



HAL
open science

Wellbeing and the adaptive value of pain

Louis l'Haridon, Amanda C de C Williams, Lola Cañamero

► **To cite this version:**

Louis l'Haridon, Amanda C de C Williams, Lola Cañamero. Wellbeing and the adaptive value of pain. AR4W: Affective Robotics for Well-being, Oct 2022, Virtual event, Japan. <https://sites.google.com/rosielab.ca/ar4w2022/home>. hal-04158588

HAL Id: hal-04158588

<https://hal.science/hal-04158588v1>

Submitted on 11 Jul 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Wellbeing and the adaptive value of pain

Louis L'Haridon¹ Amanda C. de. C. Williams² Lola Cañamero¹

¹ETIS Lab - CNRS (UMR 8051)- CY Cergy Paris University, France ²Clinical, Health and Educational Psychology - University College London, United Kingdom

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.

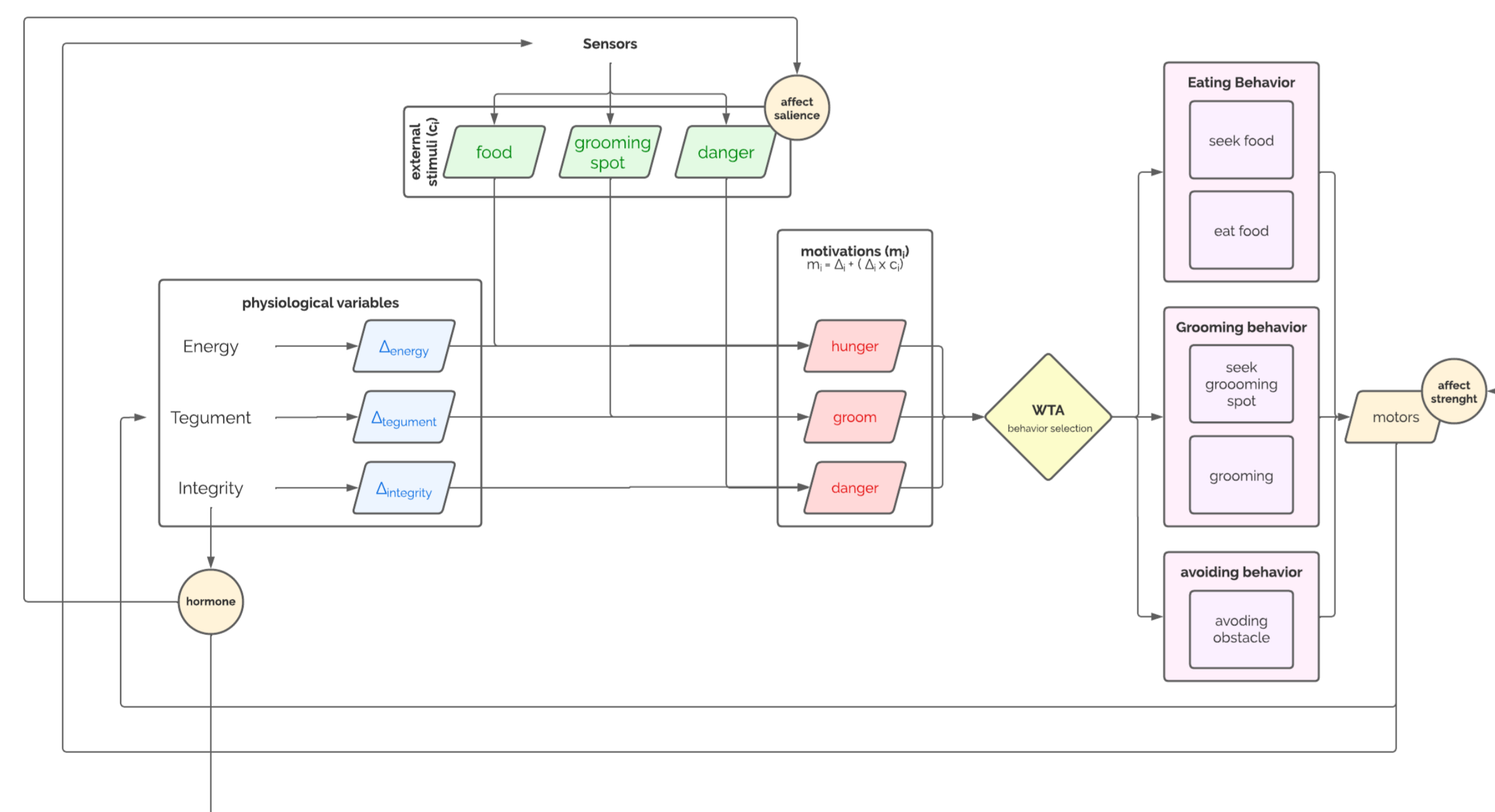


Figure 1. Model of homeostatic driven behavior-selection

- 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]



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**.

References

- de C. Williams, A.C., Craig, K.D.: Updating the definition of pain. *Pain* **157**(11), 2420--2423 (May 2016).
- Cañamero, L., Avila-García, O.: A bottom-up investigation of emotional modulation in competitive scenarios. In: Paiva, A.C.R., Prada, R., Picard, R.W. (eds.) *Proc. Second International Conference on Affective Computing and Intelligent Interaction (ACII 2007)*. Lecture Notes in Computer Science, vol. 4738, p. 398--409. Springer Berlin Heidelberg, Springer Berlin Heidelberg, Lisbon, Portugal (09/2007 2007).
- Chen, X., Zhang, J., Wang, X.: Hormones in pain modulation and their clinical implications for pain control: a critical review. *Pain* **153**(3), 313--320 (Sep 2016).
- Kandel, E.: *Principles of neural science*. McGraw-Hill, New York (2013)
- Lewis, M., Fineberg, N., Cañamero, L.: A robot model of OC-spectrum disorders: Design framework, implementation, and first experiments. *Computational Psychiatry* **3**(0), 40,F (Aug 2019).
- Maniscalco, U., Infantino, I.: An artificial pain model for a humanoid robot. In: De Pietro, G., Gallo, L., Howlett, R.J., Jain, L.C. (eds.) *Intelligent Interactive Multimedia Systems and Services 2017*. pp. 161--170. Springer International Publishing, Cham (2018)
- Paepe, A.L.D., de C. Williams, A.C., Crombez, G.: Habituation to pain: a motivational-ethological perspective. *Pain* **160**(8), 1693--1697 (Feb 2019).

Experimental Results

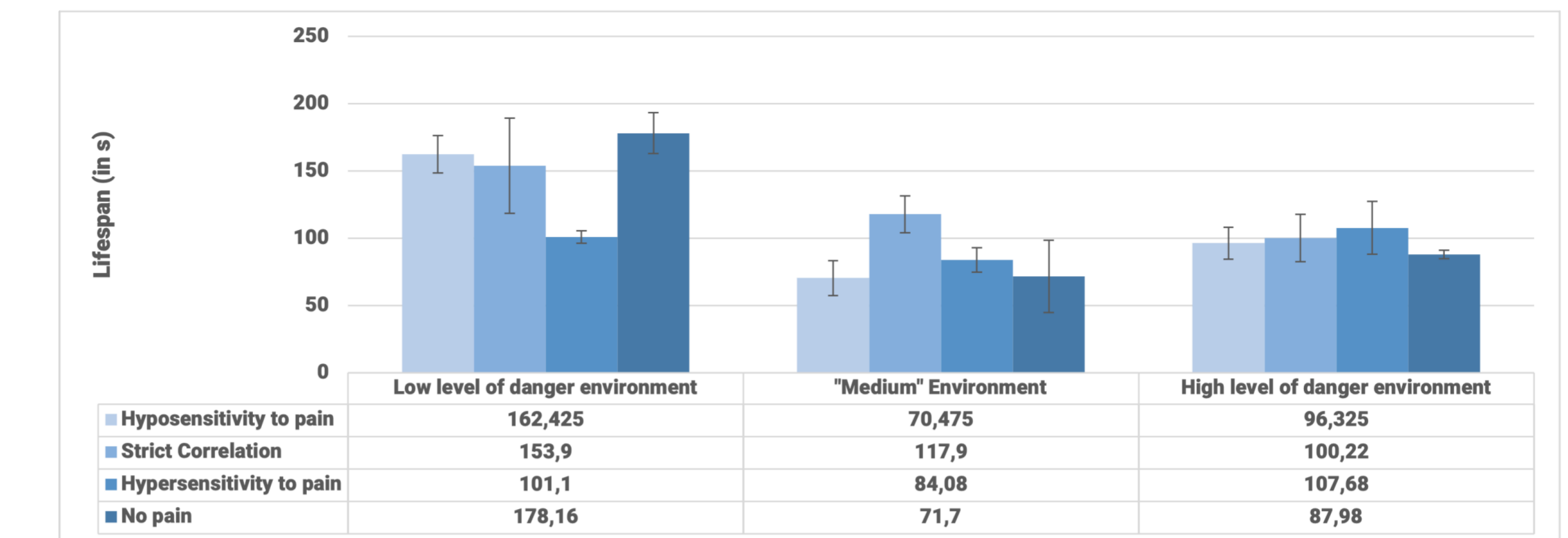


Figure 3. Lifespan (in s) depending on pain-damage correlation and scenarios

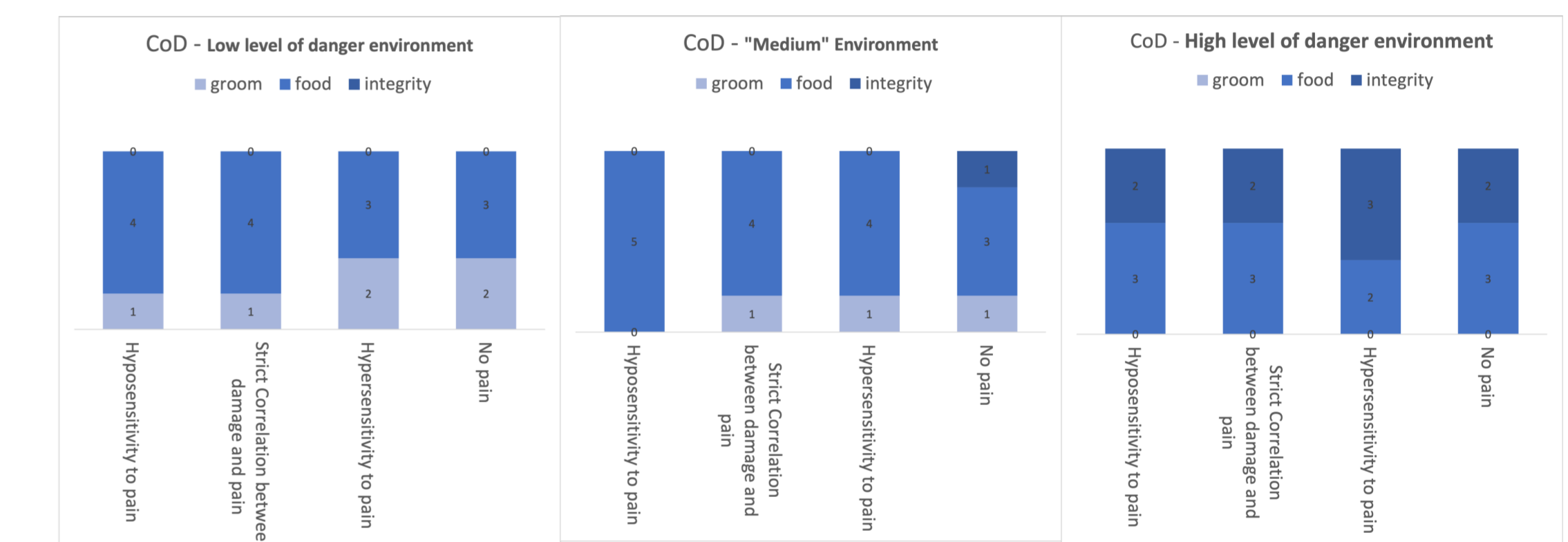


Figure 4. Cause of Death (CoD) depending on pain-damage correlation and scenarios

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.

Aknowledgments

LLH is funded by a PhD studentship as part of LC's INEX Chair in Neuroscience and Robotics.