Team Neurodynamics by The Learning Chameleon, Inc

Mapping Cognitive Attractor States during Submarine Piloting and Navigation

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1. Introduction

Teamwork is complicated, complex, and noisy. The ecological perspective of teamwork (Cooke et al, 2009) draws on this complexity to describe a dynamic view of teamwork where individuals are viewed as a rich dynamic system with the state of each member depending on the state of others. Patterns of interaction and activity qualitatively emerge that are characterized by fluctuations to and from stable states.

The goal of this study was to apply these ideas of self-organization and attractor landscapes from complexity theory to develop neurophysiologic models of teamwork that may be sensitive to levels of team experience. Our hypotheses was that more experienced teams would exhibit looser cognitive coupling than novice teams who need to more explicitly track one another's behavior. Qualitatively this would result in the use of different cognitive attractor states, and a decreased proportion of time spent in these states.

2. Methods

The task was a high fidelity Submarine Piloting and Navigation (SPAN) simulation containing dynamically programmed situation events. Each SPAN session contains a Briefing that presents the goals of the mission, a Scenario segment containing easily identified processes of teamwork and processes less well defined, and a Debriefing where team members report on their overall performance.

The cognitive measure studied was an EEG-Engagement Index (EEG-E) defined by Advance Brain Monitoring's B-Alert® system that is related to processes involving visual scanning, information gathering and sustained attention. Data processing began with eye-blink decontaminated EEG files containing second-by-second probability calculations of high EEG-Engagement (EEG-E). The next step combined these values at each second for each of six team members into a vector reflecting the state of EEG-E for the team as a whole. These vectors were used to train unsupervised artificial neural networks to classify the state of the team at any point in time. A topology developed during this training where the most similar EEG-E vectors become clustered together and more disparate vectors were pushed away. The output was a series of 25 patterns called Neurophysiologic Synchrony Engagement (NS-E) Patterns that showed the relative levels of EEG-E for each team member on a second-by-second basis (Stevens et al, 2010a).

3. Results and Discussion

The NS-E Patterns define the state space, i.e. the possible states of the team with regard to EEG-E.

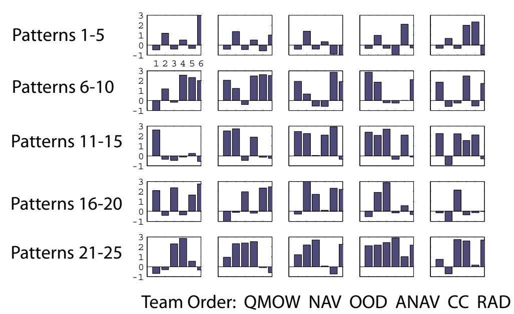

Figure 3.1 ANN Pattern Classifications for NS – E. The NS are numbered 1-5, 6-10, and etc. row wise.

The starting assumption was that many of the second-by-second changes in team Engagement would be small which would result in local transitions. With the linear architecture of the self-organizing ANN this would be reflected in transition matrices as movement around a diagonal line. Larger state space shifts would reflect either movement of the team to a different attractor basin in response to the changing task or perhaps a state shift across task boundaries.

The transition matrices with a 1 second lag are shown for pooled data from six novice or two expert SPAN sessions in Figure 3.2. The persistence of patterns and local transitions are shown by the diagonal line with the more frequent transitions shown by the higher contours. The largest pattern for novices was centered on NS 10 where many of the team members had low EEG-E. For experts the most frequent patterns / transitions clustered near NS 15 where most of the team showed above average EEG-E. A second major attractor centered near NS 22-25 where the majority of the team showed high EEG-E. The expert teams also showed more minor transitions as evidenced by the darker background contours throughout the matrix.

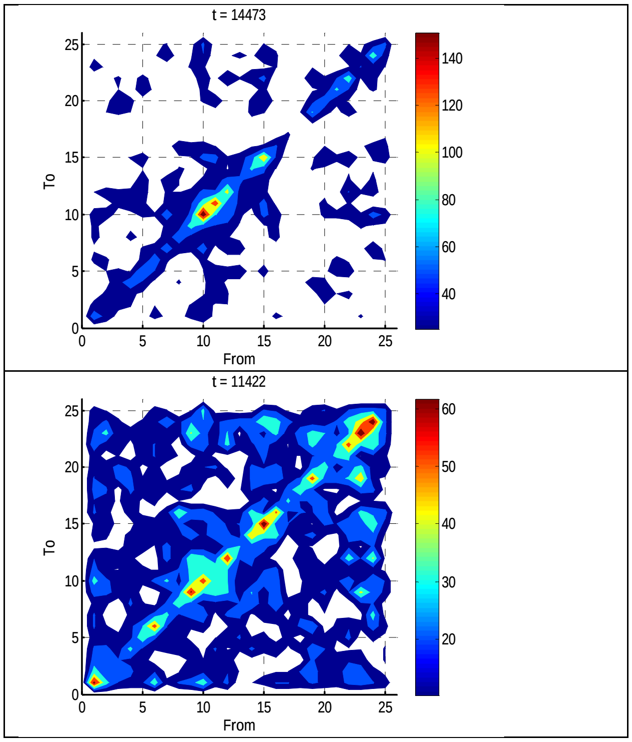

Figure 3.2. NS E Transition Matrix for Novice (top) and Expert (lower) teams.

To capture the dynamics of the NS E attractors, transition matrix movies were created for each team that updated every 8 seconds over a background of the prior 3 minutes. Two frames are shown in Figure 3.3 for team T4S2. The top frame (epoch 1646) was where there was confusion about contacting / avoiding another ship. Here the team was oscillating between two attractors centered near NS 14-16 and NS 9-11. The lower frame shows an uneventful time period.

These results indicate that the ideas of self-organization and attractor states are relevant for modeling team cognition and the engagement of teams. Changes in attractor dynamics occur across task boundaries and may become particularly apparent during periods of team attention / stress. Additionally they may be sensitive to the effects of team experience.

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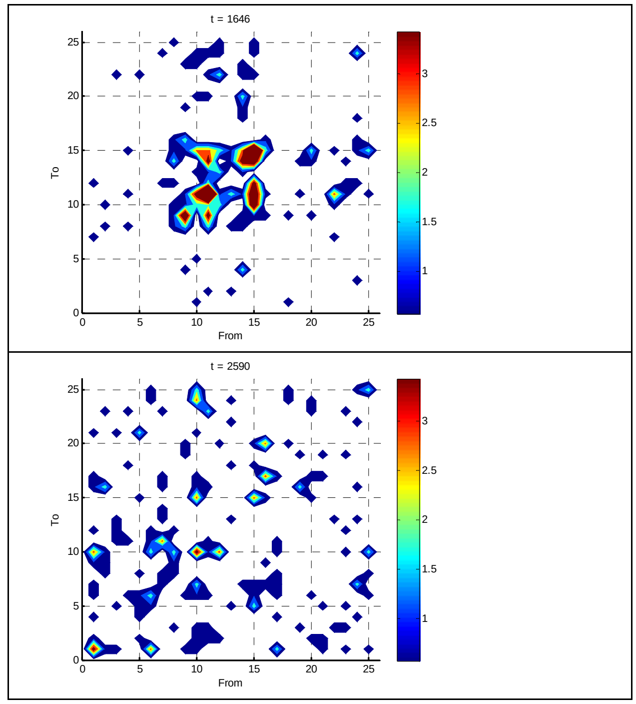

Figure 3.3. Dynamics of Changing NS E Patterns.

4. References

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