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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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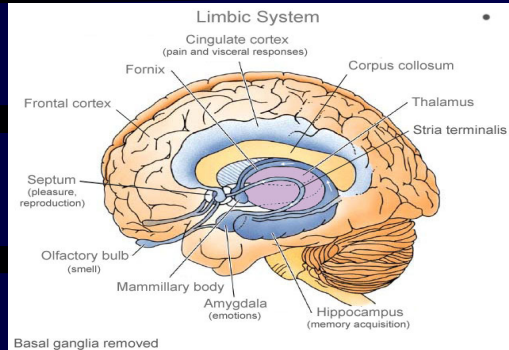
Stress and complex environment

- **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

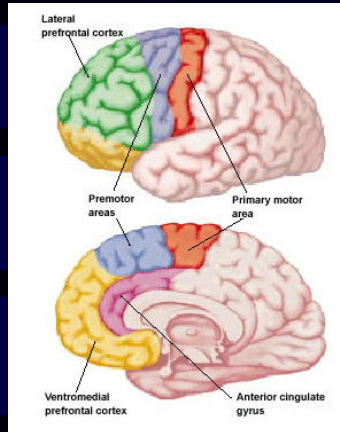


- Discovery of the “limbic lobe” by Broca (1878)
- James Papez (1930) described a “system of the emotion” located in the medial part of the brain
- Definition of the “limbic system” by Paul Mc Lean (1952)



- 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)...

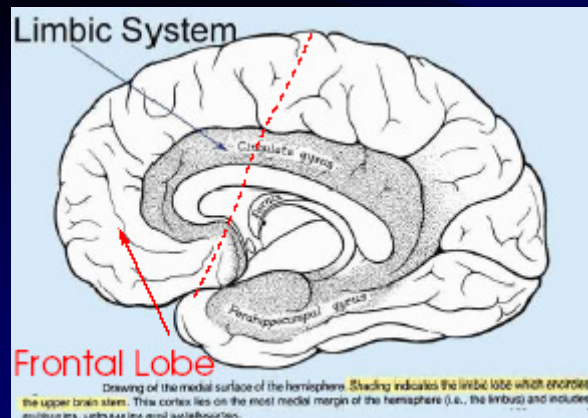
Links between emotion and cognition

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

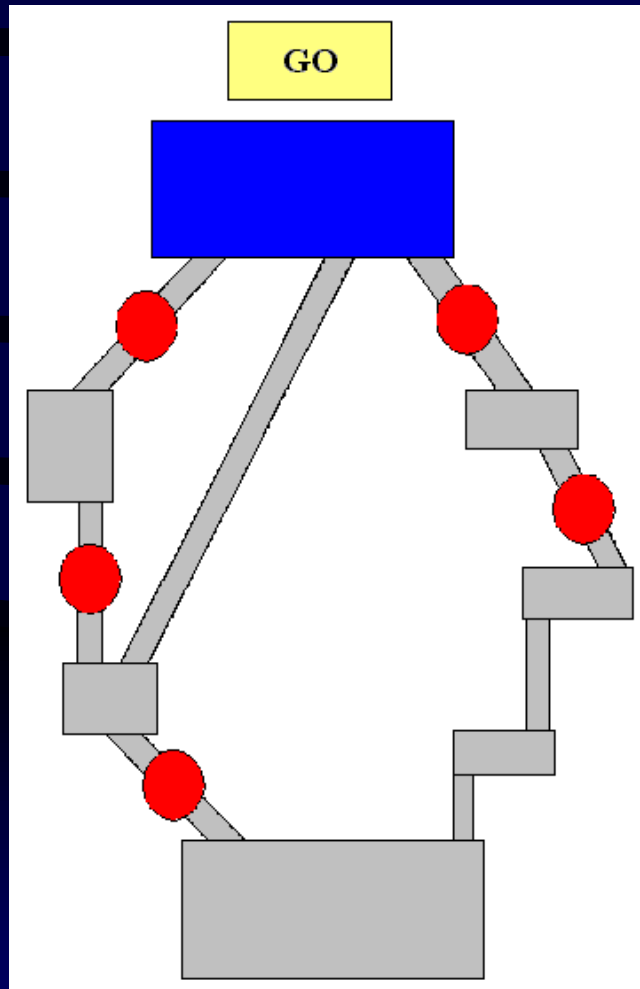
Emotion

- 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

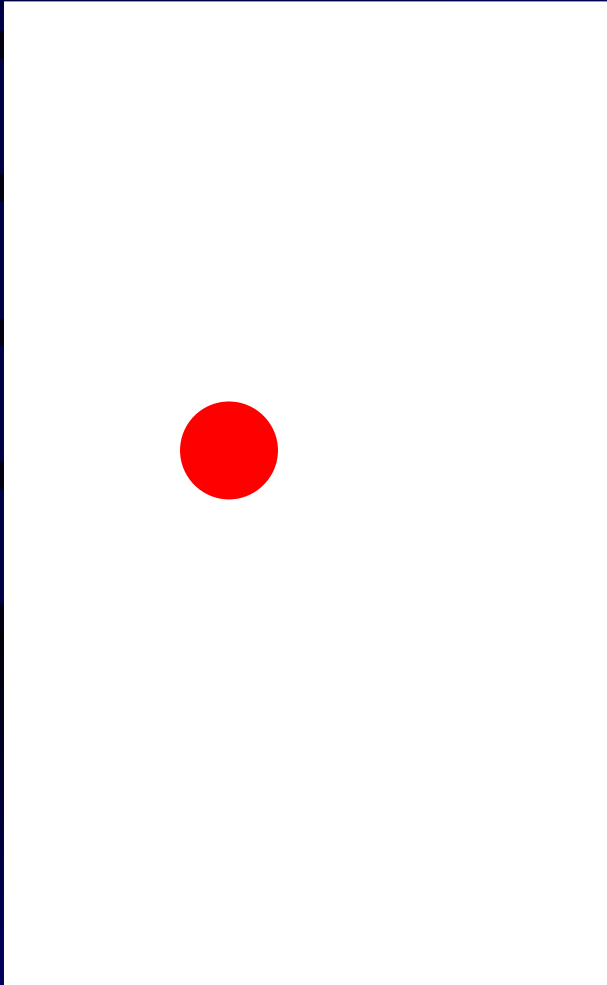
If Gao Xinjian has written « the storm », then Gao Xinjian is not a good writer

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

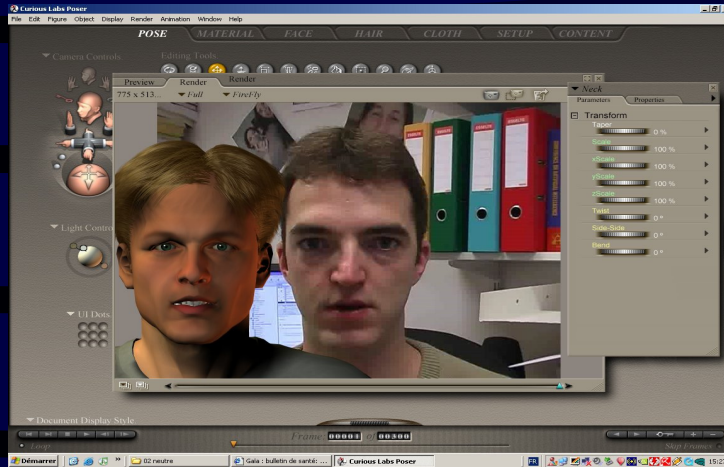
-> To hit as fast as possible a target displayed successively at random locations

Measurement :

- *Velocity index*

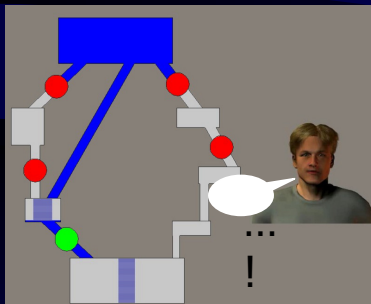


Virtual characters



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

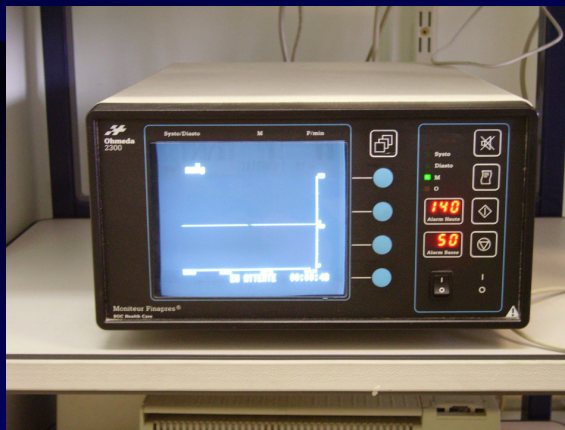
Emotional valence : contradictory results

- 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

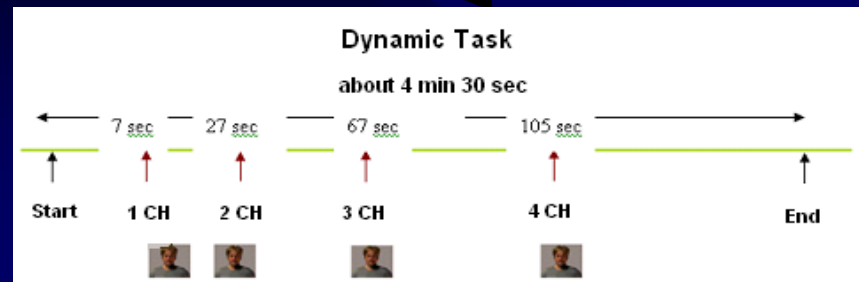
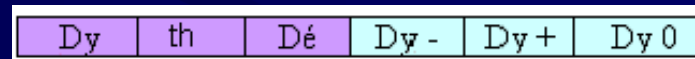
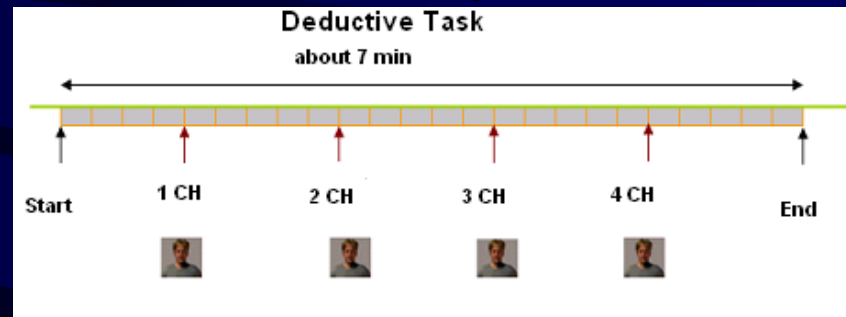
-> Exclusion criteria

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



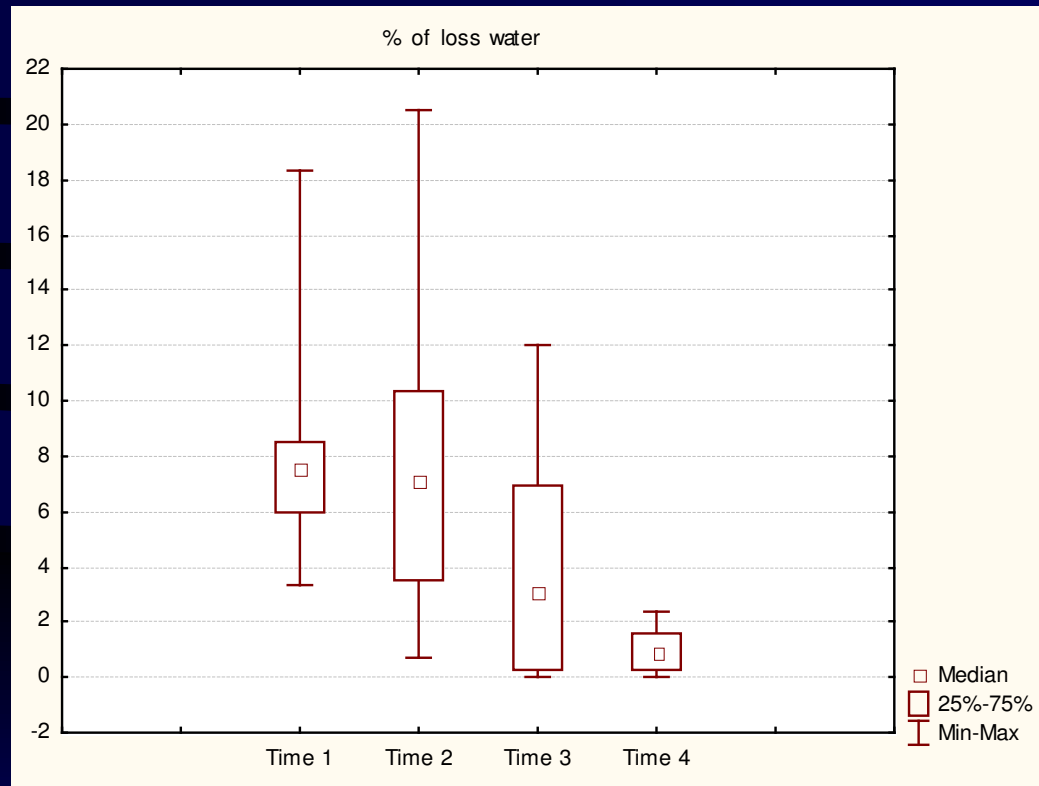
Experimental design

- 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



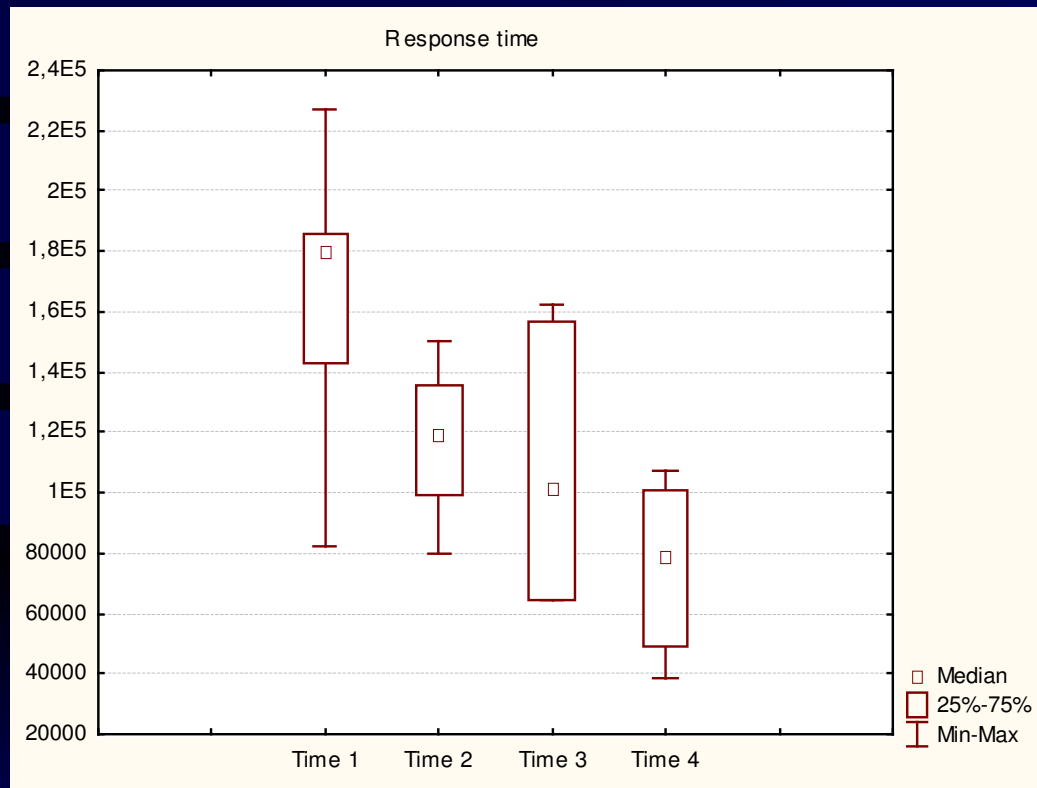
Loss of water :

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

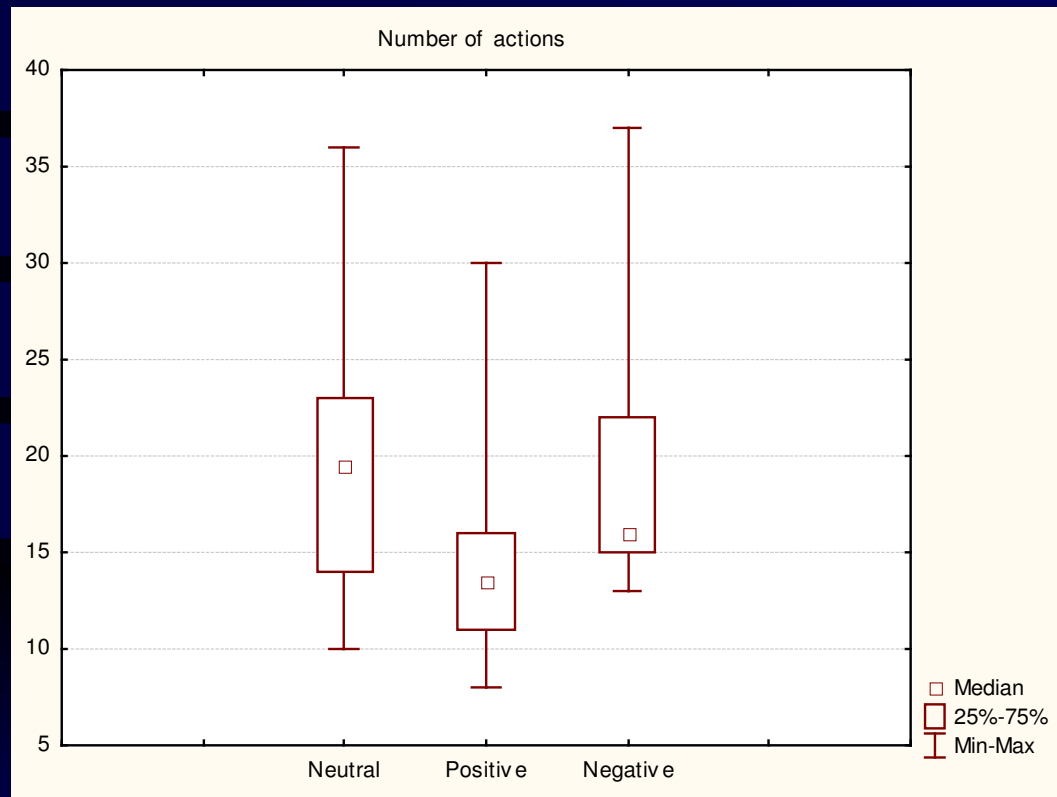


Response time :

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

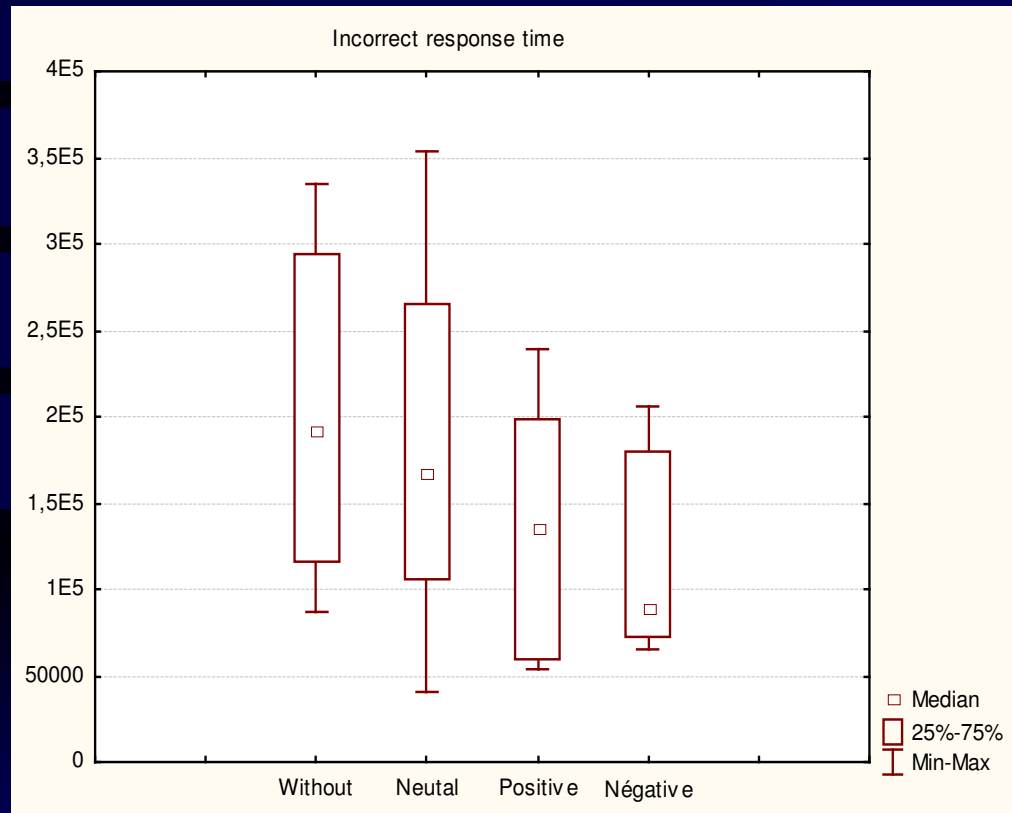


Number of actions :

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

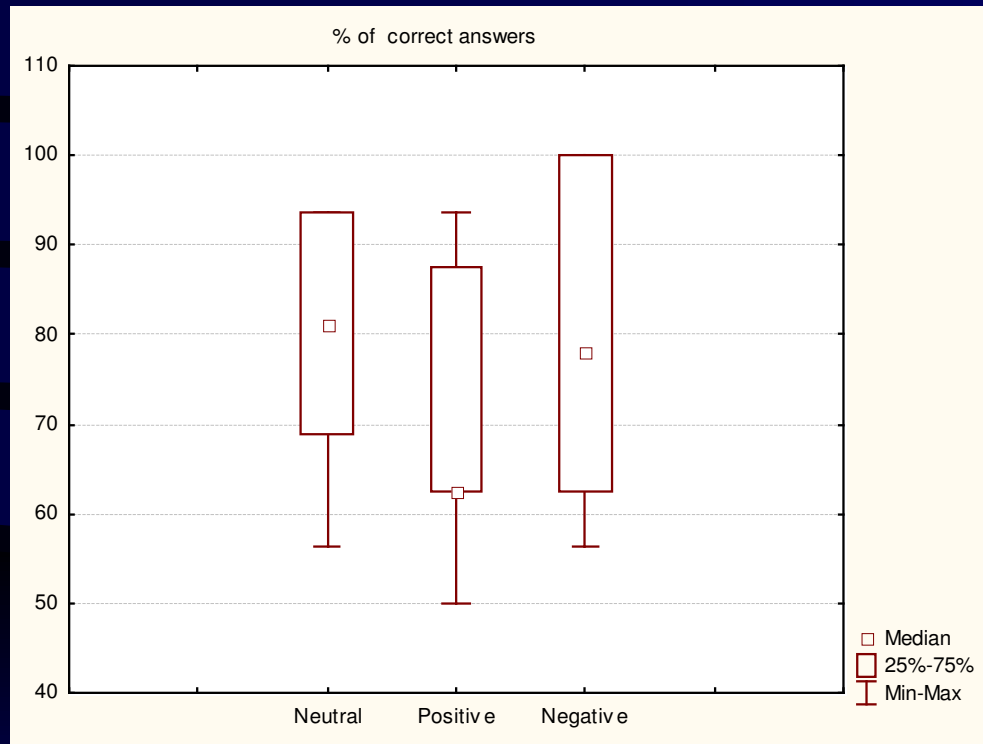


Response time:

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

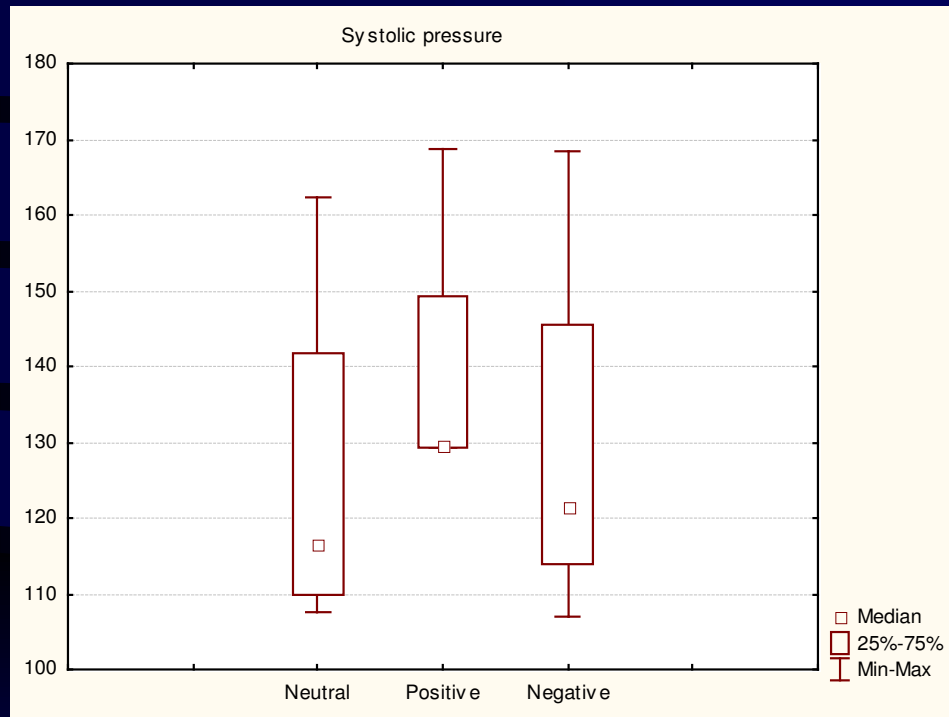


% of correct answers :

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



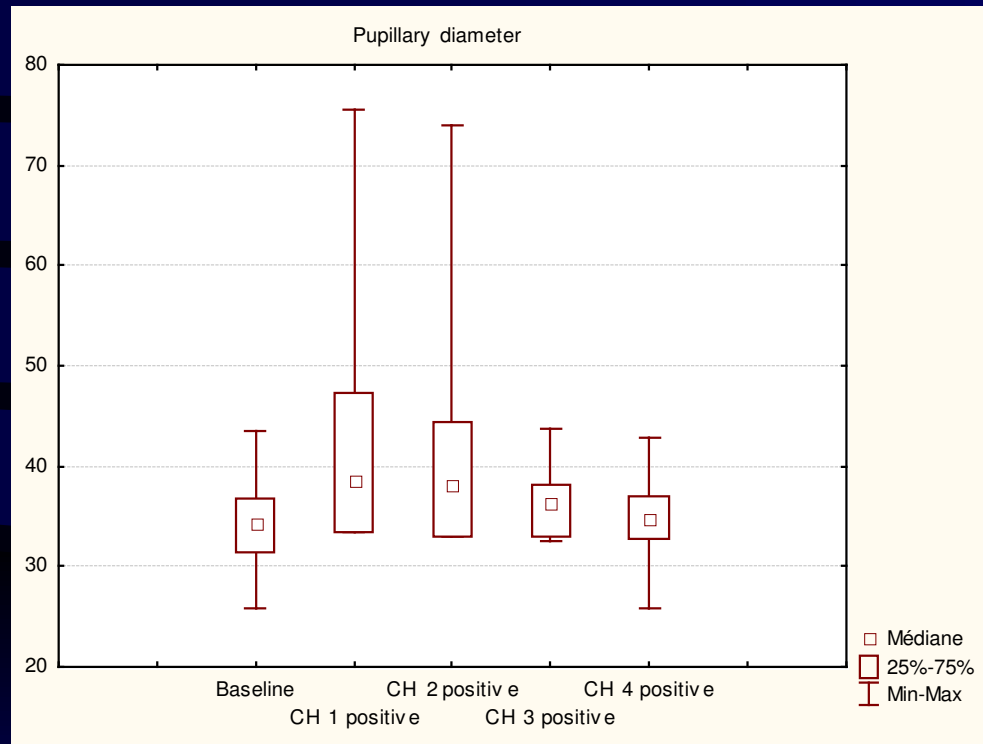
Systolic pressure :

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