Measurement of Workload by Peripheral Arterial Tone (PAT)

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Introduction

- PAT – Peripheral arterial tone. Development of Itamar and the Technion.
- The PAT measures peripheral vasoconstriction, that is argued to indicate sympathetic activity.
- Three different laboratory studies found the PAT to be sensitive for mental work load:
  - Iani, C., Gopher, D., Lavie, P. (2001)
  - Iani, C., Gopher, D., Grunwald, A.J. and Lavie, P. (2002)
  - Yariv Y. (thesis, 2004)

The present study

- The aim of the study –
  - To investigate the feasibility of using the PAT in a simulated natural environment
  - To compare the PAT measure of work load to Heart rate and Pupil dilation measures.
  - To check sensitivity of the PAT to long term load and short duration load.

The present study

- Study was conducted as part of a European research project – VINTHEC II – Visual Interaction and Human Effectiveness in the Cockpit.
- The experiment took place at the NLR full scale and full motion flight simulator at Amsterdam

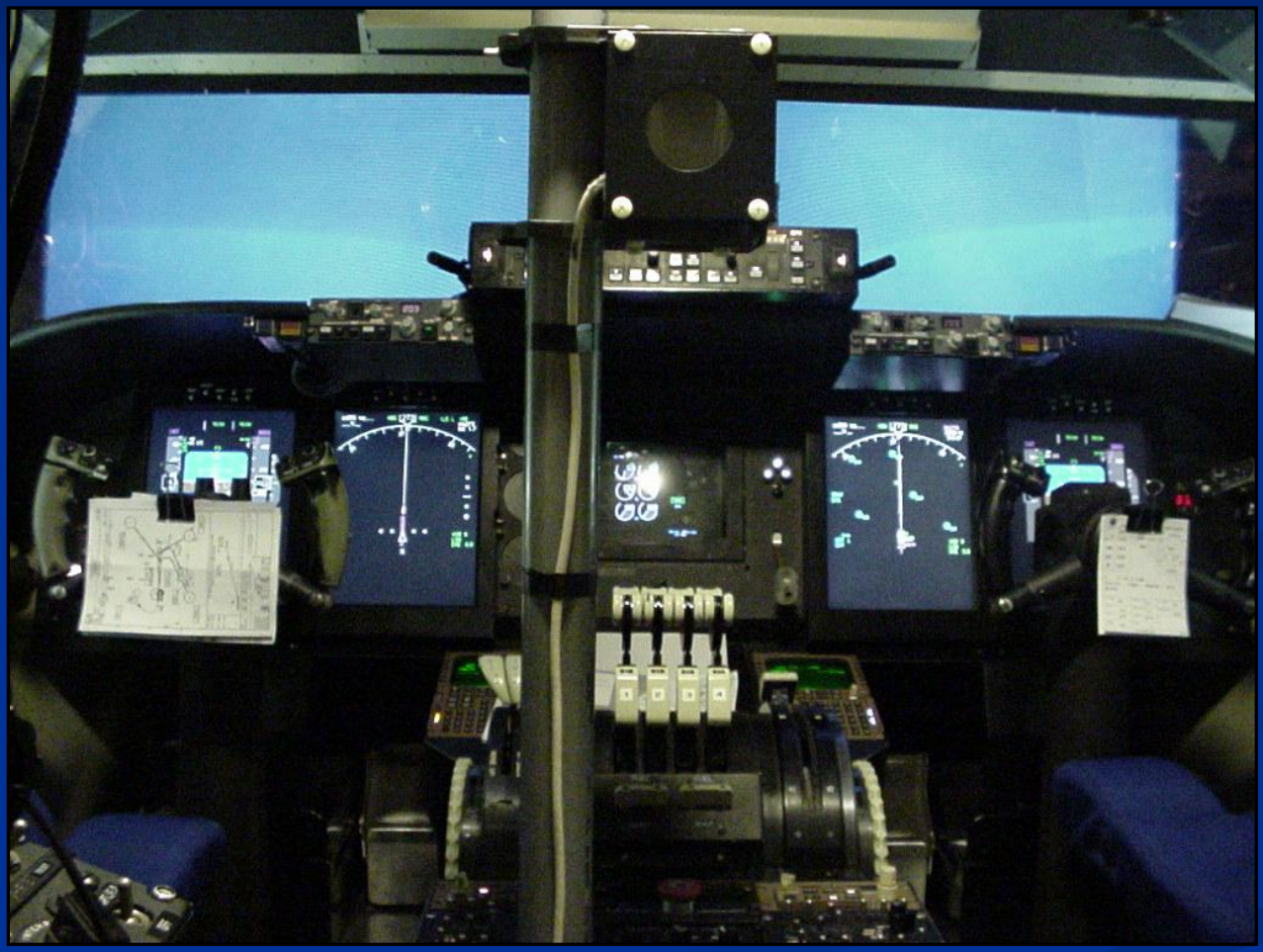
The present study

- Ten air crews of two pilots flew two flights each.
- All flights were conducted on a Fokker 100 simulator that simulated a generic two engine medium size commercial plane.
- The cockpit is very similar to Boeing 767, 737.

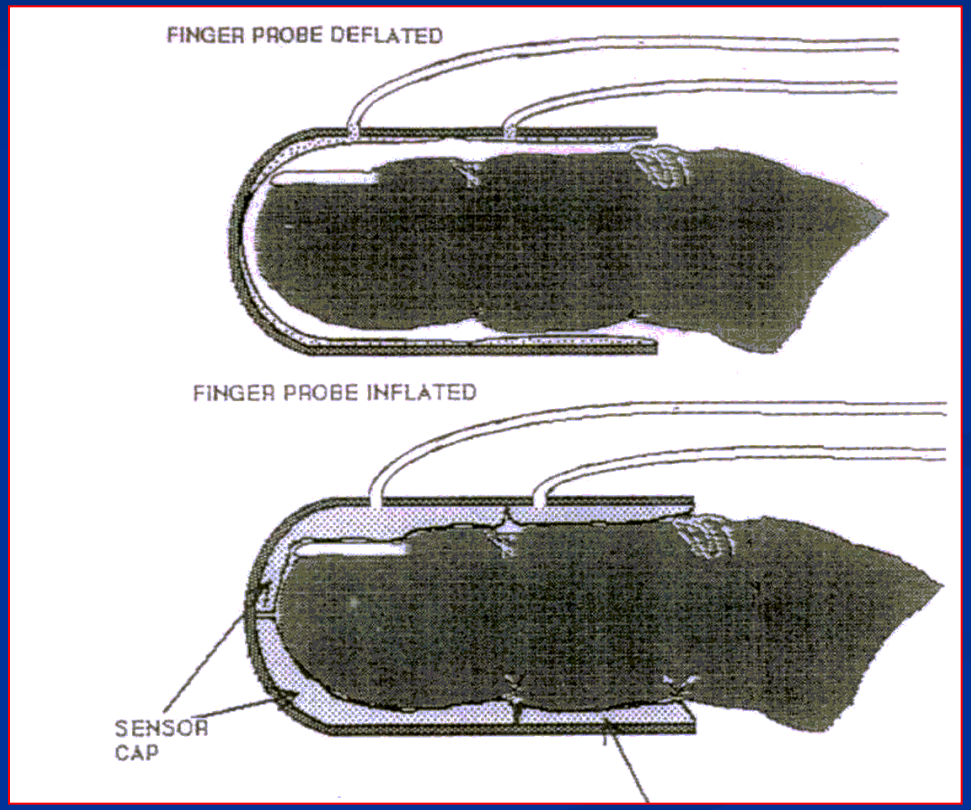
Experiment setting

- Each crew flew 2 flights
- First flight with no unusual events
- Second flight with some un expected events
  - After take off – purser reports 'sick passenger'
  - Primary flight display of the pilot flying failus
  - Purser reports – passenger with heart attack
  - Primary flight display failure (2nd time)
  - The instrument landing system fails
- Flights were as standard as possible (each event occurred under the same flight conditions).

Full scale flight simulator



What is the PAT?
Monitoring Peripheral Arterial Tone



The PAT system

Data analysis

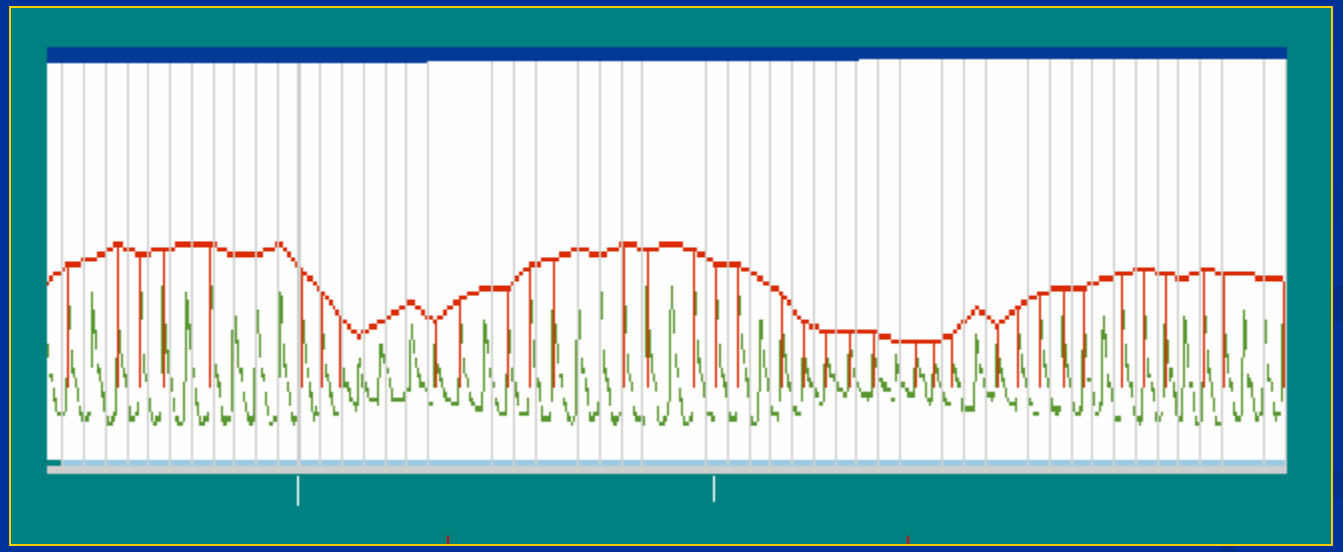
- PAT, Heart Rate and Pupil Dilation were scaled to the rest level or to the 30 seconds 'pre-event' level.
- Long term work load analysis - Rest level Vs. flight level of load
- Post event analysis – measures analysis during the 30 seconds following event onset (5 sec intervals)

PAT system

Cristina_2.vi
PAT Display and Data Logging System, Ver 2.0 - Arthur Grunwald and Ehanan Rabinovitz, Technion ISRAEL
Offset
Gain
Plot 2
STOP
Record
Heart Rate

PAT data

Vasoconstriction amplitude

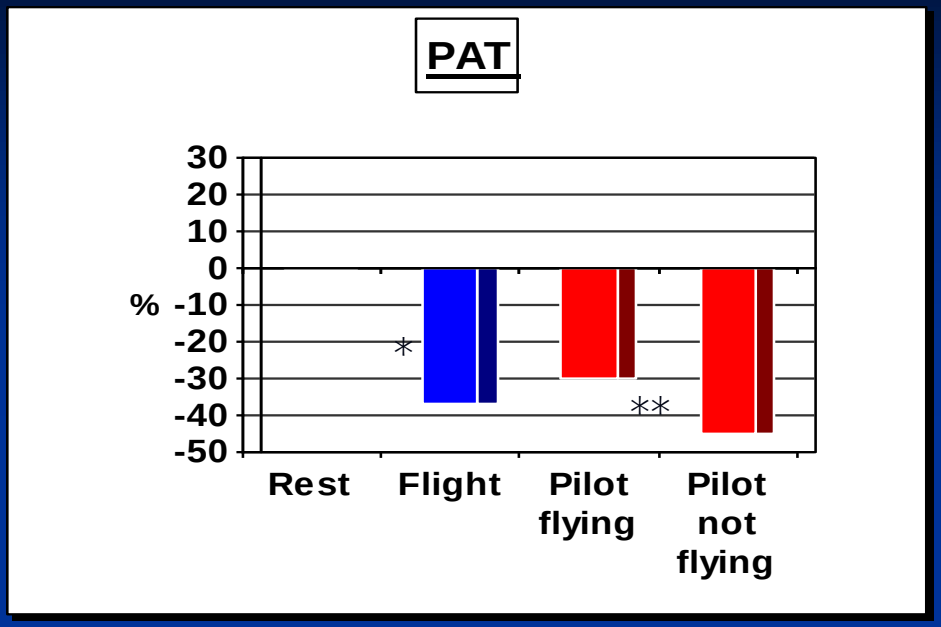


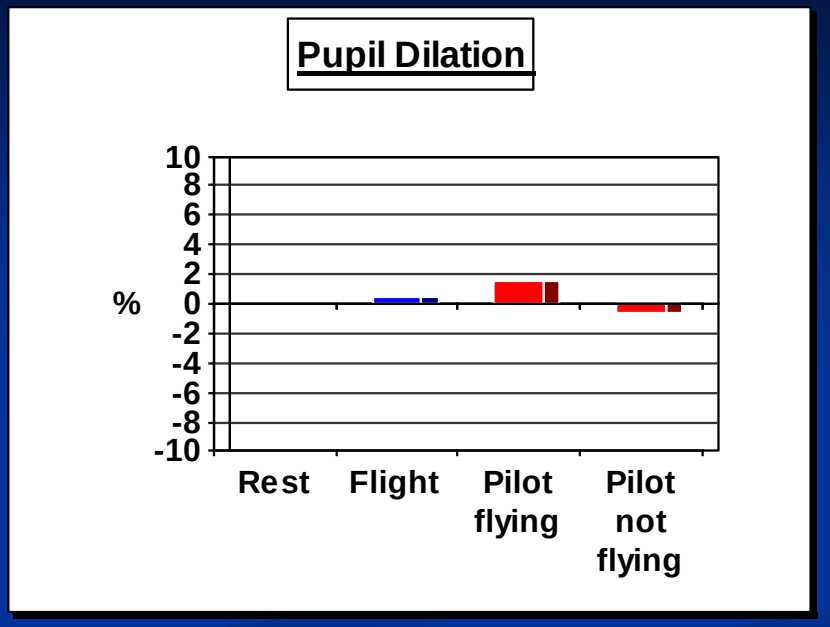
Results

Three different analyses:

- Comparison of PAT scores, Heart rate and Pupil dilation during Rest and flight phases.
- Comparison of post-event PAT scores, Heart rate and Pupil dilation.
- Reaction differences between pilots within the air crews.

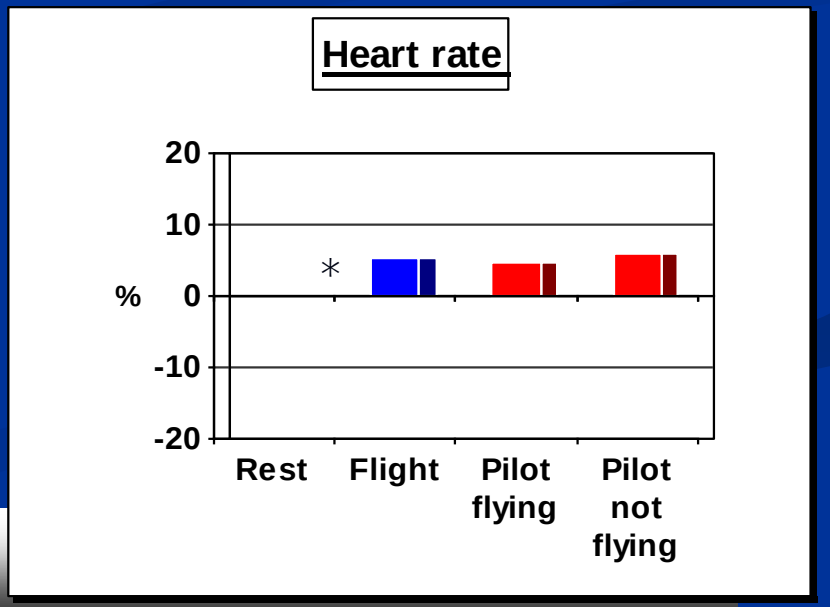
Comparative work load measures during flight



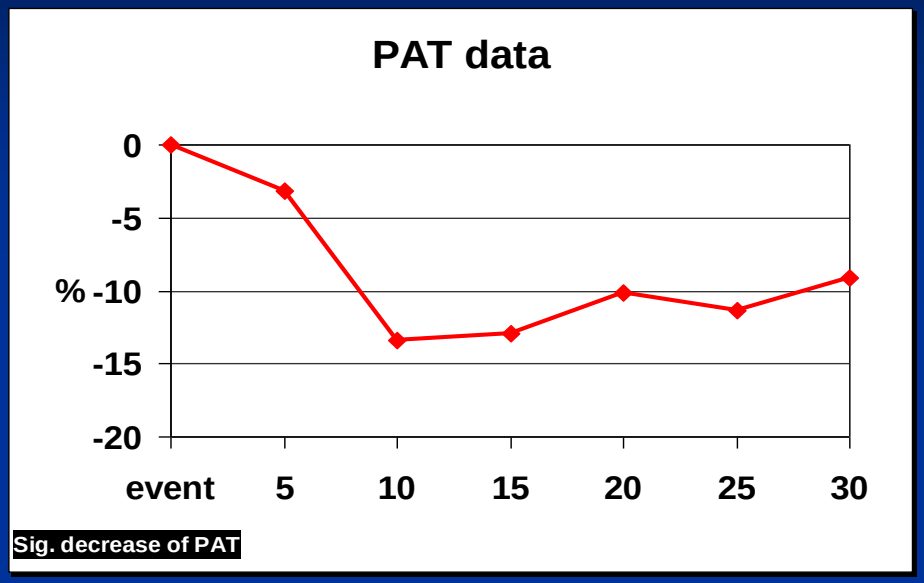


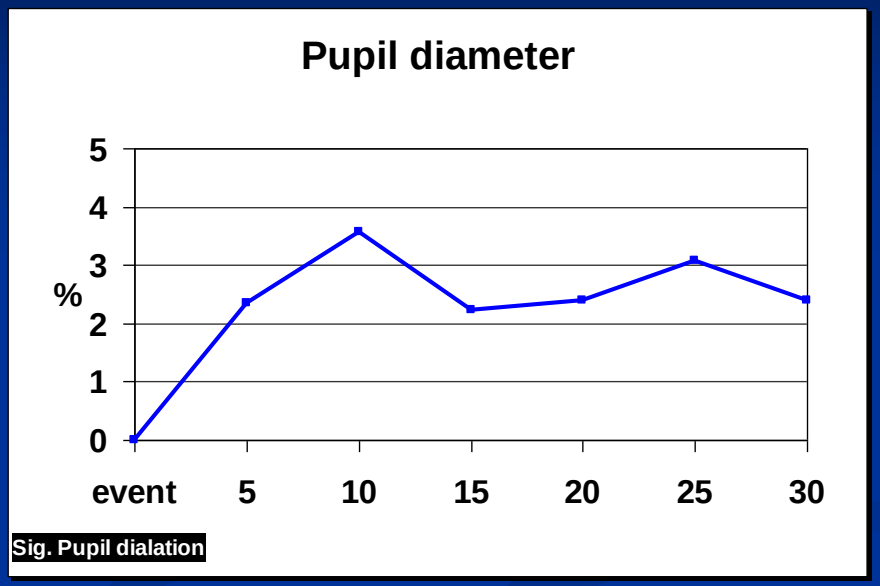
* - sig. difference Rest Vs. Flight

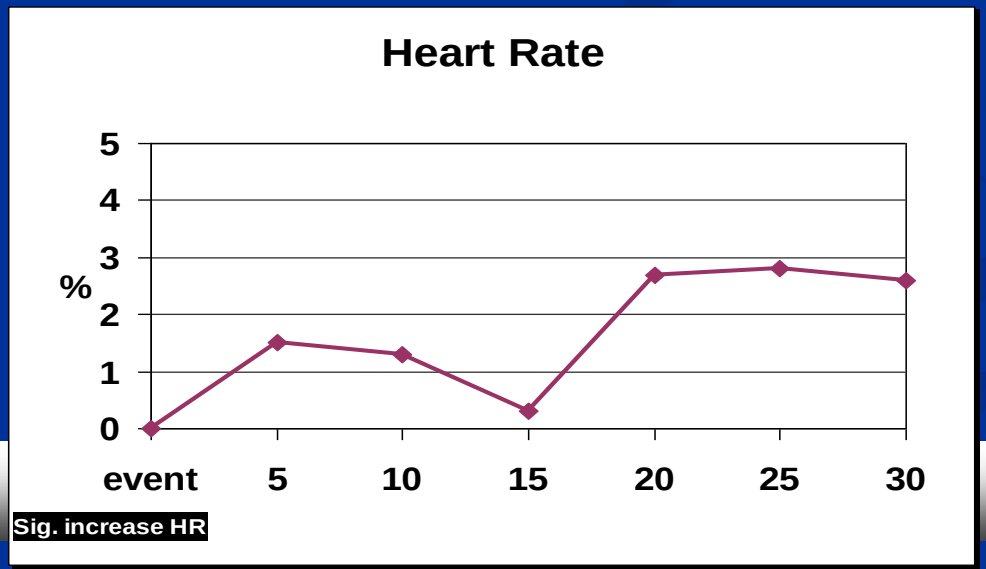
** - Sig. difference Pilot Flying Vs Pilot Not Flying



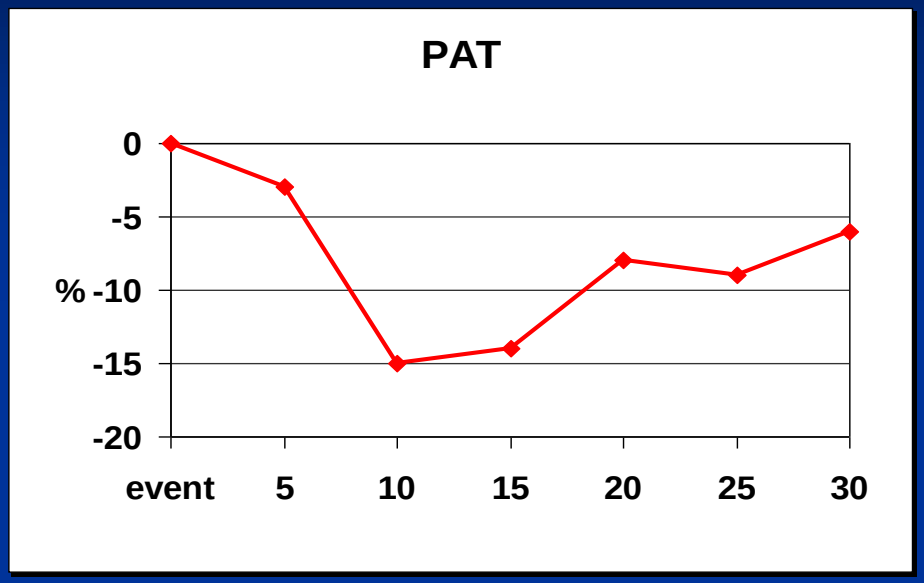
Event related (all events) PAT scores, Heart rate and Pupil diameter scores

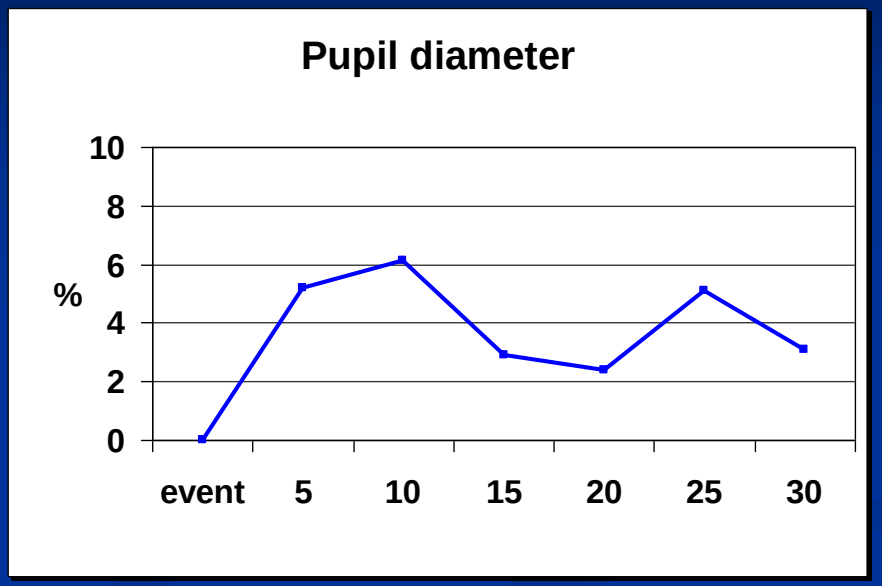


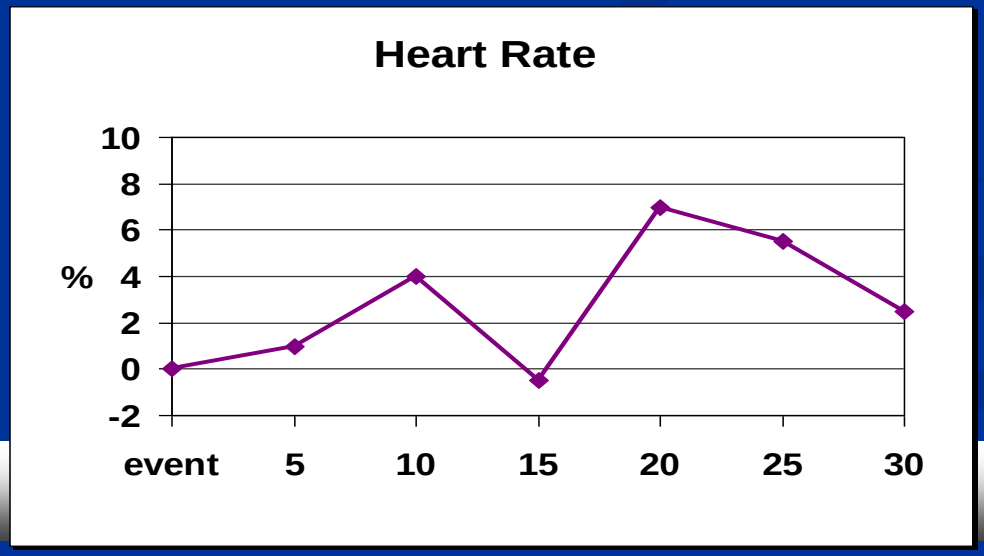




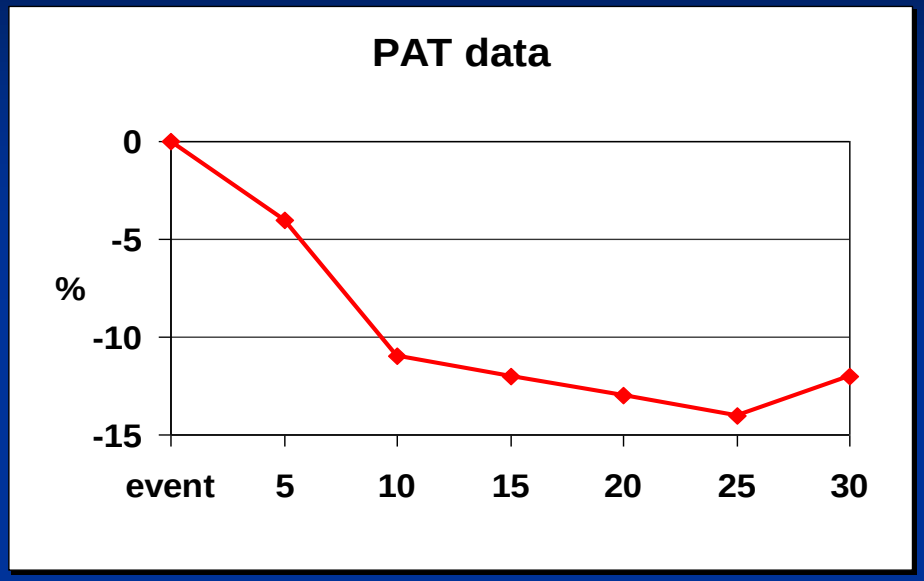
Event related measures (Primary flight display failure)

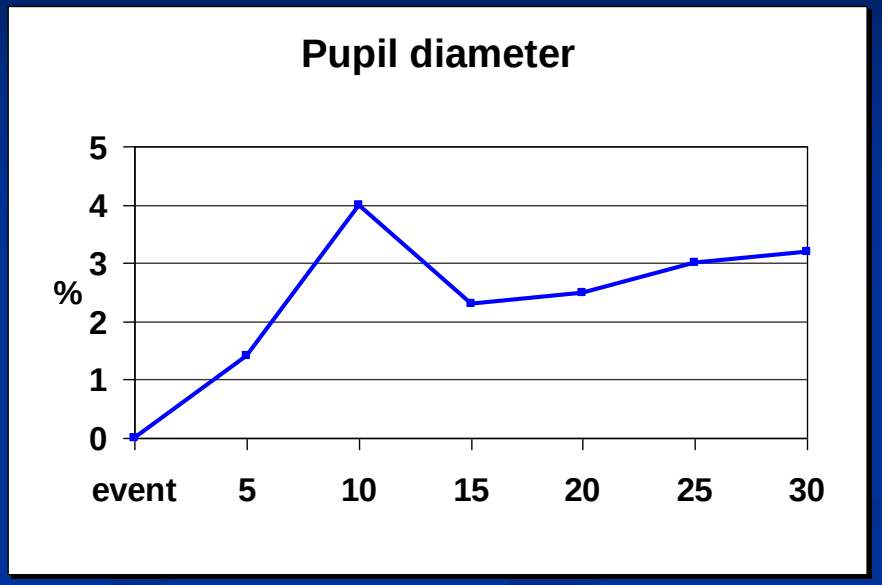


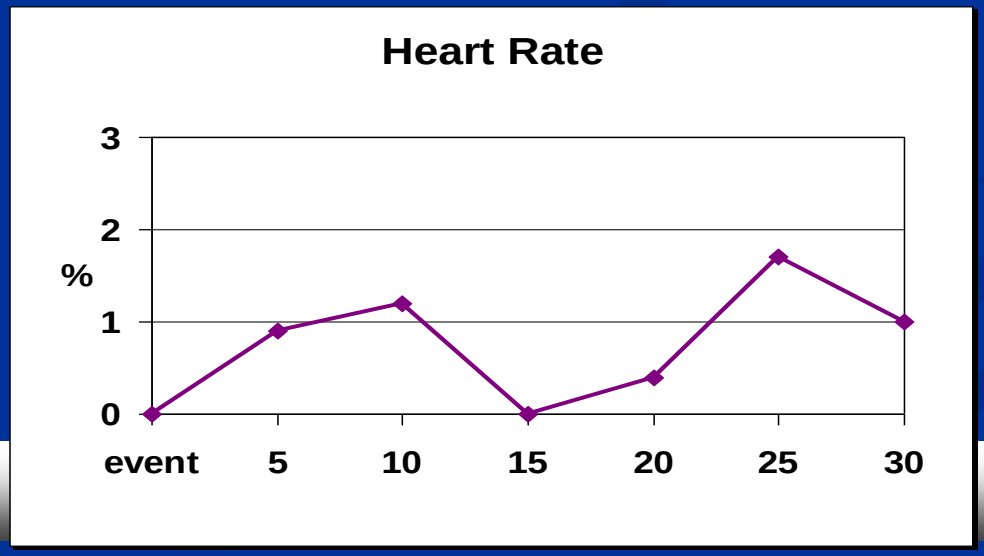




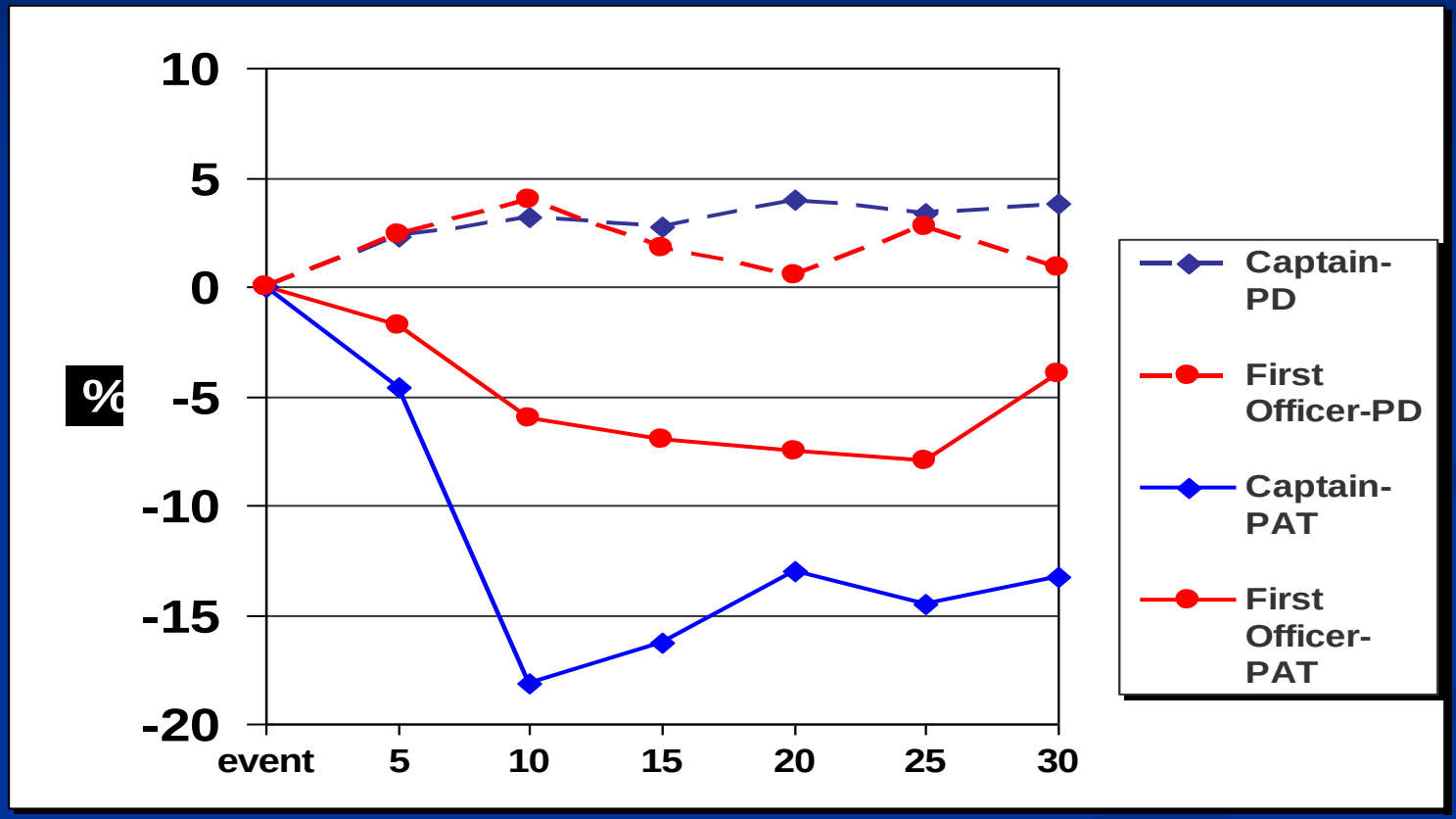
Longer event related measures (Heart attack and glide slope failure)



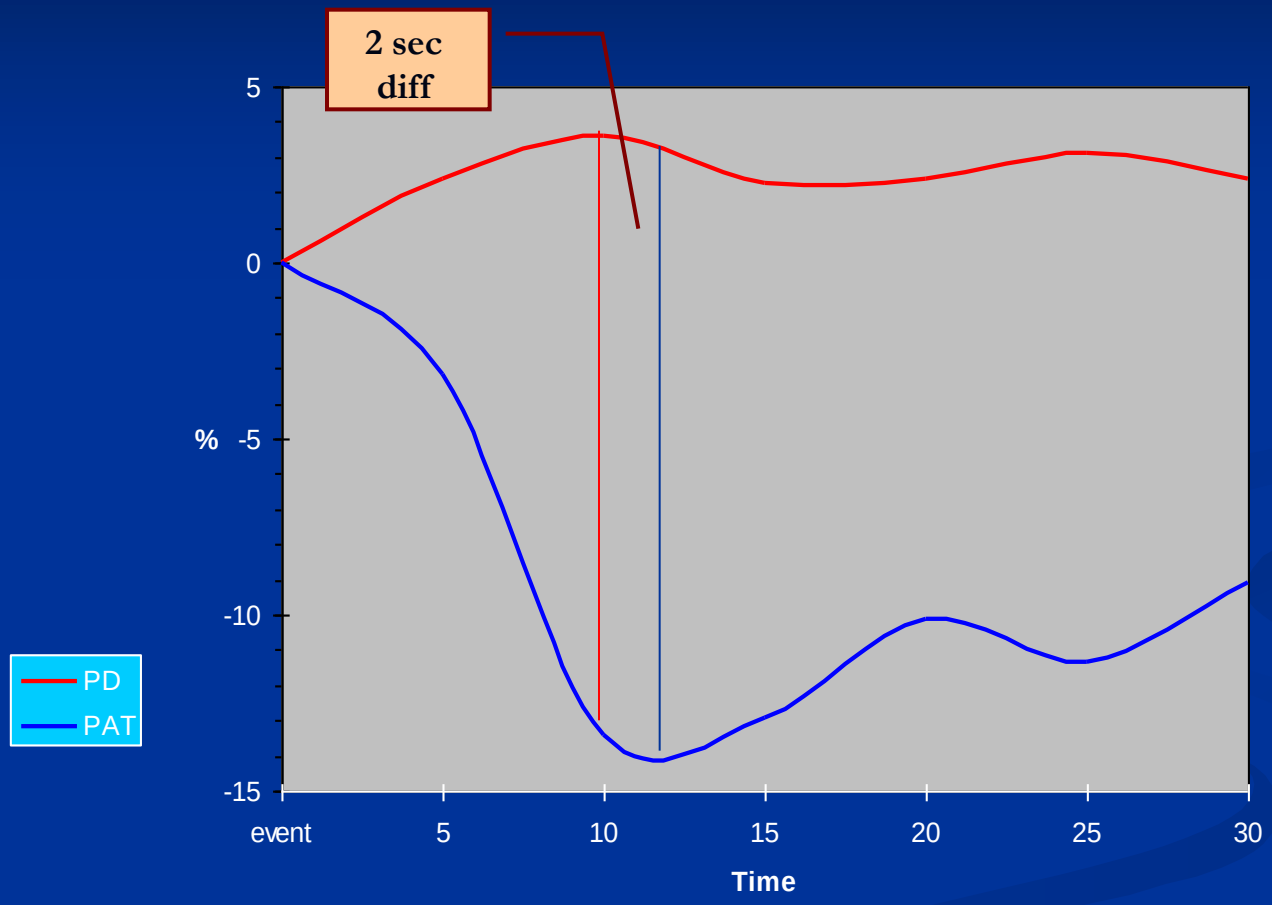




Event related scores – Captain Vs. First officers



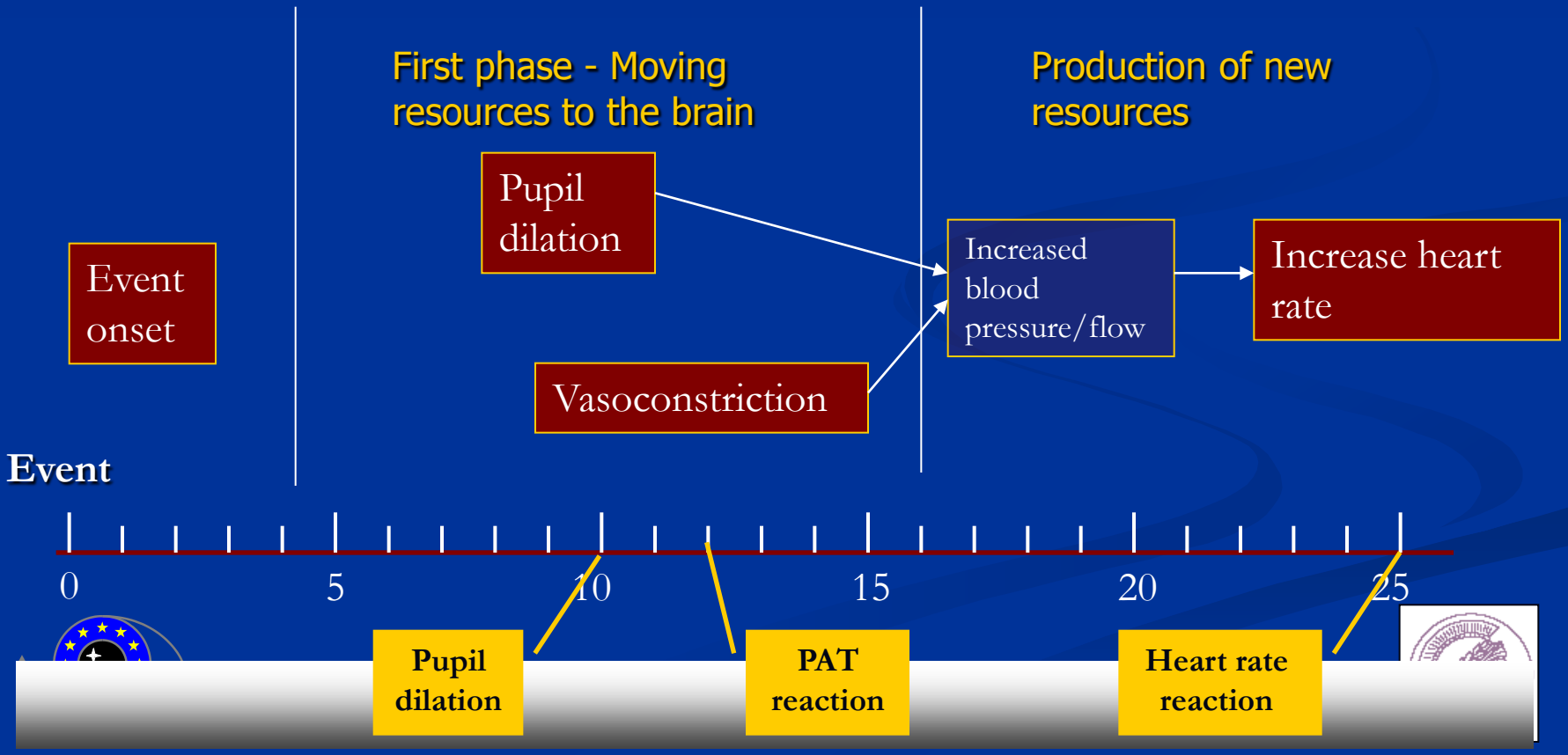
Event related - Time shift



Results

Time gaps between maximum reaction of PAT, Heart rate and Pupil diameter:

- Pupil diameter – 10 sec
- PAT – 12 sec
- Heart rate – 25 sec



Conclusions I
Overall load of flight

1. PAT measures are sensitive to the overall continuous load of flight. Average increase of load during flight is 37%, relative to rest period.

2. There is a significant difference between PF and PNF in overall load. The pilot not flying reveals higher load levels.

Conclusions II
Response to specific flight events

1. There is an additional increase in load in response to event which is significantly identified by the PAT measures, Pupil dilation and decrease in heart rate.

2. The load increase for captains is much higher than for first officers, independent of the role that they assume in the present flight (PF or PNF).

Conclusions III

1.PAT measure is a good technique to measure mental load

- Sensitive
- Valid
- Non intrusive
- Both continuous work load and discreet event related work load can be measured concurrently.