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Artificial Neural Networks For The Modern Commander Performance Improvement And Situation Awareness Assessment

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The evolution of future corps in military strategy transcends the conventional notions of a mere command echelon. In the dynamic landscape of modern warfare, these corps are envisioned as active participants in the deep battle, wielding multifaceted capabilities to decisively influence outcomes in close combat scenarios faced by their subordinate divisions. The paradigm shift towards active engagement throughout operational depth necessitates a comprehensive integration of diverse elements within the future corps. To effectively shape the battlefield and ensure victory, these corps must possess a versatile arsenal of capabilities spanning various domains. In the dynamic landscape of modern military operations, the role of a commander becomes pivotal, demanding a high level of performance and acute situation awareness. Also, the reduced time available for decision-making and the heightened lethality of weapons have resulted in increased cognitive demands and stress in modern military operations (Flood and Keegan, 2022; Grier, 2012). These escalations are concerning because both elevated cognitive demands and increased stress are well-documented factors known to raise the likelihood of errors (Thompson and McCreary, 2006). Notably, 80% of military accidents are attributed to human error (Thomas and Russo, 2007). Furthermore, stress has been widely reported to inflict long-term psychological injury on military personnel (Friedl et al., 2007). Thompson and McCreary (2006) indicated that between 10% and 50% of all operational casualties are psychological. The soldier's more stable attributes and competencies become increasingly crucial when predicting performance farther in advance of deployment (Brooks and Greenberg, 2018). In this context, the following three terms were the focus of this research:

- *Tactical Cognitive Readiness* (TCR). Definition: TCR refers to a state of mental acuity essential for ensuring an acceptable level of performance during assigned missions.
- *Operational Cognitive Readiness* (OCR). Definition: OCR encompasses the mental preparation, including skills, knowledge, abilities, motivations, and personal dispositions, that an individual requires to establish and sustain competent performance in the complex and unpredictable environment of modern military operations.
- *Strategic Cognitive Readiness* (SCR). Definition: SCR denotes an individual's potential to perform assigned cognitive tasks in the complex and unpredictable environment of modern military operations.

These terms collectively encapsulate the progressive levels of cognitive readiness required for effective performance at different stages of military deployment, ranging from specific mission tasks (TCR) to broader operational competencies (OCR) and overarching strategic cognitive abilities (SCR). A review of the military training literature on cognitive readiness let us to identify the list of constructs, which reflects mental abilities and preparation, mostly for military operations. The following defined parameters of cognitive commander functions were chosen for this study:

- *Decision making* (C1). At the core of military cognitive functions lies the art of decision-making. Military operations, often conducted in high-stakes and time-sensitive environments, require leaders and personnel to make swift and well-informed decisions.

- *General knowledge* (C2). General knowledge, a fundamental facet of cognitive readiness, plays a pivotal role in shaping the intellectual foundation of military personnel. The Army Cognitive Readiness Assessment (Swann and Schmidt, 2005) was used.
- *Cognitive capabilities* (C3). Military problem-solving extends beyond the conventional to encompass the resolution of intricate and dynamic challenges. In the face of adversity, military personnel must navigate through complex problem spaces, identifying root causes, and formulating innovative solutions. Scores for all the participants on the Armed Forces Qualifying Test (AFQT) that was given prior to their entry into the military were provided and used as the cognitive ability measure.
- *Adaptability* (C4). The planning phase is a cerebral cornerstone in military operations. Planning involves the systematic organization of resources, coordination of actions, and anticipation of potential contingencies. Individual Adaptability Measure (Ployhart and Bliese, 2006) was used.
- *Motivation* (C5). General motivation within military contexts encapsulates the overarching drive and commitment of individuals to serve their nation within the armed forces. Self-Control Scale (Buch et al., 2015) was used.

As technology continues to evolve, Artificial Neural Networks (ANNs) emerge as powerful tools capable of enhancing both the performance and awareness of contemporary military commanders. So, for this research, in mathematical terms, artificial neural network (ANN) modeling is applied for the intended purpose. The development of a novel evolutionary-based algorithm involves the concurrent modification of both the topology and connection weights of ANNs. This adjustment is achieved through various combinations of a genetic algorithm, guided by the input and expertise of domain experts. Mathematically, study results are gained after numerous NNM modelling and verifying different MLP and RBF constructs. This comprehensive modelling was completed to create an acceptable structure with an appropriate number of hidden layers and neurons. The modelling was performed considering the overfitting problem while exceeding an optimal ANN size (Caruana et al., 2001), as well as issue of data adequately while using too small number of data (Norgaard et al., 2000). These cautions were important in designing the team cohesion structure in the prediction models. Hence, this extensive modelling procedure allowed to control the optimum number of neurons, hidden layers, and transfer functions. The MLP and RBF models were validated. Following the mainstream practice (Ludermir et al., 2006) in ANN the best network model with the maximum coefficient of determination ($\boldsymbol{R}^2$) and minimum training and testing MSE was chosen for prediction.

In summary, the integration of neuroscience into the Army's training framework represents a transformative step. It not only refines the assessment of training methodologies but also introduces a level of individualization that can significantly enhance the efficacy and adaptability of training programs. The utilization of neuroscientific principles thus stands as a progressive strategy in advancing the capabilities of the Army in fostering optimal learning outcomes among its personnel.

References

Brooks, S. K., Greenberg, N. 2018. Non-deployment factors affecting psychological wellbeing in military personnel: literature review. Journal of Mental Health 27(1), 80-90.

Buch, R., Säfvenbom, R., Boe, O. 2015. The relationships between academic self-efficacy, intrinsic motivation, and perceived competence. J. Mil. Stud 6, 19–35. doi: 10.1515/jms-2016-0195.

Caruana, R., Lawrence, S., Giles, L. 2001. Overfitting in neural nets: Backpropagation, conjugate gradient, and early stopping — Penn State. Advances in Neural Information Processing Systems, 402–408.

Flood, A., Keegan, R.J. 2022. Cognitive Resilience to Psychological Stress in Military Personnel. Front. Psychol. 13:809003.
doi: 10.3389/fpsyg.2022.809003.

Friedl, K. E., Grate, S. J., Proctor, S. P. 2009. Neuropsychological issues in military deployments: lessons observed in the DoD Gulf War Illnesses Research Program. Military Medicine 174(4), 335-346.

Grier, R. A. 2012. Military cognitive readiness at the operational and strategic levels: A theoretical model for measurement development. Journal of Cognitive Engineering and Decision Making 6(4), 358-392.

Norgaard, M., Ravn, O., Poulsen, N. K., Hansen, L. K. 2000. Neural Networks for Modelling and Control of Dynamic Systems - A Practitioner's Handbook | M. Norgaard | Springer. Springer-Verlag.

Ployhart, R. E., Bliese, P. D. 2006, Individual adaptability (I-ADAPT) theory: Conceptualizing the antecedents, consequences, and measurement of individual differences in adaptability. In Understanding adaptability: A prerequisite for effective performance within complex environments. Emerald Group Publishing Limited, Bingley, UK.

Russell, S., Norvig, P. 2020. Artificial intelligence: a modern approach, 4th edn. Pearson Education, Hoboken.

Rumelhart, D., Hinton, G., Williams, R. 1986. Learning representations by back-propagating errors. Nature 323, 533–536. https://doi.org/10.1038/323533a0

Swann, M., Schmidt, R. M. 2005. Army cognitive readiness assessment: A next generation performance battery. In Human-Computer Interaction International Proceedings.

Thompson, M. M., McCreary, D. R. 2006. Enhancing mental readiness in military personnel. Military life: The Psychology of Serving in Peace and Combat 2, 54-79.