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Induced emotions and impact on reasoning and decision-making

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Induced emotions and impact on reasoning and decision-making

Contribution of virtual reality and autonomous nervous system measurements

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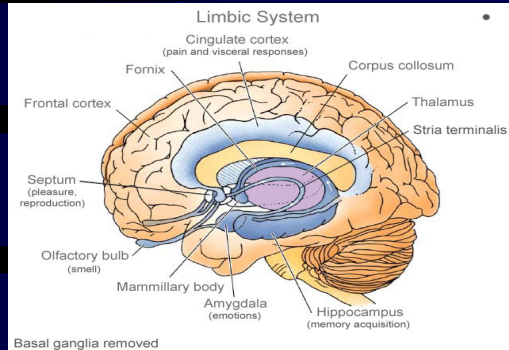
^a UMR 455 « Functional Neuroimaging, Cerebral Plasticity and Neurological Pathology », INSERM & University Paul Sabatier, Toulouse, France ; ^b IRIT, UMR 5505 CNRS, INPT & UPS

Stress and complex environment

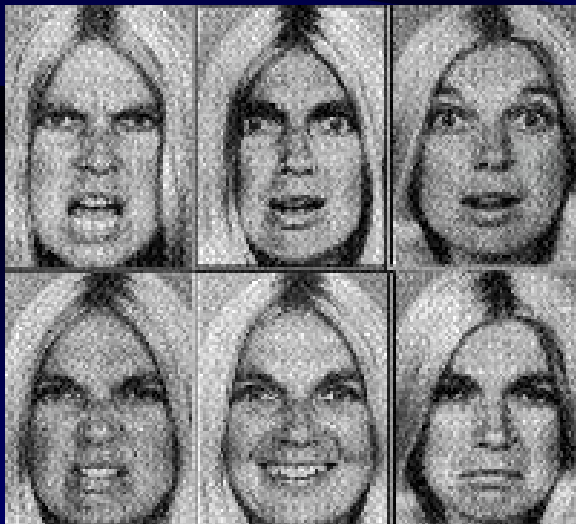
- **Pilot / Flight management system interaction that can affect pilot performance in critical situations (Sarter & Woods 1994)**
- **Degraded situations of flights (temporary dysexecutive syndrome) potentially source of air crashes (Dehais 2003).**
- **Operators of Complex Plants (Cacciabue 1988)**
- **Neuroergonomics: opportunities and challenges of merging cognitive neuroscience with cognitive ergonomics (Sarter & Sarter 2003)**
- **Neuroergonomics: the brain at work (Rizzo et al. 2006)**

 **Role of emotion on cognitive performance: cross-fertilization between neuropsychology and ergonomics**

Emotions

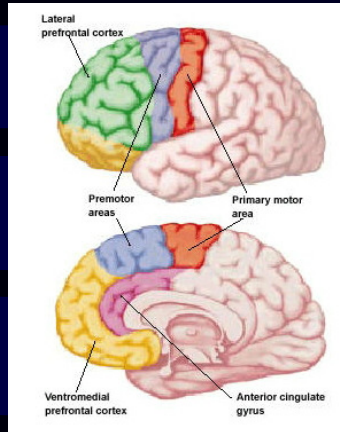


- Discovery of the “limbic lobe” by Broca (1878)
- James Papez (1930) described a “system of the emotion” located in the medial part of the brain
- Definition of the “limbic system” by Paul Mc Lean (1952)



- A physiological change in response to a stimulus (external or internal), including three main components: subjective experience, physiological answers and behavioral expressions (Scherer 2000)
- Two essential dimensions: valence and activation (Izard 1993)
- 6 basic emotions: Anger, Fear, Surprise, Disgust, Enjoyment and Sadness (Ekman 1984)
- It is distinguished from mood by its brevity

Executive functions (EF)



- Implemented by multiple areas: p.c. (in particular dorsolateral p.c), anterior cingulate cortex, striatum, cerebellum (Kramer et al. 2002 ; Gazzaniga et al. 1998)



- “Orchestra director” of the brain: motivation, production, decision-making, control and evaluation (Lezak, 1994) of goal oriented actions. In particular during new situations
- Three main executive processes: update, shifting and inhibition (Miyake 2000)
- Introduced in neuropsychology by the concept of dysexecutive syndrome (Baddeley et al. 1998)
- Can be depleted by traumatic brain injury (Cicerone et al. 2006), Alzheimer (Waltz et al. 2004), Parkinson (Elias et al. 1999)...

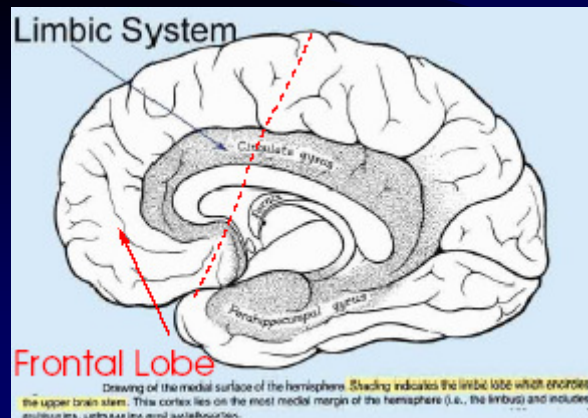
Links between emotion and cognition

A Recent interest:

- Somatic markers (Damasio 1994) stored in orbitofrontal C. (Iowa Gambling task Bechara 1997)
- Impact of the emotions on memorizing (Phelps 2004)
- On the logical reasoning (Blanchette & Richards 2003)

Contradictory results :

- Positive emotion can play a facilitating or disturbing role (Philips et al. 2002),
- Negative emotion may create an improvement (Van Strien et al. 1995) or a degradation (Hogan 2003)
- Diminished emotional abilities degrade (Bechara et al. 2000) or improve decision-making (Shiv et al. 2005)



→ **Modulation of ventromedial P.C on dorsolateral P.C (Simpson et al. 2001)**

Goal of the study

To propose an ecological and well controlled protocol allowing to clarify the ambiguous links between emotion and executive functions

- To measure the variations of the performance generated by the presentation of emotional stimuli
- To record the activity of the autonomous nervous system to guarantee the effectiveness of the emotional stimulation

General hypothesis

- The emotional induction has an influence on the executive functions
- The impact of the emotional stimuli is not an attentional one
- The emotional stimuli lead to modifications of the autonomous nervous system

Experimental protocol

- Material

- Dynamic reasoning
- Deductive reasoning
- Target hitting
- Virtual characters
- Ans measurements

Cognition

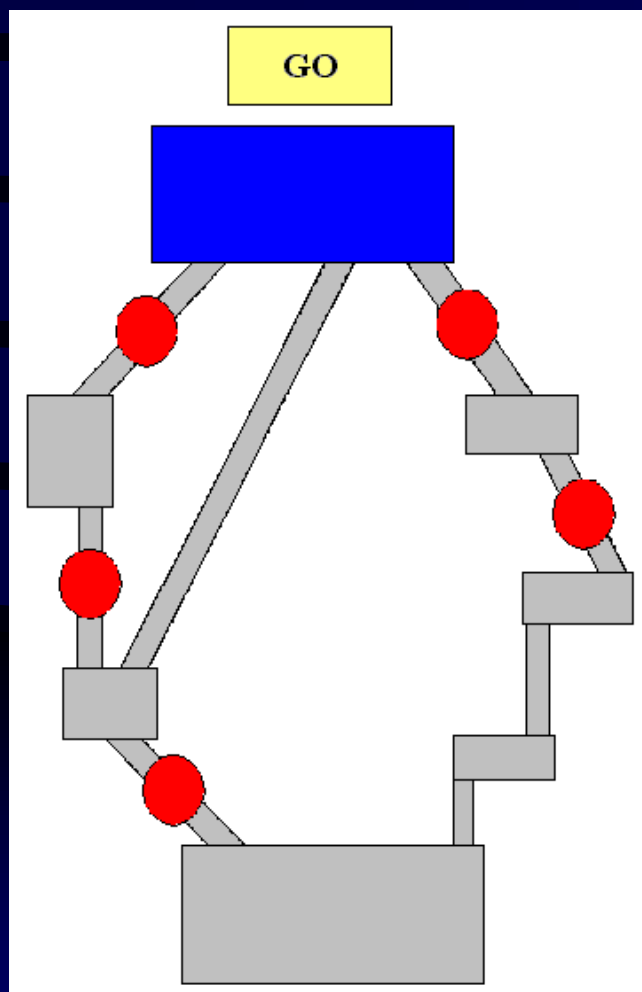
Emotion

- Methods

- Participants
- Experimental design

Microworld test (© Inserm)

Pastor et al. (1998), Pastor



Problem solving in a dynamic environment

An ecological task that strongly involves EF.

-> fill the bottom tank as quick as possible by controlling with on/off valves the water flowing by gravity through a network of tanks and pipes and avoid as much as possible overflowing the intermediate tanks.

Measurements :

- *Loss of water*
- *Time to achieve the task*
- *Strategy*



Déductive Task

Inspired by Natsopoulos et al. (1997)

Evaluation of deductive reasoning abilities

-> Choose among the 3 suggested solutions the one that allows to conclude logically

Measurements :

- % of good answers
- Mean reaction times for correct and incorrect answers

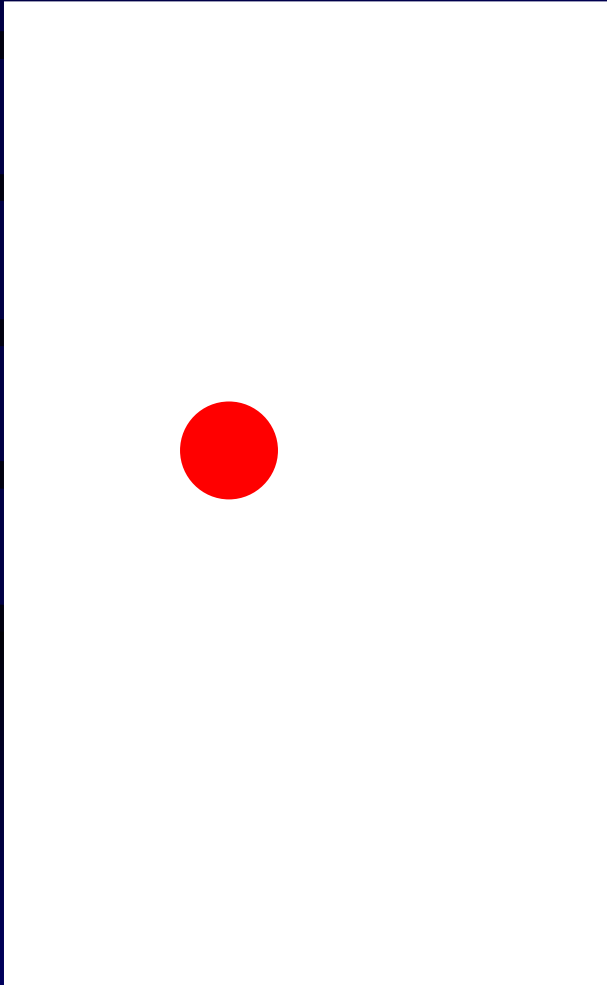
If Gao Xinjian has written « the storm », then Gao Xinjian is not a good writer

Gao Xinjian has not written « the storm »

- 1) *I can't say nothing on his writer abilities*
- 2) *Gao Xinjian is not a good writer*
- 3) *Gao Xinjian is a good writer*



Target hitting (© Inserm)



Visual motor task

Evaluation of visuomotor abilities

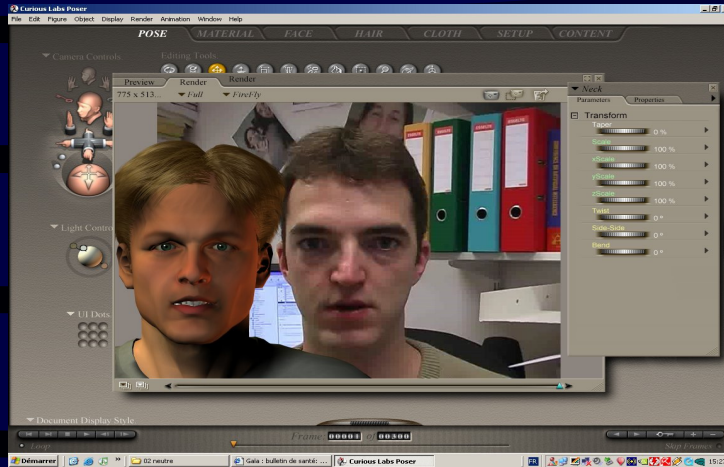
-> To hit as fast as possible a target displayed successively at random locations

Measurement :

- *Velocity index*

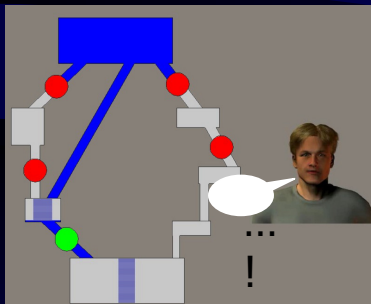


Virtual characters



Poser 6.0 : © Curious labs

- Emotion only conveyed by facial expressions and prosody. Neutral Semantics
- Credibility of the comments
- Intensity of facial expressions quantitatively controlled
- Easy control of visual characteristics such as the luminosity
- More ecological than static images



- Displayed at the periphery of the screen during critical periods in dynamic reasoning task



- Intercalated between syllogisms in full screen for the deductive task



ANS measurements



Eye Tracker (SMI)

■ Pupillary diameter

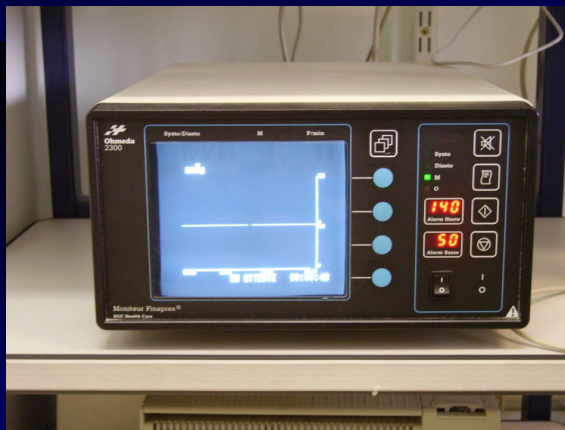
Emotional valence : contradictory results

- Physiology: positive valence → dilation, negative valence → constriction (Hess 1972)
- HMI: pupillary diameter larger during negative stimuli than positive ones (Partal 2000)

Emotional activation: assumption of a continuum (Janisse 1974)

■ Cardiac rate/pressure

- Blood pressure increases during positive and negative emotional stimuli (Nyklicek et al. 1996). More important systolic pressure during a negative emotion than a positive one (Prkachin et al. 1999).



ECG (Finapres)



Participants

12 healthy men

-> Inclusion criteria

- Right handed
- Mother tongue: French
- Age between 22 to 35 years
- Undergraduate or graduate degree

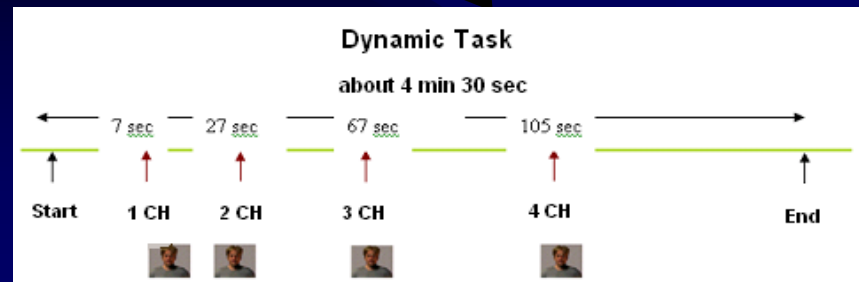
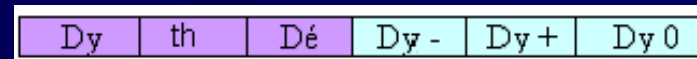
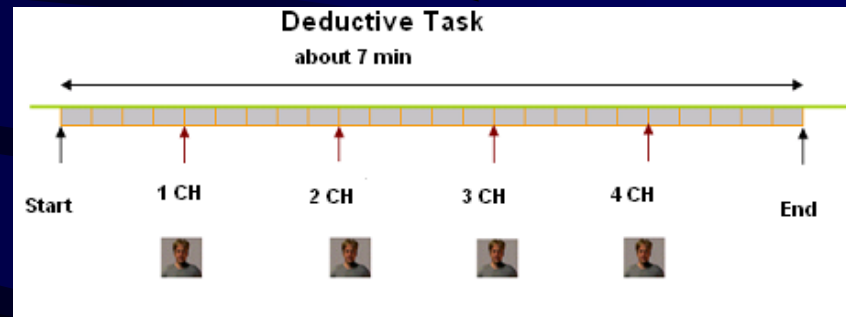
-> Exclusion criteria

- Medications affecting CNS (antidepressants, psychotropics)
- Neurological or psychiatric antecedents
- Sight or hearing deficits
- Logics studied at school



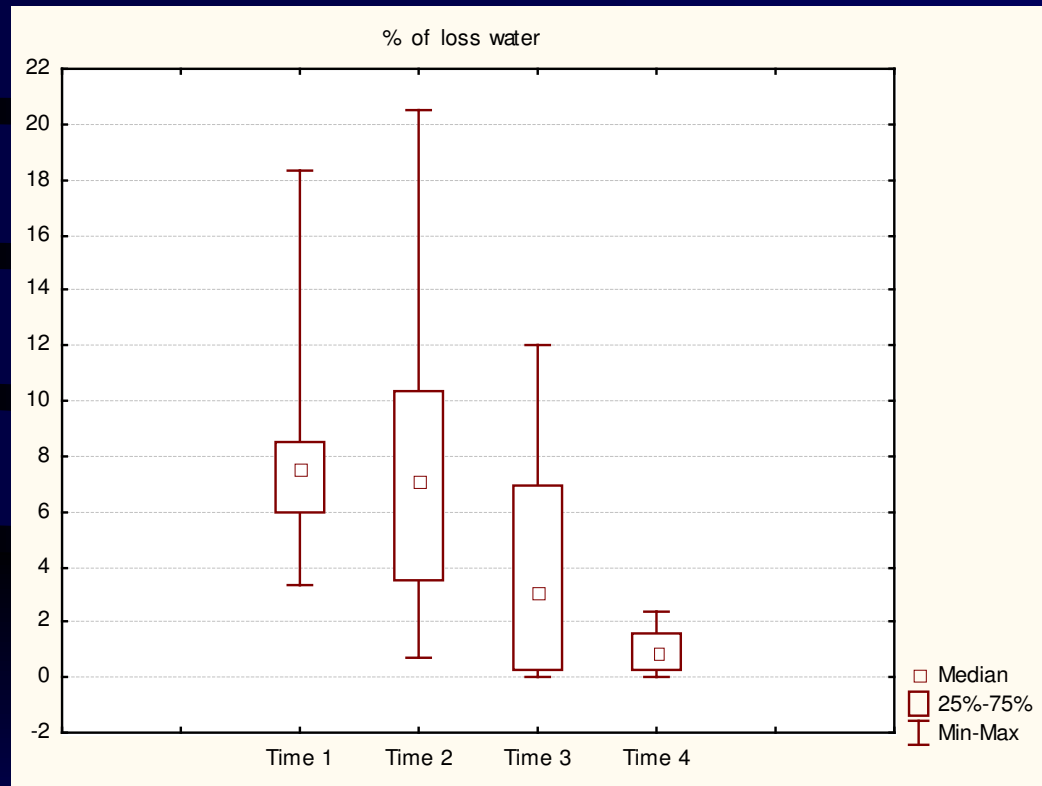
Experimental design

- Independent groups design (dyn and ded)
- Each subject carries out 6 tasks
- Counterbalancing of virtual characters conditions
- Control task always at the same distance of tested tasks



Behavioral results

Dynamic task, learning effects



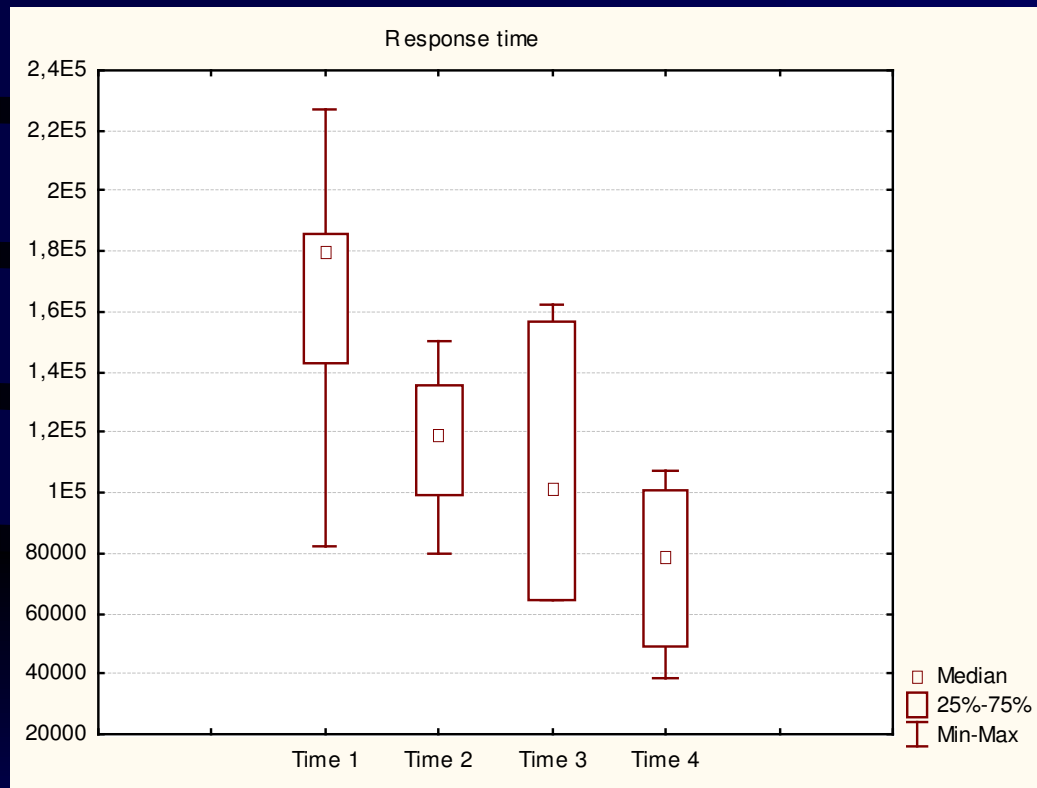
Loss of water :

Participants loose progressively less water during the 4 trials (Friedman $p < 0.01$). Variations mainly between T1 and T4 and T2 and T4 (Wilcoxon $p = 0.04$ in both cases).

No effect on other variables

Behavioral results

Deductive task, learning effect

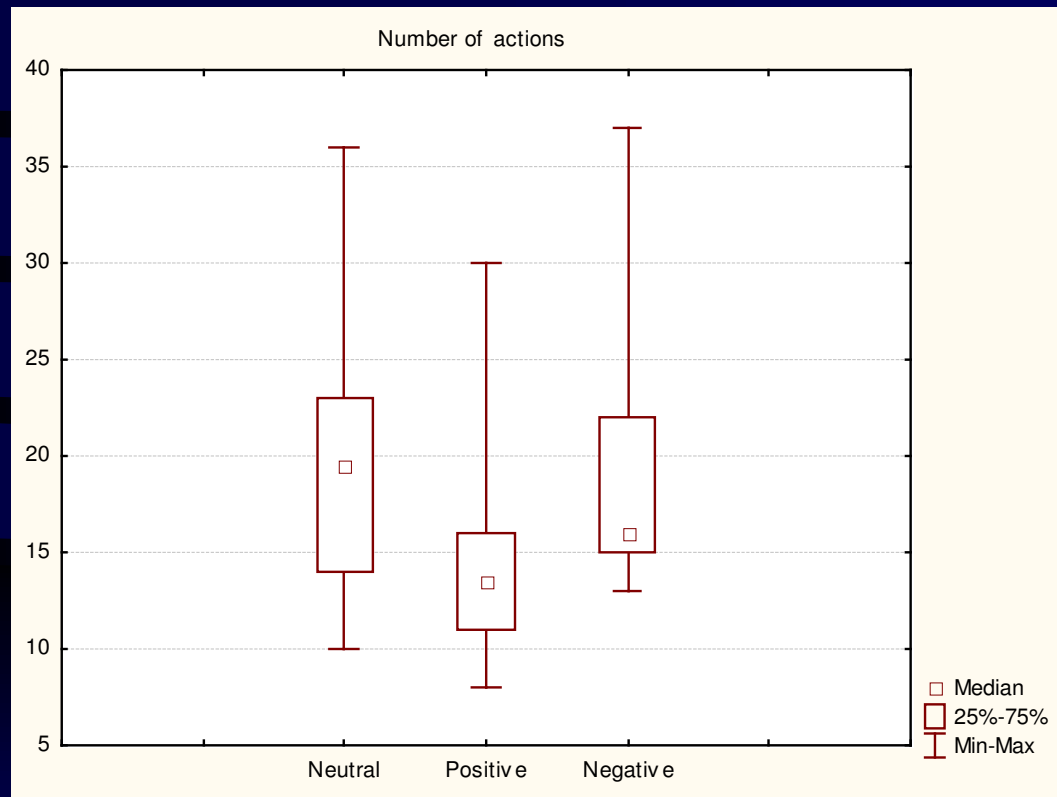


Response time :

Reduction of correct response time during the 4 conditions (Friedman $p < 0.02$) but no improvement in terms of correct answers

Behavioral results

Dynamic task, emotional effects

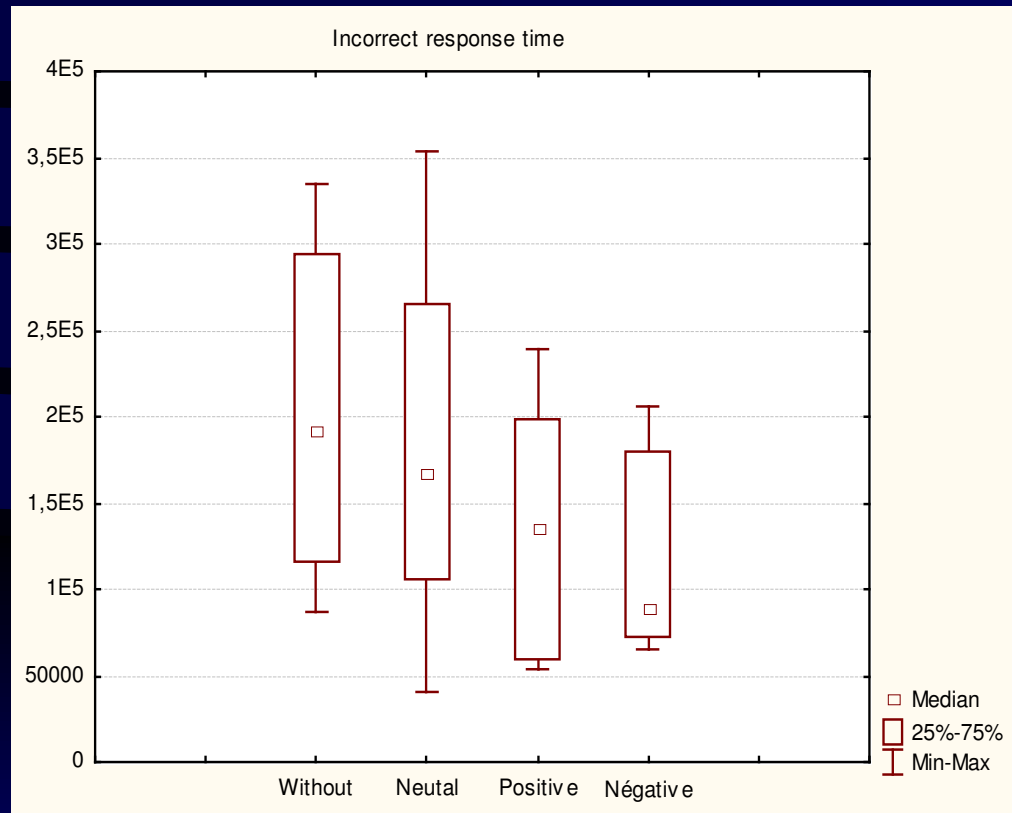


Number of actions :

Significant difference of number of actions (openings and closings of valves) between the 3 emotional conditions (Friedman $p = 0.03$). In particular during the negative condition regarding to the positive one (Wilcoxon $p = 0.02$)

Behavioral results

Deductive task, emotional effects

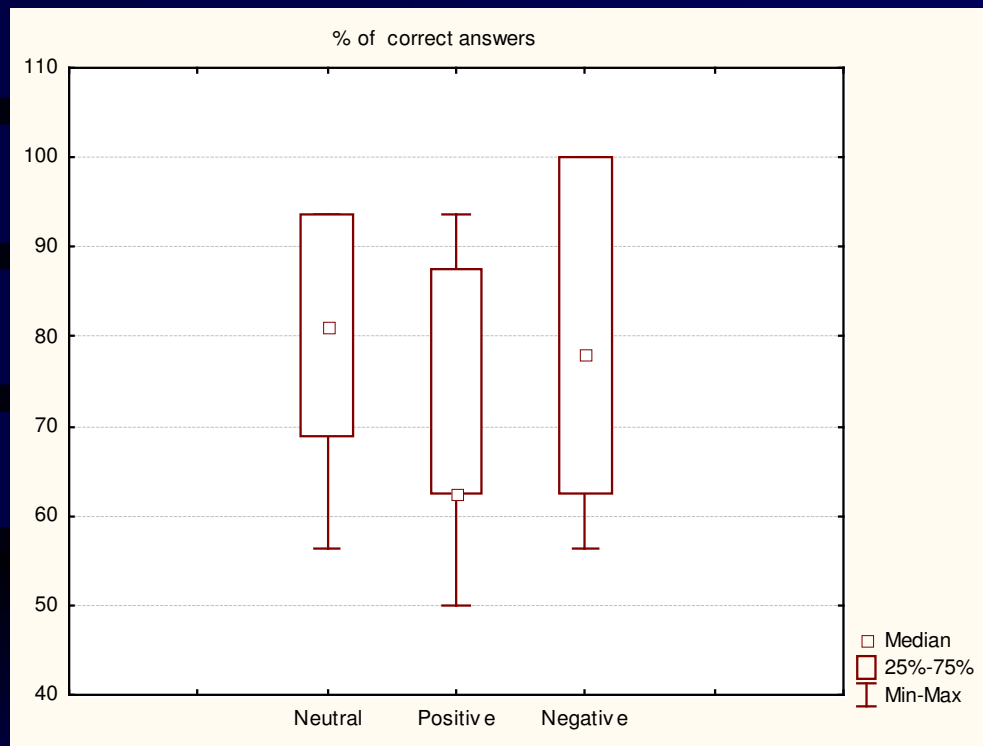


Response time:

Incorrect response times differ between the 4 conditions (Friedman $p = 0.05$). In particular reduction of incorrect response time during the negative condition compared to the without one (Wilcoxon $p = 0.04$)

Behavioral results

Deductive task, emotional effects

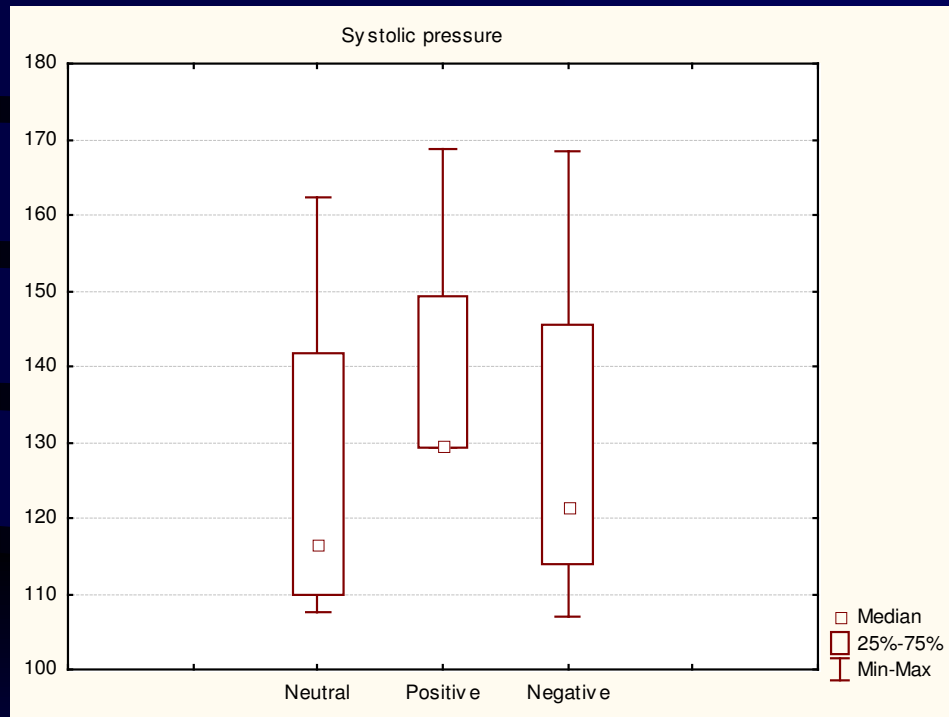


% of correct answers :

Difference between conditions (near threshold: Friedman $p = 0.06$). Degradation of appropriate answers in positive emotional condition compared with the others (Wilcoxon: $p=0.04$ regarding to neutral and $p=0.06$ regarding to negative).

ANS results

Deductive task, emotional effects



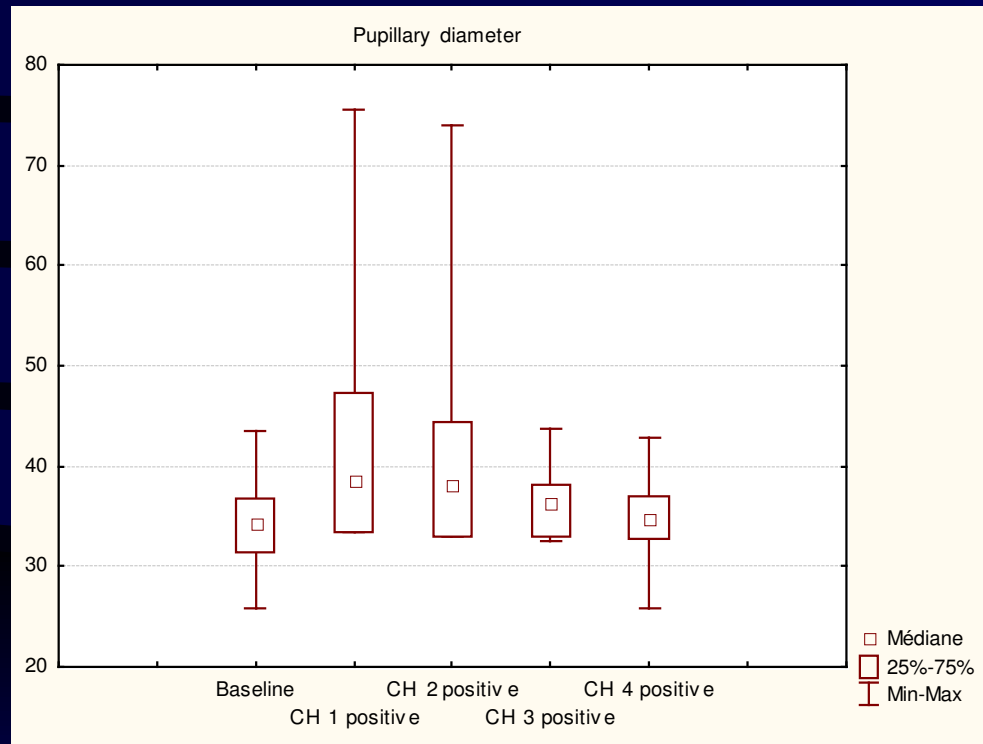
Systolic pressure :

It differs globally for the 3 conditions (for each condition, we consider the average systolic pressure during characters display minus the baseline value) : Friedman $p = 0.01$. Tendency of the systolic pressure to be higher during the positive condition than during the negative one (Wilcoxon $p = 0.06$)

ANS results

Deductive task, emotional effects

Pupillary diameter :



In the positive condition, increase in the average pupillary diameter compared to the baseline (Friedman $p < 0.01$). In particular during virtual character 1 and virtual character 2 (Wilcoxon $p = 0.02$ in both cases)

Discussion

- The presentation of the neutral characters has no effect: behavioural modifications are not attentional artefacts
- In the deductive task positive emotion decreases the performance (in agreement with Phillips et al. (2002)). Fact confirmed by the variations of the physiological parameters
- Negative emotion leads to ineffective actions: more actions (dynamic), more quickly (deductive)
 - But dissociation between performance and measurements of the autonomous nervous system
 - Mood Behavior Model (Gendolla 2000) ?
 - Coping with stress (Gianakos 2002) ?
- Poor results for the dynamic task:
 - Size and location of virtual characters
 - The task generates a high cognitive load: emotional modulation due to strong involving of executive functions (Hoeksma et al. 2004)
 - A stressing task: Mean SYS BP = 134.8 (ded T. = 124.6)

Discussion

- Results showing under certain conditions the reality of links between emotion and cognition (Gray et al. 2002)
- Heavy new protocol, small sample size
- Role of activation : more powerful effect of positive condition?
- Emotional induction of virtual characters weaker than true movies? (Ku et al. 2005)
- Emotional profiles?
- Virtual characters became less effective with repetition?

Interest of handling the emotional factor

Neuropsychology and Neuroergonomics

- Assessment: cognitive state of patients, human factor research
- Rehabilitation / Training protocols: cognition and emotion cross-improve (Mateer et al. 2005)
- Emotionally and cognitively relevant HMI: complex environment (error and stress), disabled persons
- Fundamental research: connectivity, localization

Prospects

- Neuroergonomics: define and monitor the stress and perseveration signatures during critical periods of aircraft piloting thanks to MRI and physiological measurements. Develop HMI designs implementing countermeasures (SUPAERO & INSERM)
- Neuropsychology: disentangle the emotional impairments and dysexecutive syndrome in the early stages of Alzheimer's disease (INSERM & Neurology Department, Toulouse Purpan University Hospital)

Thanks for your attention