Non-kinetic Effects Model (JNEM) (Provenzano, 2008). However, a review of current literature and information available in the morale area revealed no such source for the UK model (Evans, 2007). As a result the UK team were required to generate its own dataset.

Morale is a challenging concept with many and varied definitions and applications. As Rowland (2006) states, it is an abstract concept, and is difficult to quantify and measure. He also notes that morale has been the subject of much military interest since World War II, when a scientific study of morale was recognised as necessary. Since this time little appears to have been done to resolve the situation. The importance of morale to the military makes it a key issue for investigation, however small. Due to the lack of progress on this front, current simulations are unable to express or quantify morale. Any work undertaken to address this problem would therefore present an opportunity to test the potential for the latest breed of simulations to represent a complex human behavioural construct.

This paper presents an early exploration of the factors associated with morale. A collaborative, "bottom-up" approach to the model was taken between UK government (Dstl) and industry (QinetiQ). The requirements for the data collection were developed with the capabilities of the CGF and the application of the data in mind. The research protocol had to incorporate enough latitude to address the needs of the modelling and simulation experts, whilst being able to handle dataset options available from a semi-structured interview. A novel dataset based on the expertise of military Subject Matter Experts (SMEs), which would be appropriate for a CGF model, would be produced.

A recent study sought to determine the factors associated with morale, with over two hundred morale-related factors being identified (Evans, 2007). The factors were refined, with the key factors represented in a multi-level mind map, displayed in Figure 1.

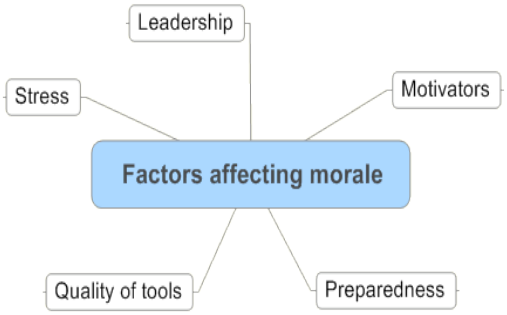

Figure 1: Summary diagram of top-level factors affecting morale.

The refined factors were grouped into five top-level factors: Leadership, Preparedness, Motivators, Stress and Quality of Tools. Sub-factors contributing to each of the top-level factors were also identified. For example, 'Stress' included physiological and psychological stress factors, Quality of tools included tool adequacy and confidence in equipment and tools, whilst 'Motivators' included political, financial and cultural motivators. This diagram formed the basis of the interview schedule, and an initial conceptual model.

As documented above, previous research on morale has sought to define the construct, and consider influencing factors. The present study extends previous work by utilising military judgement to consider the factors that influence morale. Given that it is unfeasible to track the changes in the morale of deployed military personnel over the course of a real operation, the study then seeks to test a novel method for estimating likely changes in morale given a series of events in a military-relevant scenario. Finally, the study draws upon military experience to identify potential behaviours influenced by changes to morale, which can then be used as an initial framework to considering how to represent variations in morale and its subsequent effects on behaviour.

2. Method

A combined approach was designed, in which the participants were to be asked to estimate (through the use of graphs) changes in the morale of a given unit as a function of a series of events presented in a set of operational scenarios. Methods such as this provide estimates that could be modelled, when it is clear how these changes in morale then influence behaviour; the graphs could be used to indicate the level of impact on the morale of a unit, which could later be implemented within the CGF subject to the identification of how morale might affect behaviour.

As the study addressed the factors associated with morale in a military land operational context, the decision was taken to use British Army personnel as interview participants. The rank of Major was viewed as a position at which awareness of the impact of changes in morale would have been experienced or perceived throughout the ranks. The interview would also be used to gain an understanding of the dynamics of the concept across a range of groups, levels and factors.

A semi-structured interview was conducted with twelve British Army Majors across a variety of Corps and Regiments (Cavalry, Infantry, Artillery, etc). A further selection requirement was that the participants had to have operational experience within the last five years. The

interviews lasted approximately two hours and comprised two parts:

Part 1 focussed on the definition and meaning of morale according to military judgement, and the subsequent impact of changes to morale in a military context. It consisted of eight structured questions that focused on the factors affecting morale, assessments of the conceptual mind map, and the impact of changes in morale on behaviour. The participants were also asked to provide examples and anecdotes from personal experiences.

Part 2 involved a practical exercise that sought to examine and quantify the changes in morale over time and according to certain events. Participants were presented with three representative military scenarios (a Peace Support Operation, a Counter-Insurgency mission and a Warfighting Withdrawal event). For each scenario, initial background information to the situation was provided, with further information provided according to discrete events occurring over a period of time. Participants were given a blank chart for each scenario and were asked to mark the level of morale for the group or unit (between 0 and 100). Levels were provided for the baseline levels of morale (based on the background information) and then for the morale of the group following each discrete event. These numbers were not taken as concrete but were used as relative points to describe the pattern of changes over time and events.

3. Results

Content analysis (Bryman, 2001) was conducted on the semi-structured aspect of the interview findings and the results of the practical task were aggregated across participants. Using the SMEs' critique of the mind map (part one of the interview) the content was revised to provide a conceptual map validated by British Army Officers. Finally, an exploratory analysis of the changes in morale across discrete events was conducted.

3.1 Part 1 – Factors affecting morale

Participants identified the aspects of morale that they regarded as important for a military definition of the concept. There was a general consensus that a definition of morale should consider some of the following aspects:

- Working together as a group
- A common purpose/goal
- Individual-level factors
- Working in a testing environment

There was also a strong feeling that the important factors that affect morale include:

- Leadership
- A clear purpose/goal
- Welfare issues
- Home concerns
- Training and Preparedness
- Equipment
- The impact of the media
- Environment and working conditions

The initial mind map generated considerable discussion, yet there was reasonable consistency in the participants' appraisal of the factors. The top-level groupings (Leadership, Motivators, Preparedness, Stress and Quality of tools) were regarded as appropriate for the factors, yet there was a strong opinion that the 'Quality of Tools' factor should be amended to 'Equipment and Support' and include new factors, such as medical welfare and casualty evacuation (CASEVAC). The amendments made to the Equipment and Support strand of the map are shown in Figure 2. This section was regarded by the participants as the weakest of the top-level factors and did not accurately reflect the importance of the entire equipment and support process. Re-naming the section reflects this and enables the inclusion of important and previously unconsidered factors such as CASEVAC, medical care and re-supply.

Though interviewees felt that on the whole the initial mind map was a fair representation of morale factors, some adjustments were made. For example, factors thought to be not relevant to morale in the British Army were removed and several related factors were amalgamated. Factors removed included the importance of religious motivators, some political motivators, fear and commitment. Physiological factors such as fatigue, sleep, heat and temperature, for example, were amalgamated into broad inclusive factors. A revised mind map was then produced.

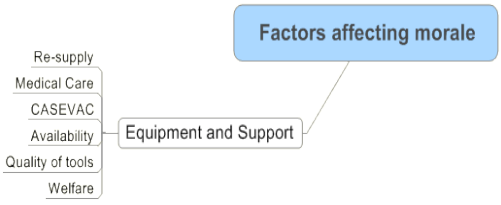

Figure 2: Equipment and Support section of revised mind map.

When the participants were asked to identify psychological and behavioural variables that can be influenced by changes in morale, the responses were many and varied, with both positive and negative impacts were identified. Factors that were positively influenced as a function of increases in morale include:

- More purposeful engagement with the enemy

- Increased pride
- Increased humour
- Increased Resilience
- Exceeding expectations

Variables thought to be influenced by low morale include:

- Reduced communications and feedback
- Increased risk-taking
- Sloppiness
- Slower completion of tasks
- Drop in marksmanship
- Discipline issues
- More complaints of fatigue and illness
- Loss of trust

The participants also provided anecdotes and examples from personal experience where changes in morale were thought to have had a recognisable impact on soldier performance. These anecdotes helped to contextualise the interviewees' responses and provide an initial list of candidate behaviours (that are potentially sensitive to changes in morale) that could be modelled within the system.

3.2 Part 2 – Changes in morale across discrete events

Vignette 1 – Peace Support Operation (PSO)

This scenario was based on an incident in Srebenica during the Balkans war in the 1990s. Participants were provided with background information and asked to determine a baseline level of morale for the Blue (friendly) forces. Nine discrete events were then presented during the course of the vignette, against which participants were required to estimate the relative change in morale for the unit. Aggregated participant responses are illustrated below in Figure 3.

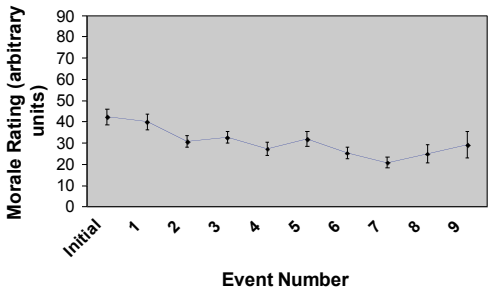

Figure 3: Mean of responses to Vignette 1 (PSO) including standard error.

The estimates of morale levels are shown to vary according to the events presented in the scenario. Though there was variability in responses, this could be expected from questions asking to provide estimates on a given measure.

Vignette 2: Counter Insurgency (COIN)

The scenario used in this vignette was based on the counter-insurgency operations similar to those experienced by British forces in both Iraq and Afghanistan. Participants were given background information and asked to determine a baseline level of morale for the Blue forces. Ten discrete events were then presented during the course of the vignette against which participants were required to estimate the relative change in morale level for the unit. Their aggregated responses are illustrated below in Figure 4.

This vignette again demonstrated the sensitivity of the morale estimates to the events presented in the scenario. Though there is a degree of expected variability associated with the estimates, the responses to specific events further demonstrated the potential for future exploitation. For instance, a CASEVAC (Event 4) prompted consistent estimates of increased morale, indicating that despite the loss of a colleague, the fact that CASEVAC had been provided would boost morale, owing to the knowledge the casualties were being supported and looked after, as indeed they would if an incident occurred. The interviewees did however suggest that the impact of these losses may be felt at a later point, after the battle had ceased. These findings demonstrate that discrete events could be modelled in CGF systems to influence morale, and that morale and associated behaviours may need to be considered in long-running simulations (over days or even weeks).

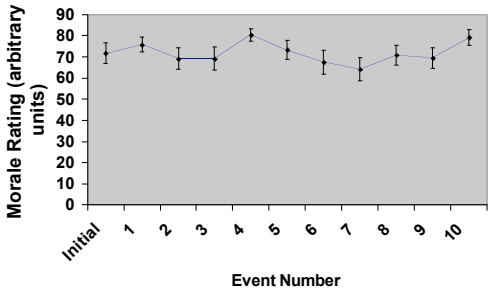

Figure 4: Mean of responses to Vignette 2 (COIN) including standard error.

Vignette 3: Warfighting Withdrawal

This vignette used a scenario based on the beginnings of the Gulf War in the 1990s. Participants were presented with background information to determine a baseline level of morale for the Iraqi forces. Twelve discrete events were then presented throughout the vignette against which participants had to estimate the change in morale level for the unit. Aggregated interviewee responses are illustrated below in Figure 5.

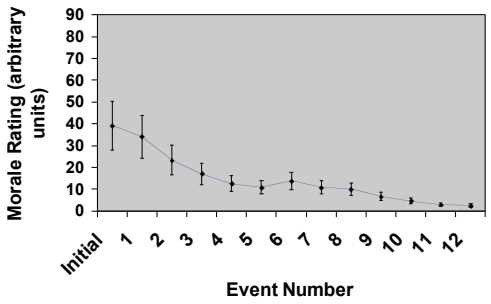

Figure 5: Mean of responses to Vignette 3 (Warfighting Withdrawal) including standard error.

Vignette 3 again demonstrated the sensitivity of the estimates to the scenario events, with the trend for morale to drop and remain low indicated by all participants (with the exception of several events during which the Iraqi forces obtained a degree of control over their situation). This scenario did however highlight a potential flaw in the methodology, with a distinct 'floor effect' seen in the estimates and their variability.

Across all three scenarios it is evident that the participants' estimates were sensitive to the events presented as part of the scenarios. The scenarios therefore provide candidate discrete events that could be represented in CGF models in order to cause morale levels to vary. For example, a positive boost to morale following a CASEVAC, reduction in morale after prolonged attacks from Indirect Fire (IDF), a boost when Close Air Support (CAS) is provided, and the importance of a sense of control over the situation at hand.

4. Model Implementation

The aim of the study was to create a morale model which could be integrated into the OneSAF™ Objective System, and so close attention has been paid to the development process used by the OneSAF™ team. Key early steps in the OneSAF™ development process are Knowledge Acquisition/Engineering (KA/KE) and Conceptual Modelling.

The conceptual modelling process aims to derive an intermediate model, understandable by all members of the software lifecycle process, in a concise and unambiguous format. This provides a powerful tool to fill the *"chasm between the subject matter experts' understanding and description of the real world and the computational representations created by software developers"* (Karr, 2005, p1).

The revised mind map of morale presented above was identified as a potential starting point for the development of a OneSAF™ compliant conceptual model, which could be used in future to rapidly facilitate the transition of SME interviews into implemented OneSAF™ models.

In tandem with the effort to determine the morale factors, a search for any similar research taking place in the public domain took place. There are a vast number of potential approaches to modelling morale, and so there was a need to gain an awareness of how researchers have tried to tackle this problem. Improving the representation of human behavioural factors is an area receiving constant attention, with research being conducted by academic and government institutions, as well as commercial organisations. The increasing maturity of cognitive architectures such as Soar (Lehman, Laird, Rosenbloom, 2006) and ACT-R (Anderson, Bothell, Byrne, Douglass, Lebiere, Qin, 2004). highlight the capability of computational models to accurately represent human cognition, with demonstrations such as dTank showing their applicability to the CGF domain (Morgan, Ritter, Cohen, 2005). Other maturing architectures show particular relevance to morale modelling, PSI being of particular note because it delves into issues related to motives and emotion (Ritter, Shadbolt, Elliman, Young, Gobet & Baxter, 2003).

A previous review compared biological, cognitive, rational and social models of human behaviour representation (Biddle, Henninger, Franceshini, & Jones, 2003) and how they might be modelled, indicating that these different perspectives might offer benefits to CGF systems.

Several other approaches have been put forward, focussing more heavily on a mathematical representation of the process. Proposals have included Markov modelling (Pentland & Liu, 1999) for its predictive qualities, Neural Networks to mimic behaviour and Bayesian Network representations (Yu, 2000).

These approaches highlight the dichotomy that exists between work undertaken within the psychological community, and the software engineering domain. This needs to be considered during the development of the morale model, in order to maintain as much psychological credibility as possible throughout the process.

This variation in implementation approaches highlights an area rich for further investigation. The approach taken in the previously mentioned combat participation model (Rooney, Smith, McInerney, McGahan, 2000) was to conduct an historical analysis followed by a mathematical implementation.

The approach put forward for the morale model in the present study started with a literature search, with SME interviews providing the dataset with which an implementation could be created for the OneSAF™ Objective System.

The implementation process used here adopts an 'Occam's razor' approach to develop a solution based on the available validated SME data, rather than being led by intuition as to what factors may or may not be involved in the calculation of morale. It became clear that certain events considered during the aforementioned vignettes had a distinct effect on morale, and this could be captured via a succinct set of rules, linking simulation events to a change of morale value.

Table 1: Simulation events and their quantified effect on current morale level (Mc)

Simulation Event	Result	Effect
CASEVAC request	Given	+1
CASEVAC request	Denied	-1
CAS request	Given	+0.5
CAS request	Denied	-0.5
IDF Attack > 1 Hour	Occurs	-0.25

Table 1 shows a partial data set illustrating how effect data can be derived from the SME interviews. These data can underpin an implemented morale model, where the simulated unit has an initial morale value set (M_U), which is then modified by a value assigned to specific simulation events. Once the scenario begins, the morale value dynamically changes over time, represented by a current morale level (M_C).

The OneSAF™ Objective System lends itself to such an implementation, as it is possible for an implemented model to receive notification whenever an event of interest occurs. This approach also matches that used for the existing implementation adopted by the OneSAF™ team to model 'quality of life' within the simulation.

Other candidate implementation solutions were considered, with a fuzzy logic approach having a number of positive points in its favour. It was felt that the ability of fuzzy logic to cover a wide problem space with a small set of rules, coupled with its handling of the sort of linguistic hedges likely to occur in definition of morale factors, was favourable. However, following the SME interviews, it became clear that a rule set based on events and their impact on morale allowed the implementation to stay true to the interview data. This implementation also allows greater transparency to researchers wishing to develop the work further. The table clearly correlates morale effects to simulation events, which can be extended upon and refined based on further research.

The implementation of this morale model in the OneSAF™ Objective System would provide the measure of the current level of morale, changing dynamically during the simulation as key events occur. It is hoped that this morale value can be used as a starting point for further studies, where the effects of various morale levels on CGF behaviour will be implemented – for example, combat participation. Whilst there are aspects of the simulation which could be readily modified depending on the morale value (e.g. weapon reload time), there is, as yet, no validated data for an implementation of such effects. The use of this morale model as an effect on behaviour, especially goal-orientated behaviour (e.g. performance) could enable the system to be used as testbed for research into how changes in morale affect operational effectiveness.

5. Discussion

An important aspect to this study was the multidisciplinary approach to tackling the problem, with psychologists and simulation modellers working together in order to understand each others needs. Pew and Mavor (1997) suggest that in the development of human behaviour representation, use should be made of interdisciplinary teams consisting of sociologists and cognitive psychologists, computer scientists who are knowledgeable in the contemporary literature and modelling techniques, and specialists in the military doctrine (Pew & Mavor, 1997). Here we have attempted to take Pew and Mavor's approach to the challenge of modelling morale. Combining the experience, skills and approaches of the different disciplines has informed the approach with both aspects of the model in mind, attempting to ask questions of participants that can be used effectively by the modellers.

Being a complex and often intangible influence on military behaviour, the construct of morale has previously been subject to much criticism. However, it has been widely acknowledged that morale, in whatever form it takes, is an important aspect of military campaigns. As discussed earlier, it was recognised as early as World War II (by Brigadier Nigel Balchin) that there was no scientific study investigating the nature of and the impact of morale, though little has been achieved since this time (Rowland, 2006). The present study aimed to go some way to addressing this lack of research, by seeking military judgement on the factors that affect morale, and through the estimation of morale in response to discrete events featured in three military scenarios.

It is difficult to develop a measure that can be used to track state changes in morale as a function of events in real military operations, given the distraction it would generate in what can be a dangerous and safety-critical environment. To that end, the study proposed the use of military estimates of morale in response to events presented in realistic scenarios. The military estimates of morale appeared to be sensitive to the events across the three scenarios, which provides support for the use of this

method to investigate how morale might vary during military operations.

A number of potential uses for this model have been identified, where it is felt the richness of the CGF picture presented can be improved. During the SME interviews, specific examples arose where morale levels would have a demonstrable affect on behaviour. It was suggested by the SME community that there will be an increase in time to complete tasks as morale decreases (e.g. changing a wheel on a vehicle). It is feasible to develop an extended set of CGF behaviour, inheriting from the current tasks and adding a time delay variable which is determined from the current morale level of the unit. Another option would be to use the morale value to affect the reactive behaviour choices of entities within the simulation. With a high morale level, on coming under fire a unit adopts the expected drill as its reaction. However, with low morale a unit would select a different behaviour where their level of combat participation is a lot lower (e.g. non return of fire, taking cover).

These suggestions provide the link between morale and behaviour. This link is crucial in developing the model and requires further investigation. The change in behaviour that occurs as a result of changes in morale has been eluded to by the SMEs, however further research would seek to develop and validate these suggestions.

The work conducted under this study has hopefully provided a framework from which further research can be conducted. It has demonstrated how factors can be identified for a facet of human behaviour, ratified for a specific domain through SME consultation, and could be implemented in a computationally amenable format. There are many areas of research which would strengthen this package of work. The first would further investigate the link between morale and behaviour. In order to develop the model's capabilities, this step is essential to provide a quantifiable outcome of the changes in morale.

Another phase would be to broaden the SME data captured, both to additional cultures so that it is no longer UK specific, and also other military or civilian domains. Such research would allow the morale modelling to be applied to other simulated entities within the CGF, building a much richer simulation picture.
A study to validate the data table used and assess its face validity would also prove a beneficial step, and the implementation adopted should allow such work.

Further work could also attempt to classify events into types, such as "gain information/control" and to predict the morale changes associated with these types. The development of this approach would also allow an estimation of the magnitude of the effects identified.

The initial conceptual model presented describes an approach to the capture and understanding of a complex human concept. It provides the research domain with opportunities for investigation and development, and begins to address the often untouched topic of morale.

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