Modelling the Influential Factors Embedded in the Proportionality Assessment in Military Operations

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Abstract: The ongoing decade was believed to be a peaceful one. However, contemporary conflicts, and in particular, ongoing wars prove the opposite as they show the increase in context complexity when defining their goals as well as execution strategies for building means and methods for achieving them by gaining advantage against their adversaries through the engagement of well-established targets. At the core of the engagement decision relies the principle of proportionality which brings in a direct relation the expected unintended effects on civilian side with the anticipated intended effects on military side. While the clusters of effects involved in the proportionality assessment are clear, the process itself is subjective, governed by different dimensions of uncertainty, and represents the responsibility of military Commanders. Thus, a complex socio-technical process where different clusters of influential factors (e.g., military, technical, socio-ethical) play a role in the decisions made. Having said that, the objective of this research is to capture and cluster these factors, and further to model their influence in the proportionality decision-making process. This decision support system produces military targeting awareness to the agents involved in the processes of building, executing, and assessing military operations. To accomplish the aim of this research, a Design Science Research methodological approach is taken for capturing and modelling the influential factors as a socio-technical artefact in the form of a Bayesian Belief Network (BBN) model. The model proposed is further evaluated through demonstration on three different cases in respect to real military operations incidents and scenarios existing in the scientific literature in this research field. Hence, through this demonstration, it is illustrated and interpreted how the factors identified influence proportionality decisions when assessing target engagement as being proportional or disproportional. In these cases, corresponding measures for strengthening proportionality and reducing disproportionality in military operations are considered.

Keywords: Military Operations, Targeting, Proportionality, Cyber Operations, Machine Learning, Bayesian Networks.

1. Introduction

"When you change the way you look at things, the things you look at change." (Max Planck)

Recent and ongoing conflicts prove the fact that technological innovation and the integration of technological developments through advanced, adaptive, and/or intelligent means and methods of warfare, imply a higher degree of awareness and from there involvement when aiming to achieve well defined military objectives (the what) while building strategies and plans to accomplish them in respect with the necessary conditions and limitations (the how). No matter if conventional or unconventional instruments of war are being used and no matter in which operational domain (e.g., land, air, cyber), at the core of this phenomenon is the targeting process where the indispensable element in the military decision-making process when deciding if it is proper to engage a military target or not is the *proportionality assessment*. This assessment brings together two cardinally opposed components, i.e., military advantage and collateral damage (Oxford Institute for Ethics, Law, and Armed Conflict, 2009; Dinstein, 2016; McKenna, 2020).

While this assessment takes place considering the information available, it is a subjective process where the decision is made by the military Commander who has to refrain from attack in case that the incidental civilian harm is excessive in relation to the anticipated military desired effects (Preston & Taylor, 2016). In this process, a series of influential factors (of both military and human nature) play a role (Maathuis, Pieters & van den Berg, 2021). While a large body of knowledge focused on understanding the legitimacy of target engagement and the two major components involved, limited studies focused on gathering the influential factors that could play a role when conducting proportionality assessment, and such a fact could imply major and large-scale consequences on corresponding civilian and military systems and humans, and further negatively influence the mission.

Hence, the aim of this research is to identify, structure, and model various influential factors to proportionality decisions by means of a BBN (Bayesian Belief Network) model and further demonstrate the model proposed on three influencing situations. In this regard, to the best of our knowledge, this model represents the first attempt to capture and model the influential factors to proportionality decisions in military operations. Accordingly, the contributions of the model proposed are defined as follows:

- Awareness to policy and military decision makers such as military Commanders and military-legal experts on the existence of diverse influential factors to proportionality decisions.
- Support for the design and development of intelligent or software-based solutions that could assist military decision makers when conducting the proportionality assessment and further considering relevant aspects to other activities such as CoAs (Courses of Action) definition, analysis, and comparison.
- A call for further active research in this scientific domain by merging scientific discourses and means with practical perspectives and methods to assure the development, execution, and assessment of transparent and responsible military operations.

To achieve the above mentioned research goals and sustain these contributions, multidisciplinary research is carried out based on extensive literature review and model development following the Design Science Research methodology.

The reminder of this article is structured as follows. Section 2 presents the context of this research and discusses relevant studies. Section 3 explains the research methodology followed to achieve the aim of this research. Section 4 depicts and clusters the influential factors to proportionality decisions identified. Section 5 discusses the design of the model proposed in this research, i.e., variables and relations between these variables. Section 6 presents the evaluation of the model by means of demonstration of three different influence cases, and interprets the results obtained. At the end, Section 7 provides the findings of this research and addresses future research ideas.

2. Research Background and Related Research

When targeting in military operations, effects must be created to achieve the military objective(s) defined and reach the end state of the mission. This process is carried out under the guidance of the governing law, i.e., International Humanitarian Law (IHL) and the Rules of Engagement (RoEs) specifically defined for a military operation. Herein, military targets are selected, and further the anticipated military advantage and the expected collateral damage are established to decide if the attack is proportional or not, i.e., can be approved or not for execution (Henderson & Reece, 2018; Ali, 2020). This process is based on the principle of proportionality, is referred in the literature with terms such as assessment or test and has a subjective nature as it is based on human reasoning and responsibility of the military Commander in place (McKenna, 2020). Specifically, the principle of proportionality forbids the expected total incidental civilian loss (i.e., collateral damage) to be excessive in relation to the direct anticipated military advantage (AP I Art. 51(5)(b), 1977; NATO, 2016). Hence, in the proportionality assessment a balancing or comparison between antagonistic categories which reflect the 'interest of the belligerent in carrying out a military action and the interest of civilians, who, although extraneous in the conduct of hostilities, might be victimized by that action' (Cannizzaro, 2006), in other words, the intentional effects or the positive part of the (in)equation versus the unintentional effects or the negative part of the equation (Oxford Institute for Ethics, Law, and Armed Conflict (2009); Maathuis, Pieters & van den Berg, (2016); Maathuis, Pieters & van den Berg, (2018a)). As proportionality is not the singular process to be considered when preparing and executing a military operation (Gillard, 2018), so is the existence of other factors that belong to the human realm (e.g., background and experience of the military Commander). This also plays an influential role in the military decision-making processes involved (NATO, 2016; Henderson & Reece, 2018; Maathuis, 2022a).

Hence, we further consider the multidisciplinary nature of this research and discuss related studies that have investigated different types of influential factors or variables surrounding and playing a role when the proportionality assessment is carried out. On this behalf, Henderson & Reece, (2018) scrutinize what a 'reasonable military Commander' means in the context of proportionality assessment and consider that this assessment (i) is subjective when the person believes, (ii) is objective but unqualified when the person reasonably believes, and (iii) is objective but qualified when an expert is reasonable objective. To this end, a reasonable military Commander is a 'reasonably well-informed person in the circumstances of the actual perpetrator, making reasonable use of the information available' (Gall, 2004) which reflects the importance of military training and exercise that facilitate proper reasoning and explanations of the decisions taken (Ali, 2020; Maathuis, 2022b). Furthermore, Hayashi (2010) considers that proportionality decisions could be taken in very stressful circumstances, illustrates the importance of the military purpose that must be achieved, and points out the negative role that poor information could have for proportionality assessment. At the same time, Fenrick (2001) reflects on the role that the background and values of the decision-maker have when conducting proportionality assessment and pose critical questions regarding inclusion and exclusion criteria plus temporal and spatial factors that should be included when conducting proportionality assessment.

Bartneck et al. (2021) discuss AI (Artificial Intelligence) applications in the military domain, specifically, aspects such as autonomy and control regarding the use of autonomous weapon systems. On this, the authors stress that the outcome of targeting the Malaysia Airlines MH17 jet (from Amsterdam to Kuala Lumpur in 2014) would be different if an advanced system would have been put in place for making a clear distinction between civilian and military aircrafts. Moreover, the same authors highlight the multi-source nature of the information received when conducting proportionality assessment. Remaining in the same area of autonomous weapons, Morgan et al. (2020) assess that the principle of proportionality implies a case-by-case assessment which is a subjective process in which ‘the harm of possible collateral effects is weighted against the importance of the military objective’, while further concluding that the proportionality assessment is “an evaluative, qualitative, and ethical assessment by a human weighting and comparing complex values”. Along these lines, Thome (2020), Holland (2002) and Katzir (2018) argue that proportionality assessment relies on “less concrete concepts” like human judgement, values, and foresight while requiring a certain degree of military operational expertise. On the other side, Whittemore (2015) and Kai (2022) consider that heuristics and different types of biases are also involved in this process. In the naval domain, Lee (2021) conducts an in-depth analysis on the role and participation of civilians in the execution of military operations, and further calls for a broader perspective and a larger dialogue on interpreting and applying the principle of proportionality. In the air domain, Gul (2021) discusses the applicability of the principle of proportionality to drone attacks and addresses a topic scarcely tackled in the existing body of knowledge, i.e., military advantage which plays a direct and concrete role as one of the two key components of the principle of proportionality by directly contributing to the achievement of the military objectives defined. Going to the military cyber domain, Pascucci (2017) analyzes what the principles of distinction and the principle of proportionality mean. On this behalf, the author considers that the principle of proportionality is an *ex-ante* analysis that conducts to the *ex post* facto consequences. These consequences are not relevant when determining if the principle of proportionality was violated since the principle of proportionality is governed by uncertainty and is conducted before target engagement. Moreover, In the military cyber domain, Maathuis, Pieters & van den Berg, (2021) consider as influential factors concepts like military aim, the background, and experience of the military decision maker (i.e., military Commander) as well as the willingness/appetite and stress.

3. Research Methodology

To identify and capture the influential factors contributing to proportionality assessment decisions and be able to further model them, the following research questions are formulated:

- What are the influential factors contributing to proportionality decisions?
- How to model the influential factors to support proportionality decisions?

These research questions imply identifying and embedding multiple dimensions existing in different domains, i.e., (cyber) military operations, law, behavioural psychology, and AI. Hence, a call for multidisciplinary research considering a socio-technical perspective by means of building a model as an artefact with direct societal meaning, contribution, and impact. Accordingly, a Design Science Research methodological approach is considered following the succeeding research activities (Peffers et al., 2007; Kuechler & Vaishnavi, 2012; Peffers, Tuunanen & Niehaves, 2018):

Problem Definition and Aim: old as well as modern and recent military operations demonstrate their complex nature and implications plus the broad range of influential factors contributing to proportionality decisions, i.e., a key element and decisive moment in their execution. While different aspects and dimensions have been defined and analysed on this behalf, the existing need for gathering and understanding the influential factors to such decisions continues to grow as the means and methods of conducting war are becoming more intelligent and adaptive to different (new) situations. On this behalf, this research captures influential factors to proportionality decisions through extensive literature review conducted using combinations of keywords like ‘proportionality’, ‘targeting’, ‘assessment’, ‘test’, and ‘influence’ in scientific databases such as IEEE Xplore, ACM Digital Library, Springer Link, and Google Scholar.

Design and Development: once the influential factors are gathered, they are analysed and clustered based on their nature, and further captured in an intelligent model using BBN.

Evaluation and Dissemination: afterwards the proposed model is evaluated through demonstration considering three different situations of influence on proportionality decisions. Furthermore, the results obtained are interpreted and positioned in their corresponding situations through these article and upcoming scientific presentations.

4. Influential Factors

With respect to our research goal, to structure the influential factors identified, a clustering approach is considered based on (Da Veiga et al. 2020; Maathuis, Pieters & van den Berg, 2021; Maathuis & Chockalingam, 2022) meaning military context, military-legal, and human clusters of variables. Correspondingly, the clusters are depicted in Figure 1, below addressed, and structured in Table 1.

- Military Context: this cluster contains variables characterizing different practical aspects regarding the strategic, operational, and tactical levels of war.
- Military-legal: this cluster embeds variables related to specific military-legal dimensions applicable when building, executing, and assessing military operations in respect to the appropriate legal frameworks.
- Human cluster: this cluster immerses variables linked to human aspects such as behavior and values.

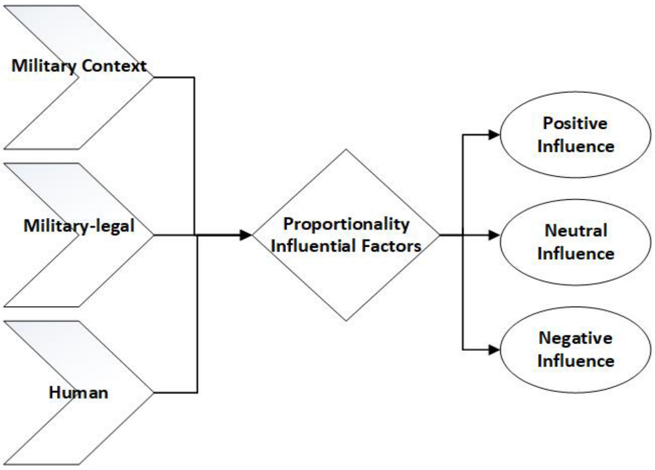

Figure 1: Proportionality decisions influential factors

Table 1: Proportionality decisions influential factors

Cluster	Variables and States	References
Military Context	Military setting: SIMPLE, COMPLEX Military goal/purpose: ACHIEVABLE, NON-ACHIEVABLE. Military requirements and conditions: UNCLEAR/ILL-DEFINED, CLEAR/WELL-DEFINED Lessons learned from previous operations: PRESENT, NOT PRESENT Military intelligence: POOR, ADVANCED	Katzir (2018); Maathuis, Pieters & van den Berg, (2021); Gul (2021); Hayashi (2010); Bartneck et al. (2021); Morgan et al. (2020); McKenna (2020).
Military-legal	Compliance with military-legal principles: LOW, MEDIUM, TOTAL {Compliance with/Status} ROEs: UNCLEAR, CLEAR	US Army (2013); NATO (2016); Pascucci (2017); Colonomos (2017); Katzir (2018); Ali (2020); Thome (2020); Maathuis, Pieters & van den Berg, (2021); Bartneck et al. (2021).
Human	Background: LOW, HIGH Training and Experience: JUNIOR, SENIOR Willingness/risk appetite: LOW, HIGH Stress: LOW, HIGH Broader effects perspective: ENABLED, DISABLED Foresight capability: LOW, HIGH Religion, Culture, Values, Moral identity, Moral disengagement, Personality type (e.g., authoritarian), Depression, Drinking problems, Genre, Bias (e.g., overconfidence, confirmation)	Holland (2002); Maathuis, Pieters & van den Berg, (2021); Gul (2021); Henderson, I., & Reece, (2018); Hayashi (2010); Fenrick (2001); Whittemore (2015); Kimhi & Kasher (2015); Colonomos (2017); de Graaff, Giebels, & Verweij, (2020); Morgan et al. (2020); Thome (2020); LeardMann et al. (2013); Kai (2022).

5. Model Design

To model the influential factors identified while taking into consideration the uncertainty and subjectivity that govern the proportionality assessment process as well as the complexity surrounding it (Pourret, Na & Marco, 2008), a BBN modelling approach is considered for designing and developing the model proposed in this research. This approach already proved its applicability in modelling complex systems and processes within diverse plethora of societal domains (Marcot & Penman, 2019), and contains two main components: (i) *qualitative* which is a Directed Acyclic Graph (DAG) as depicted in Figure 2 that captures a set of variables and direct cause-effect relationships (i.e., edges) between them; and (ii) *quantitative* component that contains the Conditional Probability Tables (CPTs) with the conditional probabilities for all possible combinations of child-parent variable states, as shown in Figure 2. It is important to note that in case a variable does not have a parent variable, the CPT contains the priori marginal probabilities of the corresponding variable. Furthermore, with respect to the existing reasoning types of BBN (i.e., predictive, diagnostic, intercausal, and combined), our model embeds the predictive reasoning approach as it is reasoning from cause (upper layer) to effect (lower layer) (Maathuis & Chockalingam, 2022).

The clusters of our proposed model together with their corresponding variables and states are captured in Table 1. The variables *religion, culture, values, moral identity, moral disengagement, personality type, depression, drinking problems, bias,* and *genre* were not included in the model as they are indirect influential factors, are difficult to assess, and are less tackled in the scientific literature in relation to the proportionality assessment. For these factors, more research is necessary, thus this is a future research line for extending the present model. The target variable (proportionality influence) contains the following values: Negative, Neutral, and Positive.

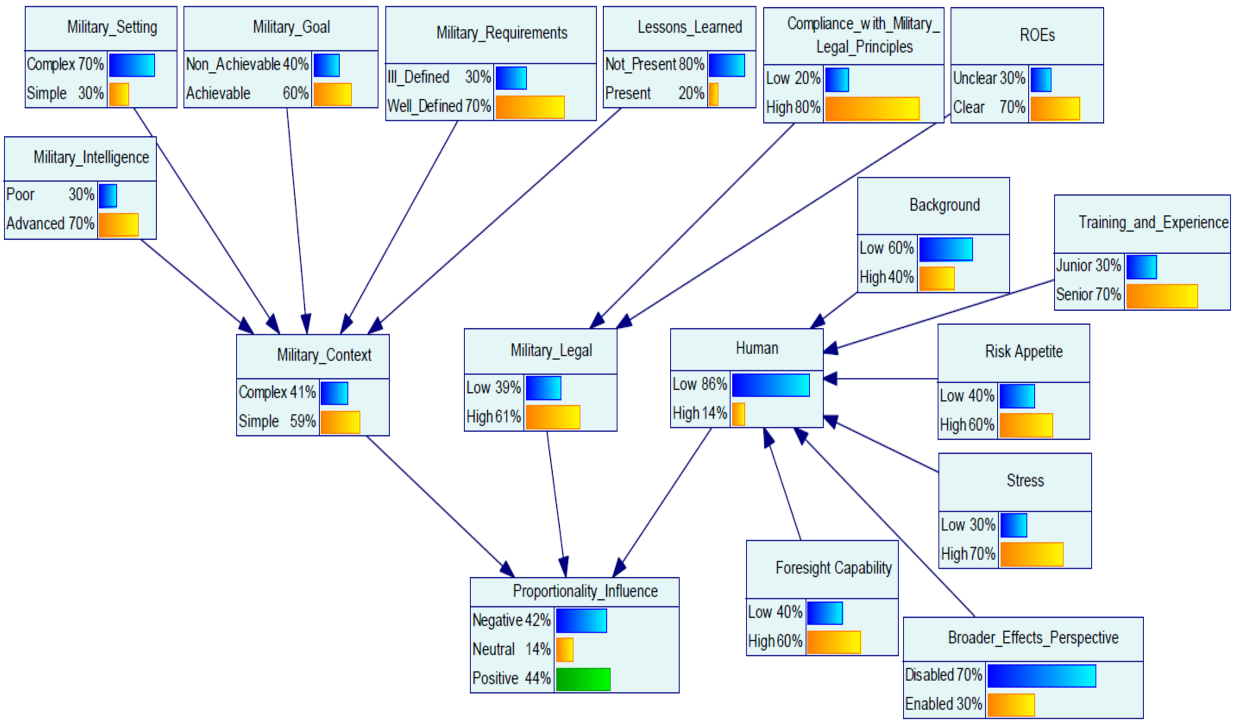

Figure 2: Proposed model without evidence provided

The conditional probabilities used in the proposed model are example values. This is to demonstrate the use of such model by providing evidence to different variables in illustrative case scenarios in Section 6. Typically, such probabilities can be elicited from experts and empirical data. In addition, approaches like Noisy-OR (lemmer & Gossink, 2004) can be used to reduce the number of conditional probabilities to elicit from experts and complete the CPTs.

6. Model Evaluation

As discussed in Section 3, the evaluation of this model is conducted through demonstration on three different case scenarios.

In the first scenario, evidence is set in the upper layer: Military Setting = "Complex", Military Requirements =

"Ill-defined", and RoEs = "Unclear", Training and Experience = "Junior", and Stress = "High". Then, the posterior probability is calculated by the model for its other variables without any evidence. Hence, as depicted in Figure 3, the results influence is "Negative", meaning that the Proportionality influence has a 57% chance of being Negative, 13% chance of being Neutral, and 30% chance of being Positive. This could be the case of a military Commander that is less experienced and has to decide when dealing with major amount of stress and unclarities regarding the military and legal requirements and possibilities.

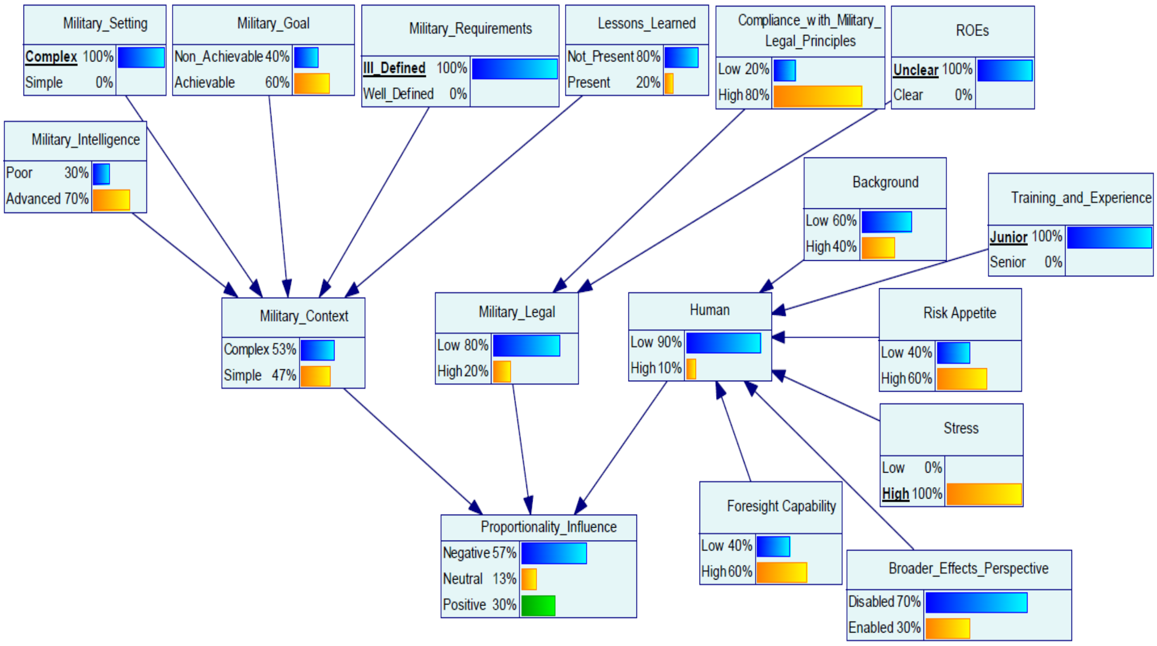

Figure 3: First case scenario

In the second scenario, evidence is set in the upper layer: Military Goal = "Achievable", Military Requirements = "Well-defined", RoEs = "Clear", Training and Experience = "Senior", and Stress = "High". Then, the posterior probability is calculated by the model for its other variables without any evidence. Hence, as shown in Figure 4, the influence is "Positive", meaning that the Proportionality influence has a 49% chance of being Positive, 14% chance of being Neutral, and 36% chance of being Negative**.** This could be the case of a military Commander that is experienced, which must make this decision decision not dealing with high stress while the military and legal requirements and conditions are clear.

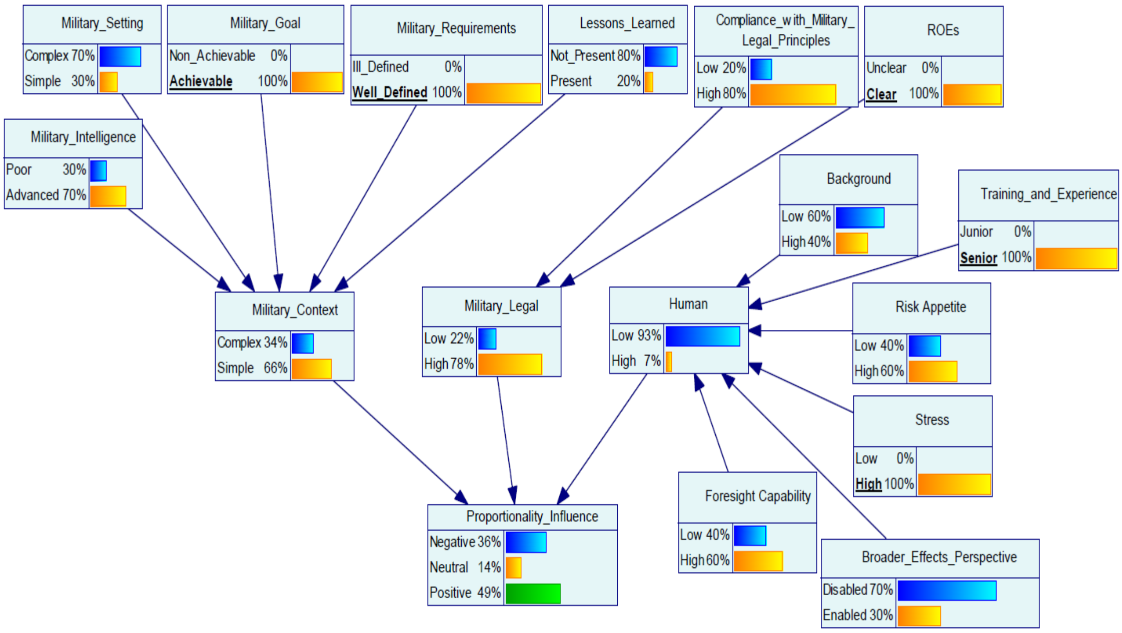

Figure 4: Second case scenario

In the third scenario, evidence is set in the upper layer: Military Intelligence = “Poor”, Lessons Learned = “Not_Present”, Training_and_Experience = “Junior”, Risk Appetite = “High”, Stress = “High”, and Broader_Effects_Perspective = “Disabled”. Based on this evidence, the posterior probability is calculated for the remaining variables. Conclusively, as Figure 5 illustrates, the influence is “Negative”. This case could correspond to the situation when a military Commander is less experienced, does not benefit from previous lessons learned (i.e., knowledge gathered from an antecedent military operation), and deals with a high amount of stress when making this decision.

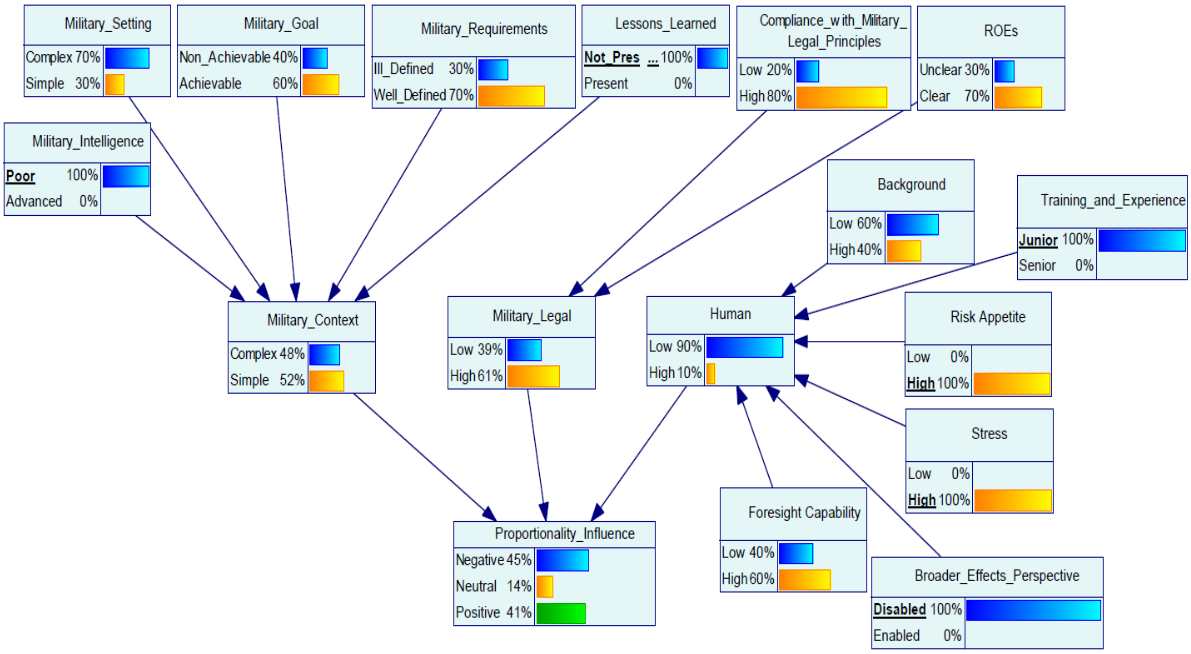

Figure 5: Third case scenario

7. Conclusions

To all intends and purposes, the laws of war could be reduced to a “subtle equilibrium between two diametrically opposed impulses: military necessity and humanitarian considerations” (Dinstein, 2016). Specifically, through its principle of proportionality and its corresponding proportionality assessment bring together two distinct military-legal constructs that should be continuously assessed on the future version of reality through the current version of reality taking into consideration the information herein available. This is a difficult process and a challenging task (Katzir, 2018) taking into consideration the high level of complexity and uncertainty surrounding the two key components of this assessment, i.e., collateral damage and military advantage together with the interpretation of the key operation between them, i.e., the fact that the expected collateral damage should not be excessive in relation to the anticipated collateral damage. All in all, as Colonomos (2017) stresses, proportionality is born as a “compromise between political constraints, military necessities, legal claims, and ethical aspirations”.

Taking this into account, significant scientific and practitioner attention is provided for analyzing and applying these perspectives, but limited attention is dedicated to understanding other factors that play a role in influencing the reasoning process of the military decision-makers that conduct the proportionality assessment. In this respect, the present research investigates and clusters influential factors participating when the proportionality assessment is conducted and further capture and model them by means of a BBN model designed pursuing a Design Science Research methodological approach. Finally, the model proposed is demonstrated through three case scenarios for understanding the influence variation of the identified factors. Through this model, this research intends to bring awareness to military and political decision-makers, and to encourage further research on identifying, understanding, and modelling other influential factors to proportionality assessment in diverse missions and operational scenarios that would contribute to both human and machine transparent and responsible behavior.

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