Comparison of Situation Awareness (SA) in Hierarchical and All-connected Network Structures



Human Factors Integration Defence Technology Centre

Content



- Theoretical Background
- Method
- Findings
- Conclusion



Theoretical background

Two opposing theories

Shared SA

- SA Definition: 'the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future'
- Team SA is presented as Shared SA where individual team members share the same SA requirements
- Psychological tradition

Distributed SA

- SA Definition: 'activated knowledge for a specific task, at a specific time within a system'
- The system ergonomics school consider SA as an emergent property arising from people's interaction with the world
- Team SA is seen as distributed and view the system as a whole: 'by considering the information held by the artefacts and people and the way in which they interact'
- Systems Ergonomics tradition

Comparison of the two theories

Comparison of two theoretical		
approaches to SA	Psychological tradition	Systems ergonomics tradition
Eurlenation of SA	Decides in the mind	Emerges from the interaction
Explanation of SA	Resides in the mind	between individuals and the world
How is team SA explained?	Shared SA requirements	Compatible, distributed SA
How is individual SA explained?	Only individual is of interest	Ind. interesting as part of a system
What is the unit of analysis?	The individual, in terms of their cognitive abilities	The interaction between parts of the system and the activation of knowledge within it
How is SA assessed?	The individual; SAGAT and SART	The System; SNA and Propositional Networks



Method

The present work sought to highlight the differences of the two theoretical approaches by comparing SA whilst exploring organisational structure and performance of two different teams in an intelligence analysis task.

- explore which theory of SA, Shared or Distributed SA, which reveal the functioning of the networks in terms of SA.
- explore which measures reveal most SA in the two conditions

Sample

- Sample of 34 postgraduate students;
 - 17 in Hierarchical
 - 17 in All-connected



- Hypothesis 1: The measures derived from the psychological tradition of SA, SAGAT and SART will reveal differences between the two network structures.
- Hypothesis 2: The measures derived from the systems ergonomics tradition of SA, SNA and Propositional Networks will reveal differences between the two network structures.
- The independent variable is organisation type; Hierarchy and All-connected, while the dependent variable is SA.



Constraints on information

Condition	Availability of information						
All-connected	Who	&	What	&	When	&	Where
Hierarchical	Who	or	What	or	When	or	Where



- **Distributed SA:**
 - Social Network Analysis tests of network diameter, density, centrality and sociometric status were performed
 - Propositional Networks were created
- Shared SA:
- Situation Awareness Global Assessment Technique (SAGAT), Situation Assessment Rating Technique (SART)
- SAGAT and SART were compared for difference in medians, Mann-Whitney U test of SAGAT and SART overall scores, test of Spearman's correlation for SAGAT and SART.
- SAGAT: Spearman's correlation coefficients calculated for level 1 level 2, level 2 level 3, and level 1 level 3; Mann-Whitney U rank-sum test.
- **Distributed SA:**
 - Performance measures; correct identify, time to complete and sharing behaviours.



Findings

ίAΤ

- There was no statistically significant differences between Hierarchy and All-connected on the overall SAGAT scale (U = 0.559, P = N.S.).
- Participants in both conditions therefore reported the same level of objective SA.
- Hierarchical SAGAT mean
- score = 12.12 (median = 12)
- All-connected SAGAT mean
- score = 12.59 (median = 13)





- Level 1: The All-connected condition achieved a slightly higher score (7) than Hierarchy (6.5)
- Level 2: The Hierarchy condition achieved a higher score than All-connected on level 2 SA (4.5 and 4 respectively).
- Level 3: Both conditions achieved the same score.





- SART scores
 - Hierarchical median = 4
 - All-connected median = 5
- No statistically significant differences was found on the Mann-Whitney rank sum test for the overall SART scale (U = 0.786, P = N.S.).
 - Participants therefore report the same level of subjective SA in both conditions.





- The two measures were compared using the Mann– Whitney two-sample rank-sum test.
- There was no statistically significant differences between the overall SAGAT (U = 120, P = N.S.) and SART (U = 129, P = N.S.) scores.
 - Hence no difference was found between the two measures for either condition.
- SAGAT's three SA levels and SART's three dimensions was subjected to Spearman's test of correlation.
 - No statistically significant correlation was found between any of the three SAGAT levels and the SART dimensions (P = N.S.).



- The Propositional Network represents a systems level depiction of SA contained within the network structure.
 - Therefore reflects Distributed SA







- Both Propositional Networks contain many of the same conceptual elements, however, there are a number of concepts that are exclusive to one network structure.
- For instance, "receive" exists only in the Hierarchical condition's network structure, while "process" is unique to the All-connected network.
 - This tells us that the way in which the two networks operated/collaborated to perform the task was different (Hierarchical team waited to receive information while All-connected team focused on the process of gathering information).
- The relationship between the concepts in any of the Propositional Networks are also qualitatively different
 - the information available to a system, and the way in which it is utilised within the team, differ for the two conditions.

ial Network Analysis

Applying SNA to the pattern of communication enables a quantitative probe of the qualitative findings.

- The All-connected network is denser than the Hierarchical network.
- also reflected in the larger number of edges found in the Allconnected network despite the smaller number of nodes found in this network compared to the Hierarchy network.
- In both conditions 'Information' is the node with highest sociometric status
 - the higher mean for Sociometric status for the All-connected indicates that 'Information' has greater connectivity in this

SNA statistics for Hierarchy Network				
Diameter	2.0			
Number of nodes	18			
Number of edges	152			
Density	0.49673203			
Centrality (mean)	9.499644			
Sociometric status (mean)	7.9411764			

SNA statistics for All-connected Network				
Diameter	2.0			
Number of nodes	17			
Number of edges	171			
Density	0.6286765			
Centrality (mean)	9.22884			
Sociometric status (mean)	9.6875			

ormance measures

prrect identify

- Commander in the Hierarchy network structure identified the task solution correctly, while three individual team members identified correctly in the All-connected network structure.
- Both network structures therefore successfully completes their task.

<u>ne</u>

The All-connected condition achieved task completion 2 min 28 sec faster than the Hierarchy condition; contrary to expectations.



aring behaviours

- Share: There were greater instances of sharing in the Hierarchy condition (326) than in the All-connected condition (119).
- Posts: There was greater number of posts in the Hierarchy condition (154) than in the All-connected condition (131).
- Pull: There were greater instances of pull, i.e. extracting information, in the All-connected condition (747) than in the Hierarchy condition (167).
- The difference in pull may be due to greater clarity in allocation of decision rights in the Hierarchy network than in the All-connected network
- The significantly higher instances of pull in the All-connected condition may be due to each individual having to take responsibility for solving the problem and as efforts are duplicated.

clusion

- The findings from SAGAT and SART did not reveal any statistically significant differences between the Hierarchical and All-connected conditions
- No support was therefore found for hypothesis 1.
- The findings from the SNA and Propositional Networks lend support to Hypothesis 2
 - SNA and Propositional Networks were found to reveal differences between the two network structures.
- The performance measures support the DSA findings, highlighting that there is indeed a difference between the two conditions.
 - The network structures enforce a difference in the way in which information is gathered, distributed and utilised within the structures.



- This study sought to contribute to the ongoing debate about appropriate measures to assess team SA.
 - By contrasting two approaches to SA the discrepancy between them has been highlighted and;
 - in applying quantitative and qualitative measures which have been developed within these approaches this incongruity is further emphasised.



Thank you.