A Preliminary Study on the Usefulness of Physiological Assessment for the ATCO Selection

Mouratille D., Amadieu F. & Matton M.
Air Traffic Controllers

General Aspect:
• Air Traffic Controllers are responsible for the organization of air traffic to ensure its:
  – Safety
  – Efficiency

• Cognitively demanding and stressful
• Work for an Air Navigation Service Provider (ANSP)
• Plural positions: en-route, approach and tower

Cognitive Aspect:
• Create a mental image of the environment by:
  • perceiving situation,
  • anticipating the future
  • and taking decisions.

• Mental image built from multiple sources of information:
  • long-term memory such as regulations and maps,
  • radio communications,
  • radar displays,
  • decision support tools,
  • colleagues and/or outside the tower
Importance of selection

• Training:
  – Duration of training = around 3 years
  – Cost of training = between 100k and 1M by student
  – Success rate: between 50% and 80%
  – Attrition = a real burden

• In France:
  – Initial training + On-The-Job training = between 42 and 84 months
  – ATCO are public servants even during training
Selection process

• Methods used by the majority of ANSP:
  – Cognitive ability assessment
  – Knowledge test
  – Biographic data
  – Personality test
  – Motivational interview
  – Etc.

• Rarely only one method is used, a combination of several is made

• France: two years of undergraduate education and only knowledge tests are used
Validity of selection process

• Latest meta-analysis (Martinussen, 2000)
  – Cognitive predictors: Correlation low-to-medium
  – Personality predictors: non-significant
• Others predictive validity studies:
  – Correlations similar
  – Never more than 10% of variance explained

• A new meta-analysis is underway ...

Figure 1: Meta-analysis results from Martinussen & Hunter (2017)
Identification of student difficulties

• One of the recurrent training difficulties: stress resistance
  – Based on interviews with instructors (4) and psychologists (3)
  – Lots of definitions
  – Distinction not always done between stress resistance and stress resilience
  – Stress resistance as the mechanisms involved in preventing a “tipping point” from adaptive to maladaptive responses (Miller, Seals and Hamilton, 2017)
Stress Resistance

• Difficult to measure with subjective and behavioral data
• Physiological measures: electrocardiogram, cortisol, galvanic skin resistance (Arza et al, 2019)
• Closest study: Cosic, et al. (2019) without predictivity analysis

• Theory of neurovisceral integration (Thayer & Lane, 2000; 2009; Smith et al., 2017): cardiac vagal tone, indexed by heart rate variability (HRV), can indicate the functional integrity of the neural networks implicated in emotion–cognition interactions
Question

• *Can stress resistance provide incremental validity in controller success?*
Protocol

• Pilot study: 16 French ATCO students (7 women)
• Longitudinal aspect
• Time 1: Assessment of cognitive abilities one month after the beginning of academic training:
  – Spatial ability, numerical ability, multiple task performance
  – Computation of composite score based on these abilities
• Time 2 (28 months after T1): Assessment of performance during two high-fidelity air traffic scenarios:
  – Easy level: Heart Rate Variability (HRV: log-transformed RMSSD) acquired by electrocardiogram
  – Difficult level: success (0 or 1 error) or failure
  – Counterbalanced
Statistical analysis

• Step-wise logistic regression
• Predictors :
  – Cognitive composite score at T1
  – HRV at T2-Easy
• Criterion :
  – Performance at T2-Difficult
Manipulation Check

**Behavioral**

Number of errors by difficulty level. ***p < .001

**Subjective**

Number of errors by difficulty level. ***p < .001
Results

- Step-wise logistic regression:
  - Step 1: Composite score ($p = .05$, Nagelkerke $R^2 = .23$)
  - Step 2: Composite score + HRV feature ($p = .02$, Nagelkerke $R^2 = .36$)

- Improvement of model is significant: $p < .01$
Results

- The higher HRV is in easy level, the higher probabilities of high performance in difficult level will be (OR = 1.04).

Figure 4: Relation between HRV in easy level and probability of success in difficult level
Conclusion

• Heart Rate Variability (HRV) is low in cognitively simple situations ➔ when in difficult situations, maladaptive responses ➔ impaired cognitive performance + bottom-up defensive responses enhanced (Spangler et al., 2018)

• HRV is high in cognitively simple situations ➔ when in difficult situations, adaptative responses ➔ good stress resistance and cognitive performance

• In accordance with the Theory of neurovisceral integration

• Stress resistance measured by HRV can provide additional explained variance
Limits

- Number of participants
- Predictor side:
  - Using physiological measures at the beginning of training
  - A more suitable protocol: stress induction (TSST)
  - Other physiological measures
- Criterion side:
  - Predict pass-fail criterion
Thank you for your listening
A Preliminary Study on the Usefulness of Physiological Assessment for the ATCO Selection

Mouratille D., Amadieu F. & Matton M.
damien.mouratille@enac.fr


