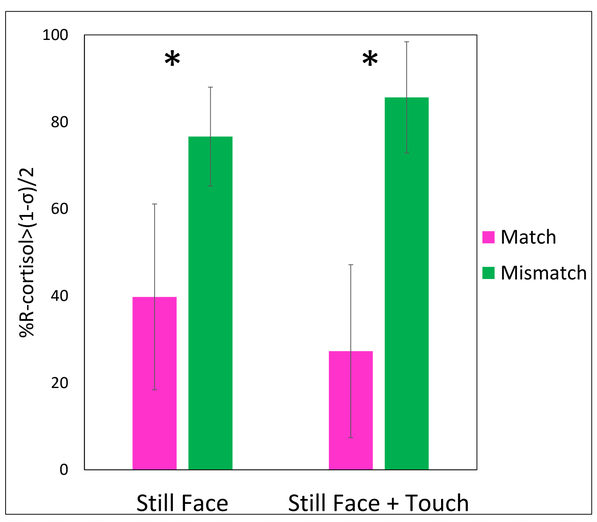
- The Still Face period elicits a higher R-cortisol growth in the anxious profile than the Still Face + Touch, and vice versa for the avoidant profile.



- We defined the participant as "interactive" if *(%TimeTouch + %TimeSmile)>35%.* Hence participants' interaction style could match (or not) with the robot's attachment style:

	Anxious	**Avoidant**
Interactive	Match	Mismatch
Not interactive	Mismatch	Match

The R-cortisol is lower if there's a match during the interaction then a mismatch, as in [4].



Discussion

❖ We tested two robot's attachment styles and the cortisol-inspired framework with different sets of stimuli, and the preliminary results are in line with findings in human literature [5].

❖ The dynamic of the R-cortisol, coupled with the knowledge of the robot's attachment style, reveals the style of the interaction experienced.

Future Work

❖ Integrate a speech detection into the perception.

❖ Test the framework in free-form human-robot interactions.

References

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