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Wellbeing and the adaptive value of pain

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Background

- Pain is an important feature of our **survival system** [1], as it conveys an **unpleasant sensory and emotional experience** linked to real or potential physical **damage** [4].
- Pain also has a big negative impact on *physical and mental wellbeing*.
- In evolutionary older environments, with survival-related dangers such as predators, this signal gave us advantages by allowing us to **perceive, respond to, and avoid** such dangers.
- However, **nowadays environments**, with **fewer survival-related dangers** and presenting very different features, pain is less often associated with survival threats or with actual physical damage (e.g., **chronic pain**), and the **perception of pain does not necessarily have a strict correlation with physical damage**.
- Given the very disruptive consequences on people's daily activities, health and wellbeing, **it is not clear whether it is still adaptive to feel pain** [7].

Robot model

We present a **bio-inspired decision-making robot model** and experiments to study the adaptive value of pain and its perception in environments with different amounts of survival-related dangers - ranging from high levels, as found in "ancestral" environments, to low levels, as in "modern" environments - and different levels of correlation between physical damage and pain - strict correlation between damage and pain, hypersensitivity, and hyposensitivity to pain.

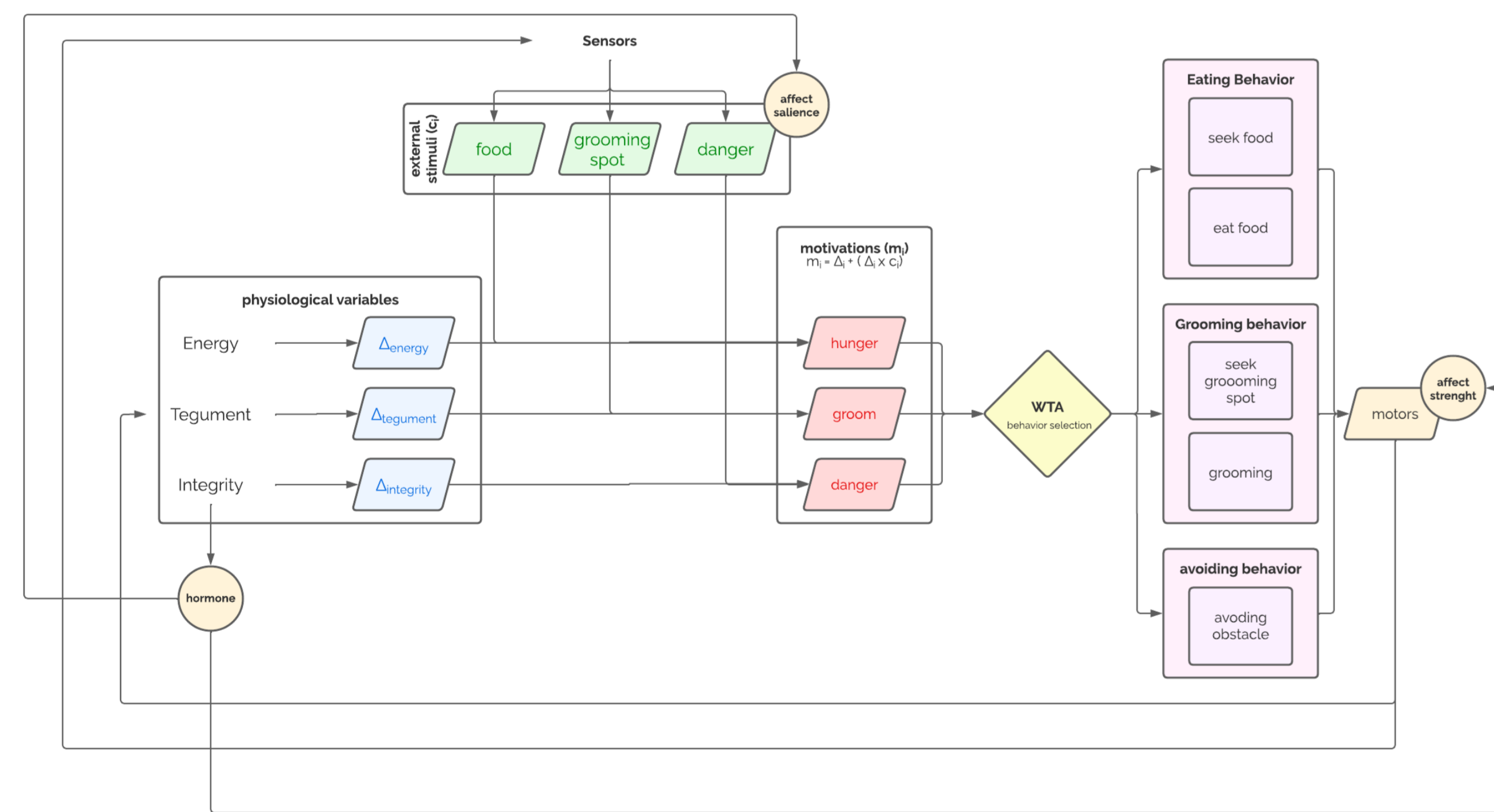


Figure 1. Model of homeostatic driven behavior-selection

- Physiological variables** defines robot internal state
- Deficits** defines the error of the variables' value with its ideal value
- Cues** represent the signal that warns robot about resources
- Motivations** are computed using the following formula : $mot_i = \Delta_i + (\Delta_i * cue_i)$ [2]

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AR4W: Affective Robotics for Well-being

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Figure 2. Experimental setup

Damage, Pain and neuromodulatory effect

In addition, the robot can suffer *damage* to its physical integrity from collisions and attacks from predators.

- Damage is detected by **artificial nociceptors** sensitive to different types of contact [6]
 - Scratching
 - Impact
- A simulated *hormone* signaling *perceived damage* is released upon detection of damage at a *release rate* :

$$r_g = \alpha * damage$$

- The hormone release rate (r_g) is set (through the α parameter) to correspond to a
 - strict correlation** between damage and pain,
 - hypersensitivity** to pain,
 - hyposensitivity** to pain
- Hormonal concentration* c_t is computed as follows :

$$c_t = \max(1, c_{t-1} + r_g - \mu)$$

- where μ is a decay rate slower than the release rate, producing a "memory" over time.
- Hormone concentration has a **"neuromodulatory" effect** [3] on the **salience** of the **external stimuli** linked to motivations (and, hence, indirectly on the intensity of motivations) and on the **strength of motor actions**.

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Experimental Results

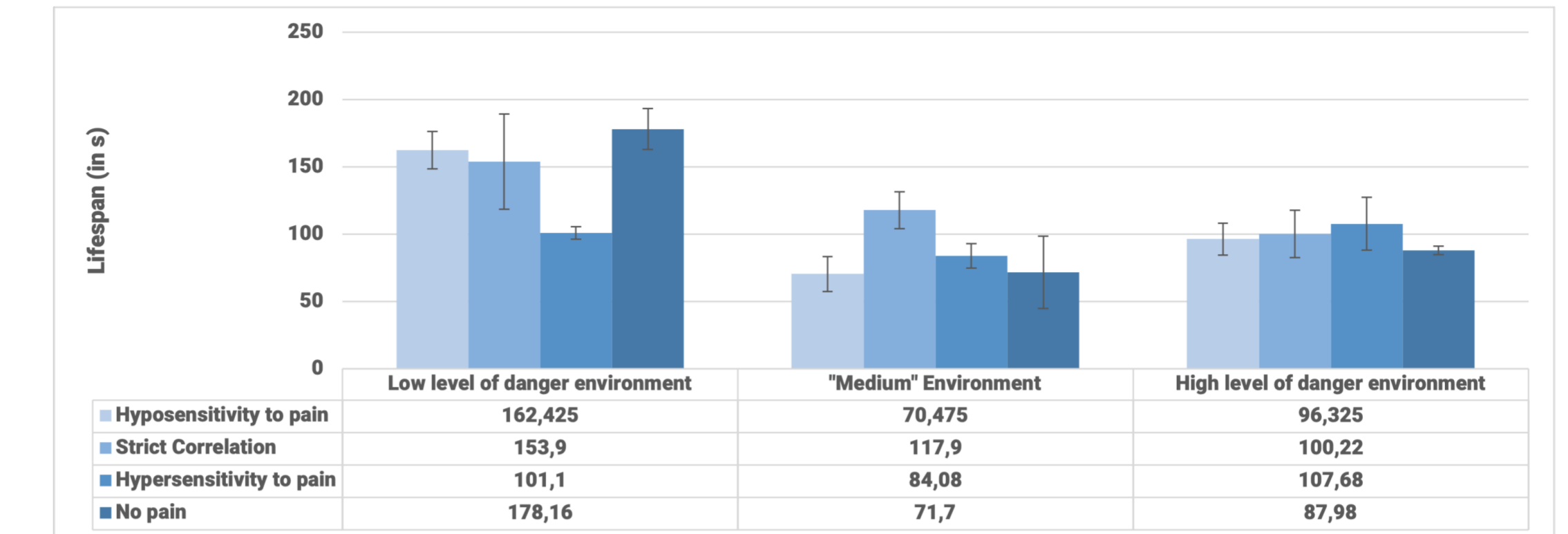


Figure 3. Lifespan (in s) depending on pain-damage correlation and scenarios

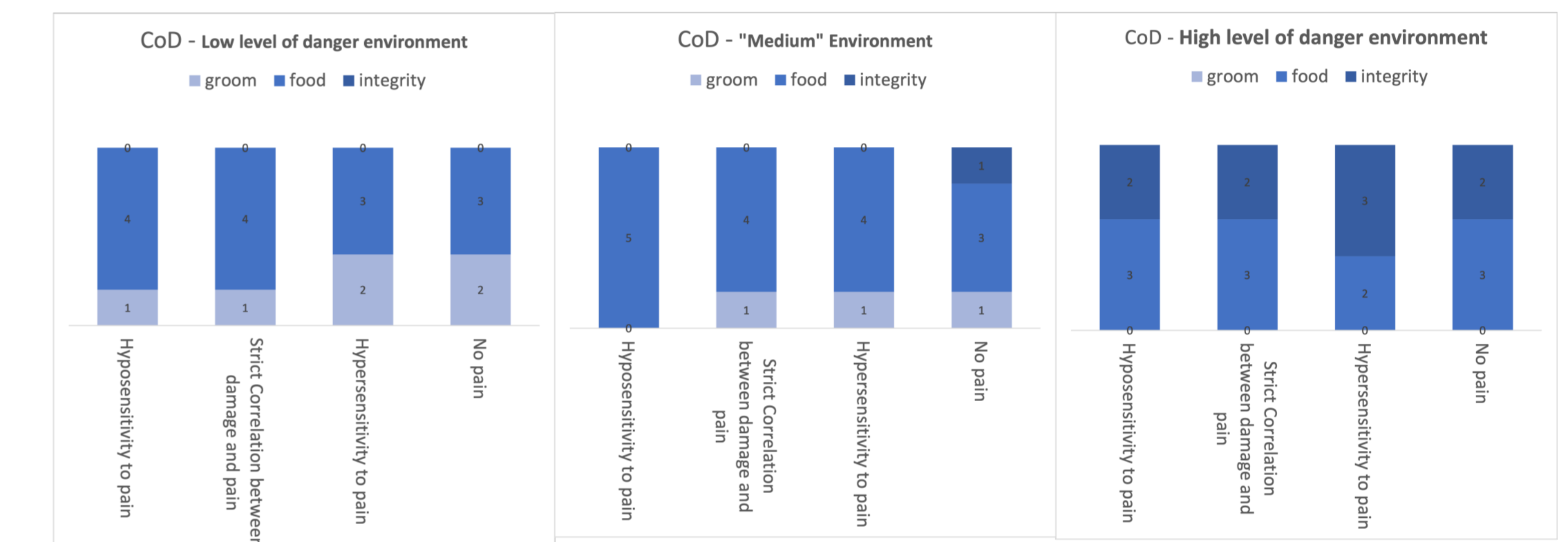


Figure 4. Cause of Death (CoD) depending on pain-damage correlation and scenarios

Conclusion and perspectives

- We measured the performance of the robot under these different conditions in terms of its *lifespan* (Fig. 3), *cause of death* (C.o.D) (Fig. 4). Our results show:
 - In our specific conditions, the adaptive value of pain seems to depend on both environment and sensitivity
 - In environments with many dangers, the higher the level of pain "experienced", the better the performance of the robot in terms of survival
 - in environments with little danger, the lower the level of pain "experienced", the better the performance of the robot
- We believe that this robot model can be useful first step towards understanding pain perception in humans in environments with different features, particularly regarding how different sensitization to pain can affect our behavior.
- It can also contribute to gain understanding of the evolutionary origins of pain, which are often neglected in clinical research.

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