Education for Cognitive Agility: Improved Understanding and Governance of Cyberpower

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Abstract: Introducing novel techniques designed to scaffold learning and measure performance in military learners being trained to defend computer networks requires alternative education models. This paper presents how methods of Slow Education and Accelerated Learning could lead to greater Cognitive Agility in cyber defence operations. This study builds on earlier empirical and theoretical human factors research in cyber defence, specifically the Hybrid Space framework, Cognitive Agility, and the Orientate-Locate-Bridge model (OLB) model for socio-technical communication. The Hybrid Space framework visualizes the intersection between cyber-physical and strategic-tactical dimensions, allowing for the application of psychological concepts in assessment, training and action. Cognitive agility demonstrates an individual's metacognitive ability, measured as movements in the Hybrid Space, to understand, monitor and regulate the use of flexible cognitive strategies that help performance. The OLB model dissects the steps of improved grounded communication based on shared mental models in complex hybrid environments. These earlier studies provide a common framework for cognitive processes that can contribute to improved understanding and modes of governance in the cyber domain. This article suggests how Slow Education inspired approaches to educating cyber cadets can support improved sensemaking and understanding. *Slow* techniques were applied to a group of 37 students during a three-year bachelor degree education at the Norwegian Defence Cyber Academy. The education culminates in a two-week cyber defence exercise where the quantitative data for this study was gathered. The praxis of combining and applying novel pedagogic and psychological techniques aimed at accelerating learning and more specifically examples of cognitive agility among cyber defence teams. As policies and doctrines for cyberspace are drafted, challenged and negotiated, the requirement for educating personnel charged with the practice of governing cyberpower effects demands close attention. Governance of cyberpower can be understood as legitimate efforts to make events by, with and through cyberspace, happen in a productive direction. When cyberpower is redefining individual and state capabilities to influence events, and traditional education models are being challenged by the digital age, then developing and making metrics available that are suitable to evaluate human performance in the cyber domain is necessary. This study will further the discussion relating to cognitive agility and adaptations to cyber education capable for improving cyberpower understanding and governance.

Keywords: hybrid space, cognitive agility, cyberpower governance, cyber defence, cyber security education, slow education

1. Introduction

Cyberpower is an emerging phenomenon in the Defence realm. It is shaping attitudes, behaviours and decision-making as a result of its ability to: "…create advantages and influence events in all the operational environments…" (Kuehl, 2009, p. 38). Gray (2013) sees cyberpower as "the ability to do something strategically useful in cyberspace" (p. 9). This can be understood as giving agency to any actor, to support or undermine systems of governance, coordination, cooperation and competition (Nye, 2010). As a productive power, cyberpower manifests through relationships and network convergence (Stevens, 2016). One can argue that governing cyberpower is essential to absolutely everything a modern military hopes to accomplish. For this reason Defence forces need to advance their understanding of the cyberspace military context, in order to mitigate negative consequences when human agency, empowered by cyberpower, is influencing and driving change at rates traditional good governance systems, and codes of practice cannot control (Stevens, 2015).

First, we look at the changing face of military operations, detailing the effects of cyberpower and the need for adaptations in educational methods to meet the cognitive challenges these effects present. The methods section begins with detailing the Slow Education interventions that were applied at the Norwegian Defence Cyber Academy to embed, inform and maintain metacognitive activity. Next, the methods section details how quantitative data was gathered during a Cyber Defence Exercise. The results section shows the correlations between specific cognitive strategies and Cognitive Agility, represented as cognitive focus movements in the Hybrid Space. Further, we discuss the results in the context of improving performance in military cyberspace operations before the paper concludes and presents future work.

The complexity of cyberspace requires a higher level of understanding regarding own and adversary actions and interactions as information is pushed and pulled from multiple-centers of gravity (Alberts & Hayes, 2003). Educating military personnel to plan, operate and govern multiple complex digital-battlespaces demands focus on the complex mental challenges presented at multiple layers of abstraction. Technological developments may lead to augmented cognition with novel techniques such as Artificial Intelligence and Virtual Reality; however before that, there is a need to improve and maintain daily operative performance. The digitized context of the future operating environment will subject tactical level decision making to increased levels of scrutiny as incorrect choices and actions can lead to geo-political consequences and unexpected collateral damage (UK MOD, 2014). For young military personnel to accurately govern themselves, technology, cyberpower effects and others in military cyberspace operations, will require application of flexible cognitions through hierarchies, as well as improved understanding across domains. For example it is important that military cyber personnel are capable of analysing, evaluating, synthesizing, interpreting and lastly articulating cyberpower effects in relation to wider geopolitical conditions, as well as relating to its application in multidomain military contexts (Knox et al, 2018). When attribution and deterrence in cyberspace are framed by uncertainty, shifting interpretations and applications of cyberpower, deciding what is a tactical attack or an advanced persistent threat becomes far more than a simple exercise in classification.

The authors define governance of cyberpower as legitimate efforts to make events by, with and through cyberspace happen in a productive direction. This definition allows for governance to be understood as a practice capable of occurring at lower levels in military hierarchies, as it meshes both the process and performance concepts of governance (Hyden, 2004). At this level, good governance is more representative of the techniques required to: "...impose a general framework of order on the disorder, to prescribe the general flow of action rather than to try to control each event" (FMFM1, 1989). Conceiving governance this way is similar to what has been described as situational leadership (Northhouse, 2009). Situational leadership is defined as leaders able to diagnose the demands of their situation (Schermermore, 1997, p. 5). Where governance differs from this perspective is its suitability to go beyond diagnosing, to actually making things happen. The chaos, complexity and hybridisation of modern warfare (Bousquet, 2009) means adaptive modes of governance praxis may be more productive when appropriating and manipulating outcomes across multiple fluid networked situations, even if outcomes are uncertain.

It is possible that 'standardization' and 'accountability' common to traditional education models (Jenson, 2016) are barriers to achieving the education appropriate for military personnel who will be operating and governing operations in cyberspace. This research introduces how pedagogical interventions at the Norwegian Defence Cyber Academy provide the context for new literacies that include metacognitive strategies such as critical thinking, complex problem solving, expert communication and applied knowledge in real world settings (Pena-Lopez, 2016). At a cyber-personal and cyber-organisational level this implies the need to develop a range of flexible cognitive strategies capable enough to build relationship capital - the productive power - necessary for governing cyberspace operations.

Previous research suggested that flexible cognitive strategies can support better performance in military cyberspace operations (Hoffman & Hancock, 2017; Knox et al 2017). The authors define the outcome of understanding and adaptable goal directed application of flexible cognitive processes as Cognitive Agility (CA). CA is founded on strategies of metacognitive awareness and self-regulatory processes and is associated with performance in complex hybrid environments (Knox et al, 2017). CA can be interpreted/defined as movements within the Hybrid Space (HS) (Jøsok et al, 2016), and used as a tool to monitor, understand and support how individuals regulate flexible cognitive strategies for better communication performance in cyberspace operations (Knox et al, 2018). The HS provides an ontology and common framework for cognitive processes that can contribute to improved performance, in the form of understanding and modes of governance. By visualizing a cognitive landscape in the intersection between cyber-physical and strategic-tactical dimensions, the HS allows for the application of psychological concepts in assessment, training and monitoring the effects of pedagogical interventions and provide the context improved CA.

Based on learner needs and cyberspace context demands, we conclude that educating military personnel into the context of cyberpower and cyberspace operations, to secure expanded domain understanding, takes a *Slow* pedagogical approach. Slow methods tend to be seen as messy, inefficient and are rejected in favor of mechanistic, one-size-fits-all time and resource friendly instructional methods (Wright, 2018). There is though, evidence that constructivist pedagogical approaches are capable of accelerating learning and improving performance by building deeper knowledge grounded in metacognitive strategies (Piaget, 1964). Inspired by constructivism, and the Slow Education approach to learning, specific pedagogical interventions designed to improve higher-order thinking and understanding, such as self-directed workshops, flipped classroom, reflection logs, and cognitive task analysis, were introduced into the bachelor degree program at the Norwegian Defence Cyber Academy.

Slow Education is an adaptive non-standards based approach to education. It is categorised alongside Slow Movement philosophies and has its roots in student-centered education methodologies where self-expression, interests and capacities are prioritised (Holt, 2002). An outcome of this method is students gaining situational self-efficacy and empowerment as they engage in critical thinking (Bandura, 1997). This is valuable for cyber education as it leads learners to: "…displaying richer intertextual connections […] and meanings beyond prescribed lesson content…" (Jenson, 2016, p. 35). Slow techniques may be more suitable for creating and deepening knowledge into the context of cyberspace operations as they have the capability to aid orientation and understanding for learners (Hannafin, 2010). They can build authentic real-world knowledge regarding political and legal limitations/frames, strategic guidance, governance, and risk analysis based on tactical, operational and strategic cyberpower effects.

In the course of implementing Slow Education measures we assessed for associations between specific cognitive strategies - metacognition, self-regulation and ruminative perseverative thinking, and CA, measured as movements in the HS framework. The intended outcome is to ensure military cyber personnel have sufficiently developed thinking skills to regulate behaviour(s) for good governance of power effects in and through cyberspace. Flexible cognitive strategies are necessary for decision-making in complexity, when digital-system-dependency and the cyberization of everything is: "…make[ing] it easier to subvert and harder to govern" (Betz and Stevens, 2011, p. 135).

Slow Education can create environments where learners gain insights on cognitive processes that could affect performance. The techniques provide access to role models and mentors and an environment where the mentors can help the learner understand adaptive and maladaptive problem-solving strategies. Trait rumination (Nolen-Hoeksema, 1991) has been shown to be one such factor that can both inhibit and help performance (Watkins, 2008). While brooding, rumination focused on internal emotional processes, has been shown to be detrimental in decision-making. In several domains rumination in the form of reflective pondering has been shown to help performance (see Lyubomirski, Tucker, Caldwell, & Berg, 1999). Other cognitive processes shown to aid performance and accelerate learning are metacognitive awareness and self-regulation. Metacognition refers to 'thinking about thinking' and includes the components knowledge of one's abilities, situational awareness, and behavioural regulation strategies. Development of metacognition is reliant on a student-teacher interaction that promotes reflective discussions, giving support in scenario testing, and developing an understanding of causes of goal achievement and failure (Downing et al, 2009). Metacognition is also considered the most powerful predictor of learning (Veenman et al., 2006). Yet metacognitive development is dependent on metacognitive instruction that incorporates three principles:

1. embedding metacognitive instruction in the content matter to ensure connectivity.
2. informing learners about the usefulness of metacognitive activities to make them exert the initial extra effort.
3. prolonged periods of training to guarantee the smooth and maintained application of metacognitive activity.

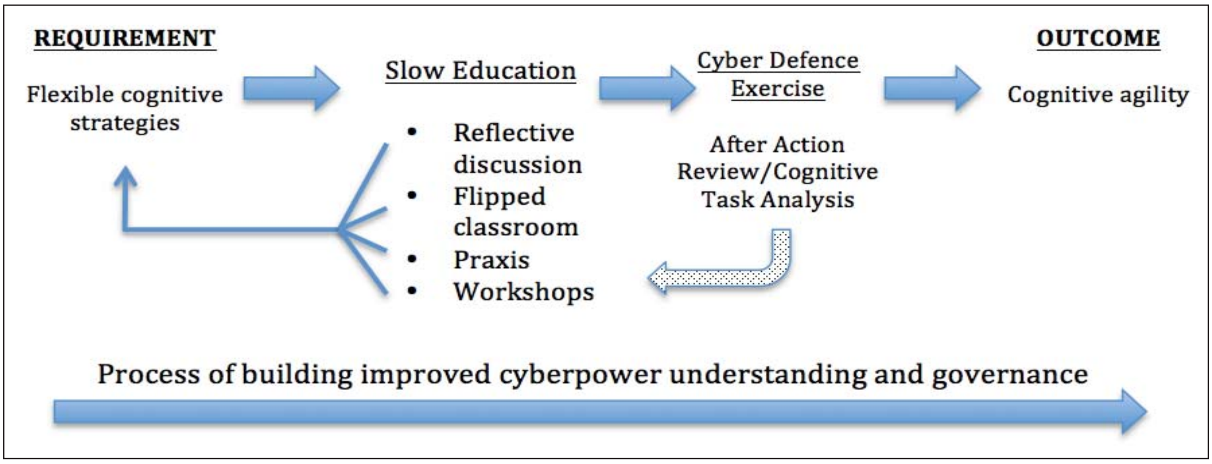

Figure 1: A learning system of knowledge acquisition through a Slow Education philosophy showing the requirement, pathway and desired outcome. At individual level the process is linear, however at organisational level there can exist a feedback loop from CDX to Slow Education, as final year students play a mentor role in the Slow Education interventions for younger students

2. Method

Integrating the three principles (metacognitive instruction, metacognitive activities and prolonged periods of training) into the educational platform at the NDCA was achieved through Slow Education approaches in the classroom and during praxis and exercise periods. Figure 1. conceptualises the process and Figure 2. details the different pedagogical approaches, inspired by Slow Education, that were applied to the research groups' educational platform.

Slow Interventions	Semester	Description	Goal
Cyber context reflective discussions	1	Cadet lead analysis, synthesis and interpretation of multiple cyber military topics introduced through an entire semester. Cadets document their ripening understanding.	Grounding understanding of the cyberspace military profession. Embedding metacognitive instruction through student-teacher interaction.
Praxis period with authentic real-world cyberspace challenges	4	Intense and enduring period of military cyberspace operations with close mentoring, available role models, focus on reflection and goal directed outcomes.	Gain insight into cognitive processes that affect performance. Help cadets understand adaptive and maladaptive problem-solving practices in complexity.
Flipped classroom	4	Traditional engineering subject taught in a learner-centered way. Skill development and concept practice via guided knowledge construction and application of high-order thinking skills.	Improve understanding through knowledge acquisition and construction of meaning.
Workshops	6	Cadets are grouped and design/deliver a one-day cyber related workshop to their peers. Workshops are developed over an entire semester. Cadets document their progress and are largely self-directed.	Build situational self-efficacy and empowerment through critical thinking, scenario testing and developing an understanding of causes of goal achievement and failure.
Daily After Action Review (AAR) including Cognitive Task Analysis (CTA) during a Cyber Defence Exercise	7	Mentor factilitated AAR and CTA process. Conducted in the evening after each cyber defence scenario. AAR completed with all teams present for knowledeg and experience exchange. CTA completed in teams with individual contributions to populate a chronological reconstruction of events and decision making in all domains.	Focussed retrospection to accelerate learning based upon improved domain and multidomain understanding.

Figure 2: Slow Educational interventions for improved cyberpower understanding and governance among cyber cadets at the NDCA

It was assessed that focusing on learner oriented, non-standards based pedagogic strategies during the educational program could support long-term development and application of CA. High-order thinking skills support building deep knowledge and adaptive expertise. They also have the ability to improve critical thinking in the form of truth-seeking, open-mindedness, self-confidence, and maturity (Miri et al., 2017). The authors view these skills and capabilities as necessary behaviours for cyber cadets who will be making legitimate efforts to make things happen in a productive direction, i.e., governance of cyberpower.

2.1 Measurements and metrics

Reflective pondering was assessed via the Rumination Style Questionnaire (RSQ; Treynor et al., 2003) after removal of depression-related items (Treynor et al., 2003). The RSQ assesses perseverative cognition on the subscales brooding and reflective pondering. Both subscales consist of five items to be answered on a 4-point Likert-scale (e.g., brooding: 'What am I doing to deserve this?' or reflective pondering: 'I analyze recent events and try to understand why I am depressed.'). The scale showed acceptable reliability for this study: Brooding Cronbach's α=.86; Reflective Pondering Cronbach's α=.84.

The Metacognitive Awareness Inventory (Shraw & Dennison, 1994) was used to measure metacognitive awareness. It is a self-report scale comprising of 52 items that includes several subscales assessing knowledge of cognition (declarative knowledge, procedural knowledge, conditional knowledge) and regulation of knowledge (planning, information management strategies, comprehension monitoring, debugging strategies and evaluation). Items are assessed on bipolar responses (true/false) and then ratios are computed from the subscales. Sample items include: 'I find myself using helpful learning strategies automatically' (procedural knowledge) and: 'I ask myself if I have considered all options when solving a problem' (comprehension monitoring). The test shows high reliability on all subscales (Cronbach's α = .90).

The Self-Regulation Questionnaire (SRQ) was used to assess the various self-regulatory processes through self-report (Brown, Miller, & Lawendowski, 1999). A sample item includes 'I am able to accomplish goals I set for myself.'. The SRQ is made up of 63 items, and each point is scored through a 5-point Likert scale (Brown, Miller, & Lawendowski, 1999). The form has good reliability (Cronbach's α = .91) and showed acceptable reliability score for this study (Cronbach's α = .75).

CA represents an individual's metacognitive ability to understand, monitor and regulate the use of flexible cognitive strategies that help performance. CA is measured as movements in the HS. The HS is mapped in a Cartesian plane and movements are operationalised through four constructs that represent the dependent variables in the study. Four dependent variables were created:

4. HSDT: distance traveled in the Cartesian Plane measured by Euclidian distance,
5. HSQC: Number of quadrant changes,
6. HSxM: Movement along the cyber-physical domain (x-axis), and
7. HSyM: Movement along the strategic-tactical domain (y-axis) (Knox et al., 2017).

Data was collected in the HS where 0 is the centre, Y-axis range from -100 to +100, and X-axis from -100 to +100 (Jøsok et al, 2018).

The quantitative data used to evaluate the pedagogical interventions for this study was gathered before and during a four day CDX. The CDX is an annual event designed to train cyber cadets in conducting military cyberspace operations. During the exercise the cadets operate in independent, but not opposing, cyber protection teams. The CDX contributes to developing the human and technical competencies necessary to govern the effects of own and adversaries' cyberpower capabilities. Prior to the CDX, students filled out all the trait questionnaires (Rumination, Self-regulation, Metacognition). During the CDX the cyber cadets were arranged into four teams totaling 37 (M_{age}=22.7 years, SD=0.71) resembling a complete cohort undergoing a cyber engineer education. From the 37 cadets, 23 took part in the experiment. The CDX lasted four days and participants simultaneously marked the location of their cognitive focus in the HS cognitive landscape framework every hour from 08:00-18:00 each day. This came to a total of 854 HS measurements over the four days.

3. Results

Descriptive statistics and correlations are presented in Table 1 and 2 respectively. Positive associations between hypothesized variables were significant in presumed directions (Table 2). Reflective pondering, self-regulation, and metacognition were all significantly associated with Hybrid space movements (Table 2).

Table 1: Descriptive statistics (*N*=23).

	Mean	*SD*	Minimum	Maximum
HSQC	17.39	6.92	6.00	30.00
HSxM	1539.17	740.41	456.00	3145.00
HSyM	1271.96	550.90	446.00	2595.00
HSDT	2225.09	934.71	723.00	4161.00
Self-Regulation	214.33	12.06	199.00	236.00
Declarative Knowledge*	0.71	0.21	0.25	1.00
Procedural Knowledge*	0.63	0.30	0.25	1.00
Conditional Knowledge*	0.74	0.24	0.20	1.00
Planning*	0.50	0.25	0.14	1.00
Information Management*	0.64	0.16	0.30	0.90
Comprehension Monitoring*	0.61	0.27	0.14	1.00
Debugging*	0.86	0.16	0.40	1.00
Evaluation*	0.47	0.27	0.00	1.00
Brooding	13.96	4.31	6.00	21.00
Reflective Pondering	14.04	4.30	6.00	24.00
Total Rumination	28.00	7.25	16.00	40.00

*Meta Cognitive Awareness Inventory

Table 2: Correlations (*N*=23)

	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. HSDT	.858**	.946**	.874**	.685**	.412*	.174	.157	.168	-.172	.120	.043	.024	.099	.397*
2. HSQC	1	.766**	.809**	.543*	.432*	-.049	.232	.022	-.215	.002	.138	-.089	.154	.374*
3. HSxM		1	.676**	.675**	.501**	.223	.159	.213	-.133	.214	.077	.151	.107	.387*
4. HSyM			1	.588**	.183	.130	.137	.112	-.188	-.043	.021	-.163	.062	.362*
5.Self-regulation				1	.476*	.256	.212	.515*	.315	.145	.239	.197	.116	.428*
6. Declarative Knowledge					1	-.090	.268	.455*	.115	.086	.120	.155	.257	.291
7. Procedural Knowledge						1	.579**	.298	.252	.155	.080	.461*	-.101	.312
8. Conditional Knowledge							1	.292	.529**	.332	.109	.512**	.173	.242
9. Planning								1	.412*	.452*	.083	.538**	.356*	.345*
10. Information Management									1	.599**	-.102	.531**	.311	.134
11.Comprehension Monitoring										1	.214	.737**	.258	.210
12. Debbugging											1	.210	-.237	.117
13. Evaluation												1	-.037	.144
14. Brooding													1	.419*
15. Reflective Pondering														1

**. Correlation is significant at the 0.01 level (1-tailed). *. Correlation is significant at the 0.05 level (1-tailed).

Collinearity checks were done for rumination, metacognition and self-regulation variables, and it was found that self-regulation and metacognition (declarative knowledge) were overlapping on HSDT (r = .646, p=.009). Self-regulation total was therefore used in this analysis.

To test the idea that variables associated with Slow Education, rumination, metacognition and self-regulation, would predict HS movements, hierarchical regression analyses was performed to show how they influenced each HS movement with rumination entered as a predictor variable in step 1, and metacognitive regulation and knowledge were entered in step 2 and 3 respectively (Table 3).

Regression analysis showed that reflective pondering and self-regulation were significant variables that influenced HS movements for DT and X-axis movements and almost significant for Y-axis movements. Self-regulation was the only significant predictor for distance travelled, X-axis and Y-axis movements.

Table 3: Hierarchical regression on all HS variables

Dependent Variable	R^2	*F*	ΔR^2	*β*	*T*
HSDT					
Reflective Pondering	0.096	1.484		0.310	1.218
Self-Regulation	0.469	5.751**	0.374**	0.694*	3.026
HSQC					
Reflective Pondering	0.090	1.388		0.300	1.178
Self-Regulation	0.297	2.744	0.207	0.516	1.955
Declarative Knowledge	0.332	1.988	0.035	0.208	0.795
HSxM					
Reflective Pondering	0.103	1.614		0.321	1.270
Self-Regulation	0.455	5.428**	0.352*	0.674**	2.897
Declarative Knowledge	0.479	3.672**	0.024	0.170	0.736
HSyM					
Reflective Pondering	0.073	1.102		0.270	1.050
Self-Regulation	0.345	3.430	0.272	0.593*	2.326
Declarative Knowledge	0.409	2.766	0.063	-0.280	-1.135

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

4. Discussion

Whether cyber is understood as a substrate for modern warfare (Dombrowski & Demchak, 2014), or as an independent operations domain (NATO, 2016); cyberpower effects are an emerging and globally shared phenomenon: "…posing more questions than answers" (Tapscott, 2014). This paper suggests that the answer to questions relating to what is the right education model for governing cyberpower effects, may lie in alternative approaches. Adapting certain technical and non-technical subjects at the NDCA meant educators avoided following only instructionist models that are: "…largely ineffective at helping learners acquire the skills and knowledge needed for the 21st century" (Keith Sawyer, 2014). Instead, education practices founded upon methods that are able to: "…unlock powerful learning opportunities…" (Dede, 2014, p. 5) and require educator humility, creativity and critical thinking were introduced.

The Slow Education interventions at the Norwegian Defence Cyber Academy showed partial support for the idea that reflective pondering, and self-regulation predicted certain HS movements, i.e., CA. All three independent variables (rumination, metacognition, and self-regulation) each showed positive associations with HS movements, however when a collinearity check was done for metacognition and self-regulation, these two factors described the same association for total distance travelled (Table 3). Since metacognitive awareness and self-regulation were shown to be overlapping, only self-regulation was used in further analyses. The results indicate that Slow interventions may have lead to more positive performance related to reflective cognitions, reflective pondering and self-regulation, as postulated.

Adaptations to traditional educational models have been identified as a pathway to better performance among learners in the digital age (Pena-Lopez, 2016, Tapscott, 2014). The data from this study shows that a: "…novel educational model" (Jenson, 2016, p. 21) such as Slow Education can potentially deliver deep-learning experiences and enhance current instructionist education systems for cyber cadet education. The necessity to improve cognitive skills and capabilities among cyber cadets is founded on the complexity of the current military context. Educators must ensure cadets have been given the opportunity to sufficiently develop thinking skills to regulate behaviour(s) for good governance of power effects in and through cyberspace. Many cadets have advanced technical competence giving them an intuitive advantage concerning cyberspace understanding and tactical, operational and strategic considerations. This can mean they are open for accelerated learning due to the knowledge authority they possess relating to such things as electronic connectivity, system layering, information system architectures, as well as meshing of real-world and cyber relationships; the "virtual-human network overlap" (Kilcullen, 2015, p. 183). Officers with a non-technological military education lack this nuanced understanding and will have to engage in more basic programs to ground cyber-technical and socio-technical knowledge if they are to understand military cyberspace operations. This may compromise their leadership potential, as their ability to sense-make for tactical and operational level understanding and decision-making will be limited. A consequence being their role will be restricted to one of officer-administrator or liaison-officer; rather than operative planner, leader and decision-maker. In this context, the cyber engineer will have increased responsibility to govern cyberpower effects as they are required to operate closer to the operational edge. This will require they are cognitively agile and capable of building relationship capital - the productive power - necessary for governing cyberspace operations. Being able to appropriate and manipulate outcomes across multiple fluid networked situations founded on their metacognitive skills that enable understanding, sense-making, and collaboration in uncertainty.

The model and interventions (Figures 1 & 2) were designed to match the dynamic context of cyberspace, as they facilitate learning by empowering cadets to find information through interactions, and construct knowledge in a manner that reflects the innovation-age (Keith Sawyer, 2014), where performance assessment requires students: "apply their knowledge and skills to real world contexts" (Dede, 2014, p. 1). Slow Education encourages positive rumination in the form reflective pondering as it allows the learner to profoundly learn and build a positive self-image through authentic experience; cultivating the necessary skills to participate in digital environments (Hannafin, 2010, Clayton, 1996, Kellner, 2002). As the results of this study show, where education encourages the development of understanding and adaptable goal directed application of flexible cognitive strategies, the outcome is revealed as cyber cadet CA. In practical terms, this can be presented as meaning better governance of cyberpower effects in complex hybrid environments.

Using a Cyber Defence Exercise to observe for CA allowed the researchers to validate Slow pedagogical interventions designed to accelerate learning and improve performance. Research has shown that rumination is a significant factor in performance, where reflective pondering is a more adaptive process over brooding (Lyubomirski, Tucker, Caldwell, & Berg, 1999). Applying Slow methods provides situations that can help reflective pondering over brooding rumination. This is due to training simulations guided by mentors with substantial and appropriate feedback. Whereas traditional education approaches tend to move forward and leave the reflection to the learner, unintentionally supporting more maladaptive strategies (brooding). This supports the notion of using training to increase more adaptive cognitions (reflective pondering) to help consolidate metacognition (Veenmen et al., 2006). Slow Education is able to help metacognitive development (both awareness and regulation) due to more opportunities to inform, discuss, practice, and evaluate the effectiveness of implementing metacognitive strategies in learning. By providing opportunities, i.e practice and targeted feedback, Slow methods are better equipped to support self-regulated learning strategies, which facilitate more adaptive regulatory behaviours. This study tried to address these aspects, and while not finding full support, did find that the variables had positive associations with performance.

Military cyber personnel need a developed cognitive repertoire if they are to effectively govern the effects of cyberpower. For example when experiencing the feeling of lack control in cyberspace operations it is absolutely critical that they have enough self-regulatory skills to be at their most motivated, even though they are most likely at their most uncertain. This condition mirrors the scientific work of John Boyd who saw uncertainty and ambiguity as an ‘irreducible characteristic of being and nothing less than the very condition of possibility of change and creativity’ (Bousquet, 2009, p. 193).

5. Further research

This was not systematic controlled research. The approach was a naturalistic, descriptive and correlative study in an applied setting. Systematic research comparing different pedagogic techniques and the comparative impact in objective measures of performance in larger samples are required. This study, however, aims to provide first arguments based on observations that Slow approaches might be able to improve CA for understanding and governance in the cyberspace military context. Technologies are able to extend, augment, even supplant individual cognitive processes (Iiyoshi, Hannafin, & Wang, 2005 in Hannafin, 2010). However, it is argued that metacognition and prior knowledge are needed for sense making (Land, 2000). In particular, when appreciation and understanding for political and legal limitations/frames, application of strategic guidance, governance of cyberpower effects, and risk analysis is no longer confined to higher ranking personnel.

6. Conclusion

This study is - to the best of our knowledge - the first to provide descriptive data on measures of cognitive performance in cyber defence. These data suggests that Slow interventions, capable of improving learners’ cognitive repertoire, may help support good governance in military cyberspace operations and utilisation of cyberpower. Specifically, the flexible cognitive strategies of self-regulation and reflective pondering correlated with CA, measured as movements in the HS. As the goal of Slow methods is to improve high-order thinking skills, such as reflective cognitions, then these findings can be seen as positive outcomes for measuring performance.

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