



HAL
open science

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

Damien Mouratille, Franck Amadiou, Nadine Matton

► **To cite this version:**

Damien Mouratille, Franck Amadiou, Nadine Matton. A Preliminary Study on the Usefulness of Physiological Assessment for the ATCO Selection. 2021 International Symposium on Aviation Psychology, May 2021, Corvallis, OR, United States. hal-03274237

HAL Id: hal-03274237

<https://hal.science/hal-03274237v1>

Submitted on 29 Jun 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



This is a prerecorded presentation for the 21st International Symposium on Aviation Psychology.

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

Mouratille D., Amadiou 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-signifiant
- Others predictive validity studies :
 - Correlations similar
 - Never more than 10% of variance explained
- *A new meta-analysis is underway ...*

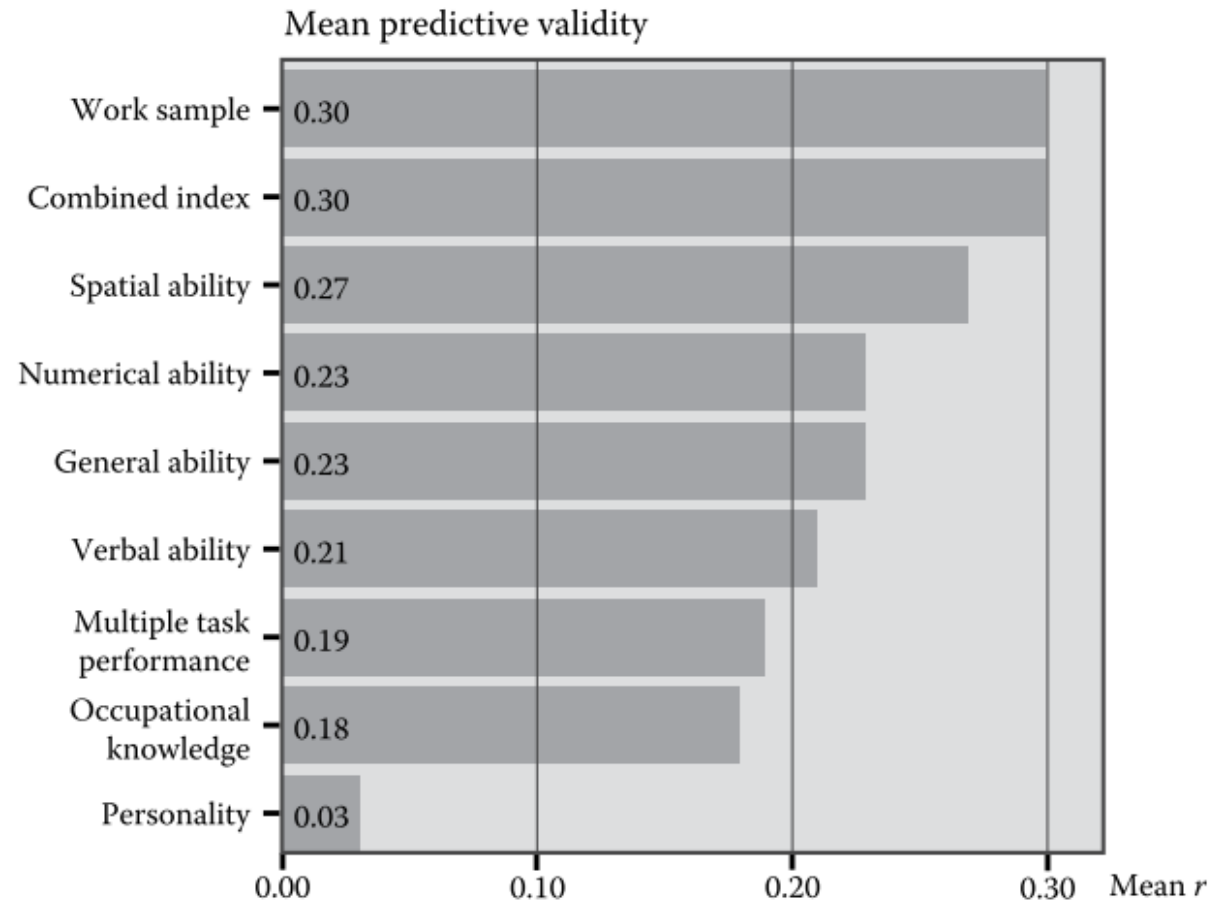


Figure 1 : Meta-analysis results from Martinussen & Hunter (2017)



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

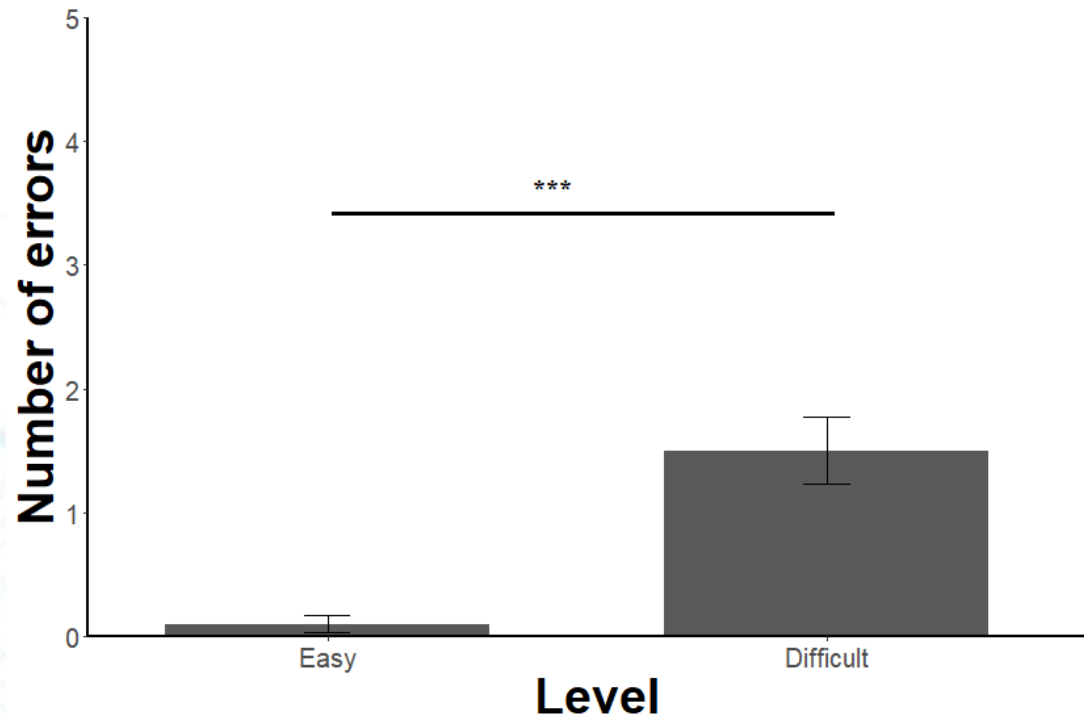


Figure 3 : Number of errors by difficulty level. *** $p < .001$

Subjective

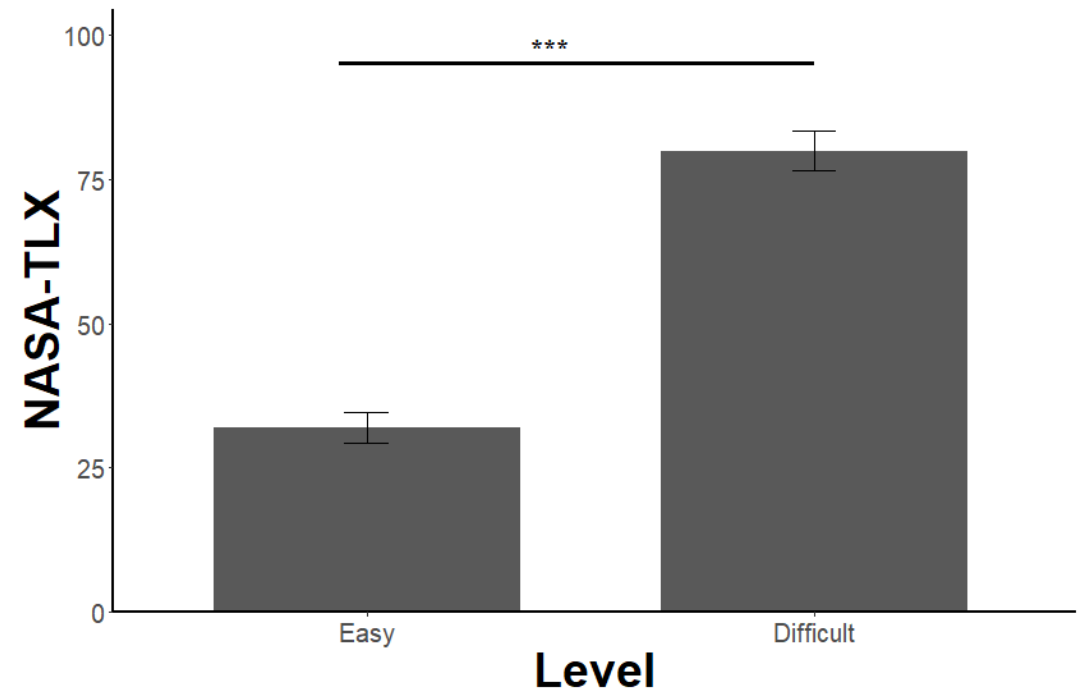


Figure 4 : Number of errors by difficulty level. *** $p < .001$



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

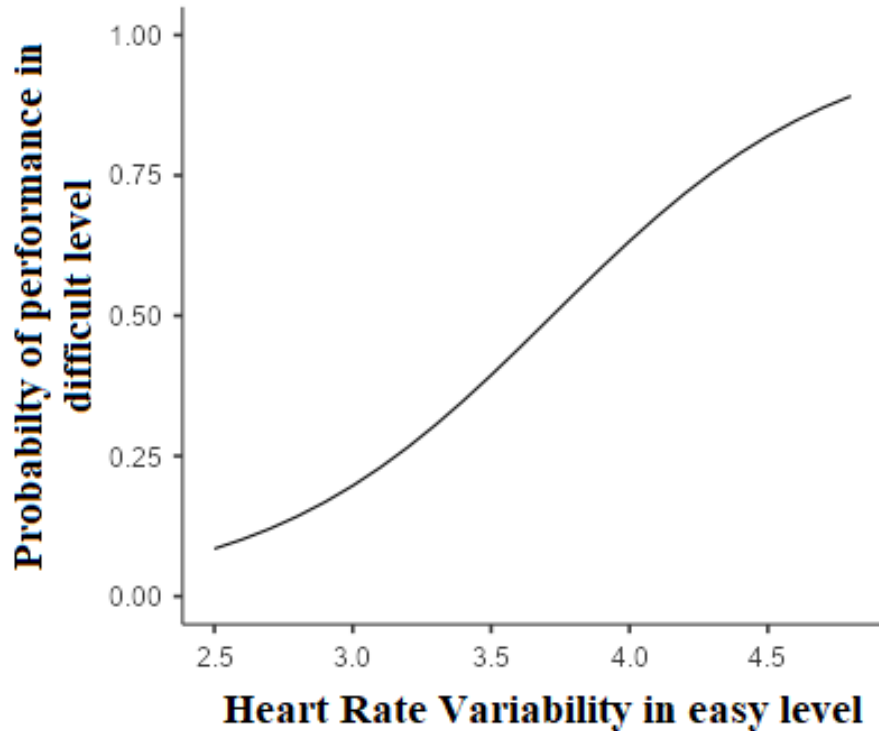


Figure 4 : Relation between HRV in easy level and probability of success in difficult level

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



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, adaptive 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., Amadiou F. & Matton M.
damien.mouratille@enac.fr



- Arza, A., Garzón-Rey, J. M., Lázaro, J., Gil, E., Lopez-Anton, R., de la Camara, C., ... & Aguiló, J. (2019). Measuring acute stress response through physiological signals: towards a quantitative assessment of stress. *Medical & biological engineering & computing*, 57(1), 271-287.
- Cosic, K., Sarlija, M., Ivkovic, V., Zhang, Q., Strangman, G., & Popovic, S. (2019). Stress Resilience Assessment Based on Physiological Features in Selection of Air Traffic Controllers. *{IEEE} Access*, 7, 41989–42005. <https://doi.org/10/gghjm4>
- Martinussen, M., & Hunter, D. R. (2017). *Aviation psychology and human factors*. CRC Press.
- Martinussen, M., Jenssen, M., & Joner, A. (2000). Selection of air traffic controllers : Some preliminary findings from a meta-analysis of validation studies. Proceedings of the 24th EAAP (European Association for Aviation Psychology) Conference.
- Miller, B. F., Seals, D. R., & Hamilton, K. L. (2017). A viewpoint on considering physiological principles to study stress resistance and resilience with aging. *Ageing Research Reviews*, 38, 1–5. <https://doi.org/10/ghd73d>
- Smith, R., Thayer, J. F., Khalsa, S. S., & Lane, R. D. (2017). The hierarchical basis of neurovisceral integration. *Neuroscience & biobehavioral reviews*, 75, 274-296.
- Spangler, D. P., Gamble, K. R., McGinley, J. J., Thayer, J. F., & Brooks, J. R. (2018). Intra-individual variability in vagal control is associated with response inhibition under stress. *Frontiers in human neuroscience*, 12, 475.
- Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of affective disorders*, 61(3), 201-216.
- Thayer, J. F., & Lane, R. D. (2009). Claude Bernard and the heart–brain connection: Further elaboration of a model of neurovisceral integration. *Neuroscience & Biobehavioral Reviews*, 33(2), 81-88.