Avoiding the pain or pursuing the pleasure? The affective roots of decision making, from humans to robots and back

M2 Internship defense

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Plan

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Introduction

Aristotle

The aim of the wise is not to secure pleasure, but to avoid pain.

- Short term objectives
  - Critical analysis of neuroscience literature on the impact of pain and pleasure on decision making.
  - Creation of a first bio-inspired robotic model on pain and their impact on autonomous decision making
  - Elaboration of experiments in an ecologically valid scenario which can be later used in pain and wellbeing further studies
  - Work discussed with Amanda Williams, an academic and clinical psychologist at University College of London who specializes in pain and affective technology
- Perspectives
  - Reflection and development of a model which could be use as a theorical and experimental tool for neuroscience and psychology

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State of the art

- Biology of Pain - evolutionary roots (Williams, 2019)
  - Predators, can impress or deter by appearing healthy and strong. => Perceived pain can affect impression
  - Rudimentary form of empathy in mice, emotional contagion caused by intense pain (Williams, 2002)
  - Pain is often expressed inappropriately ("smoke detector principle", mismatch with the modern environment) (Neese, 2019)
- Biology of Pain - main features nowadays (Kandel, 2013)
  - "Pain describes the unpleasant sensory and emotional experiences associated with actual or potential tissue damage."
  - Perception is influenced by emotional state and environmental contingency
  - Not necessarily proportional to damage. (Williams, 2020)
- Nociception (Kandel, 2013)
  - Nociceptors induce pain sensation, several types.
  - First pain is prolonged with second pain (Dubin, Patapoutian, 2010)
  - Persistent pain characterizes many clinical conditions, the reason that patients seek medical attention (Paepe, Williams, 2019)

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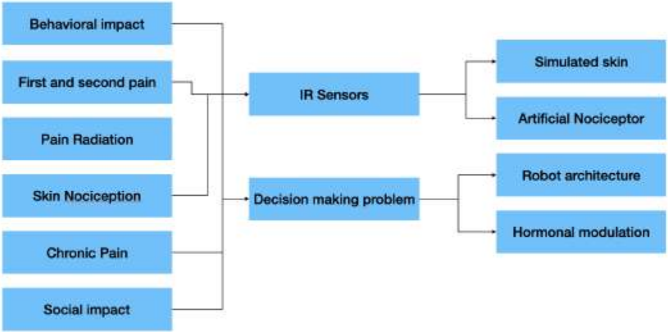
Research question

- How can pain and pleasure impact a fundamental decision-making architecture ?
- Looking at the relation between pain and physical damage, how can coorrelation hypersensitivity or hyposensitivity be adaptive or maladaptive depending on the environment ?



Robot's model

Variables, Deficits, Cues and Motivations

(Finberg, Canamero, 2019)

$$deficit_i = \theta_i - value_i \tag{1}$$

$$motivation_i = d_i + (d_i * c_i)(Tyrrell, 1993) \tag{2}$$

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Artificial nociceptors

Définition

There is two types of nociception inducing :

1. *Impact damage : speed* $= \frac{\delta_d}{T_{iteration}}$
2. *Scratching damage : speed* $= \frac{\theta r}{T_{iteration}}$

$nociceptor[i] = 0.5 * impact[i] + 0.5 * scratching[i]$

Définition

1. *Generate 5 arrays of 5 values* $array_i[5]$
2. *for i in range (5) :*
   1. $array_i[i] = nociceptor[i]$
   2. *Following a gaussian, intensity of a* $array_i[i]$ *will radiate to its neighbors*
3. *for i in range(5) :* $nociceptor[i] = \frac{\sum_{j=1}^{5} array_j[i]}{5}$

Artificial hormones : Pain

Hormone characteristics (Canamero, Avila-Garcia, 2002, 2007)

Release rate : $r_{pain} = \alpha$ * damage

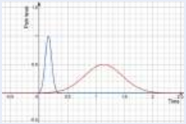
- **hypo-correlation** to damage, α=0.1
- **normal-correlation** to damage, α=0.2
- **hyper-correlation** to damage, α=0.4

Hormonal concentration : $c_{pain}(t+1) = min(1, c_{pain}(t) * \psi_{pain} + r_{pain})$

Second Pain

Bimodal distribution equation :

$$f(x) = max(1 * e^{-(0.5*(-3+18*x))^2}, 0.5 * e^{-(0.5*(-3,4+3*x))^2})$$



Artificial hormones : Pleasure

Wellbeing

$$wellbeing = 100 - (def_{energy} + def_{integument} + def_{integrity})$$

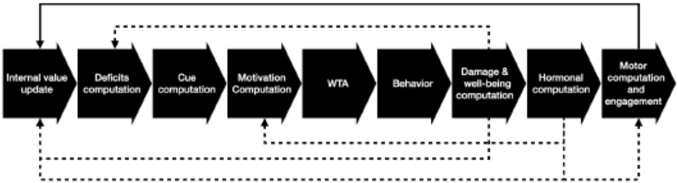
Release Rate

$$r_{pleasure} = 0.01 * wellbeing$$

Homonal concentration

$$c_{pleasure}(t+1) = min(1, c_{pleasure}(t) * \psi_{pleasure} + r_{pleasure})$$

AS Model with neuromodulation



- Damage will impact integrity internal value and so, deficit
- Pain will impact motor engagement and avoidance motivation

$$wheel[g/d] = wheel[g/d] + (1 + c_{pain}) * sign(wheel[g/d]) * cst \quad (3)$$

$$m_{avoid} = m_{avoid} + m_{avoid} * \beta * c_{pain} \quad (4)$$

- Pleasure will impact grooming and energy motivations

$$m_i = m_i + \beta * c_{pleasure} * m_i \quad (5)$$

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Condition tested and scenarios

It's pain experience rather than damage that will impact decision making.

	Hypo-Pain	Normal	Hyper-Pain	No pain
No Obstacles No Predators	1Hypo	1Norm	1Hyper	1None

Scenario 1 - no obstacle and no predator

	Hypo-Pain	Normal	Hyper-Pain	No pain
Obstacles No Predators	2Hypo	2Norm	2Hyper	2None

Scenario 2 - obstacles but no predator

	Hypo-Pain	Normal	Hyper-Pain	No pain
Obstacles Predators	3Hypo	3Norm	3Hyper	3None

Scenario 3 - obstacles and predators

Scenario 1 - no obstacle and no predator

Scenario 2 - obstacles but no predator

Scenario 3 - obstacles and predators

Predictions

1. In non dangerous environment, experience of pain is maladaptive (scenario 1)
2. In non dangerous environment, pain insensitivity is adaptive (scenario 1)
3. In moderate danger environment, experience of pain is adaptive (scenario 2 with grooming spots)
4. In dangerous environments, experience of pain is adaptive (scenario 3)
5. In dangerous environments, the more the pain is experienced the more it is adaptive (scenario 3)

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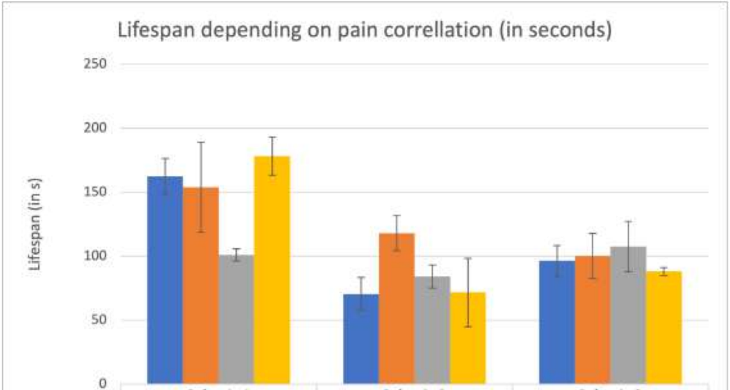
Lifespan (in s) according to scenarios and pain-damage correlation

Results after 5 runs of each.



	Scénario 1	Scénario 2	Scénario 3
Hypo-Pain	162,425	70,475	96,325
Normal	153,9	117,9	100,22
Hyper-Pain	101,1	84,08	107,68
No pain	178,16	71,7	87,98

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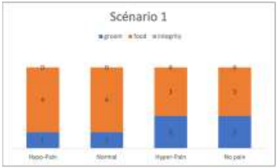
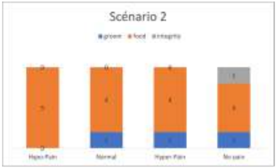
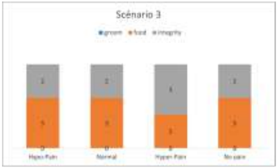
Cause of death depending scenarios and pain-damage correlation



Cause of death for scenario 1



Cause of death for scenario 2



Cause of death for scenario 3

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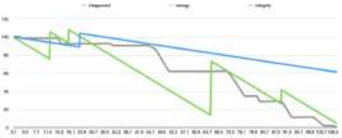
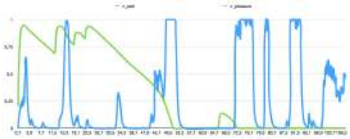
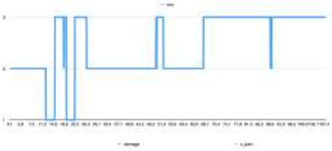
Hyper-Pain in scenario 3



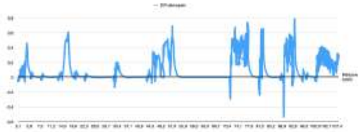
Physiological variables over time (green- energy, blue- integument, grey-integrity



Hormonal level over time (blue pain, green pleasure)

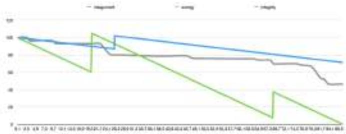


Selected scenario over time (1-groom, 2-food, 3-avoid)

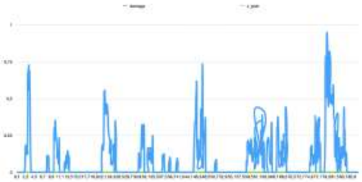


Difference between damage and pain

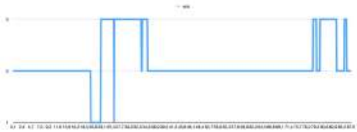
No Pain in scenario 3



Physiological variables over time (green- energy, blue- integument, grey-integrity

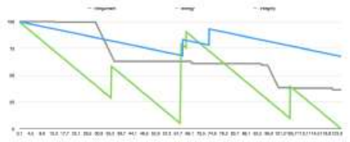


Damage level over time

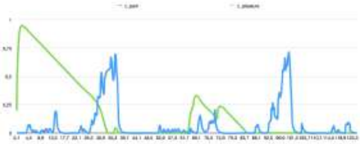


Selected scenario over time (1-groom, 2-food, 3-avoid)

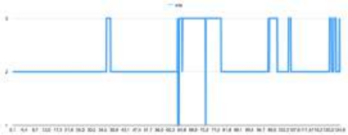
Normal pain in scenario 2



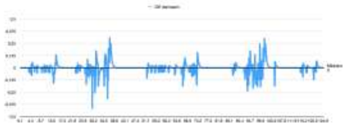
Physiological variables over time (green- energy, blue- integument, grey-integrity



Hormonal level over time (blue pain, green pleasure)

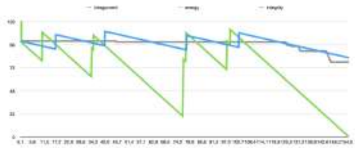


Selected scenario over time (1-groom, 2-food, 3-avoid)



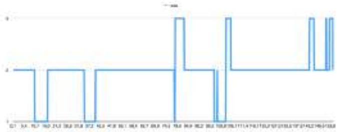
Difference between damage and pain

Hypo-pain in scenario 1

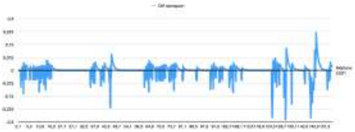


Physiological variables over time (green- energy, blue- integument, grey-integrity

Hormonal level over time (blue pain, green pleasure)



Selected scenario over time (1-groom, 2-food, 3-avoid)



Difference between damage and pain

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Predictions confirmation ?

1. In non dangerous environment, experience of pain is maladaptive (scenario 1) : **true**
2. In non dangerous environment, pain insensitivity is adaptive (scenario 1) : **true**
3. In moderate danger environment, experience of pain is adaptive (scenario 2 with grooming spots) : **true**
4. In dangerous environments, experience of pain is adaptive (scenario 3) : **true**
5. In dangerous environments, the more the pain is experienced the more it is adaptive (scenario 3) : **true**

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Conclusion and perspectives

In conclusion :

- Pain can be maladaptive in a environment with no life-threatening obstacles or predators, consistent with modern environment (Williams, 2002, 2016 and 2019) => insensitivity to pain can be adaptive in those scenarios
- Pain can be adaptive in environments with dangers and predators reminiscent of evolutionary older environments (Williams, 2019) => The more the danger there is, the more hyper-sensitivity to pain can be adaptative

Perspectives :

- We will evaluate long-lasting and chronic pain impact on our robot model
- For example we will evaluate it on a developmental context where robot has to face predating in its early life or in its later life.