



# A Multi-valued Logic Assessment of Organizational Performance via Workforce Social Networking

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**Abstract.** *Social Media* have changed the conditions and rules of *Social Networking (SNet)* where it comes from people intermingling with each other, i.e., *SNet* is to be understood as a process that works on the principle of many-to-many; any individual can create and share content. It is intended to explore the complex dynamics between *SNet*, *Logic Programming (LP)*, and the *Laws of Thermodynamic (LoT)* in terms of entropy by drawing attention to how *Multi-Value Logic (MVL)* intertwines with *SNet*, *LP* and *LoT*, i.e., its norms, strategies, mechanisms, and methods for problem solving that underpin its dynamics when looks to programmability, connectivity, and organizational performance. Indeed, one's focus is on the tactics and strategies of *MVL* to evaluate the issues under which social practices unfold and to assess their impact on organizational performance.

**Keywords:** Social media · Social science and networking · Philosophy · Logic programming · Entropy · Multi-valued logic · Organizational performance · Artificial neural networks

## 1 Introduction

*Social Norms (SN)*, the informal rules that govern behavior in groups and societies and underlie behavioral comparisons, may come from society as a whole and/or from individuals that are not only intimate but go on acknowledged, such as group members (being

a group viewed as a social unit or ecosystem) formed by one or more people with the expectation of mutual affection, responsibility and pro term duration, and characterized by commitment, shared decisions and common goals [1–3]. With a few exceptions, the *Social Science* (SS) literature conceives of norms as exogenous variables. Since norms are mainly seen as constraining behavior, some of the key differences between moral, social, and legal norms as well as differences between norms and conventions have been vague [4].

*Philosophers* have taken a different approach to norms. In the writing on norms and conventions, they are viewed as factor in a causal model or system whose value is determined by the states of the variables in the system, i.e., as the product of individual interactions [5–7]. Beliefs, expectations, group knowledge and general knowledge have therefore become central concepts in the development of a philosophical view of *SN* and as such supported by a collection of self-fulfilling expectations that will be addressed in terms of a *Theory of Declarative Knowledge*, based on an entropic perspective for *Knowledge Representation and Reasoning* (KRR) that will help to differentiate among *SN*, *Conventions* and *Descriptive Norms* [8]. This essential distinction is often overlooked in *SS* reports, but it is critical if one needs to diagnose the type of behavior pattern in organizational performance in order to intervene and express preferences, allowing for the construction of scenarios of the form *X and optionally Y* or *X or otherwise Y* based only on the empowered logic values that the alternatives may present and that range in the interval  $0...1$  [8, 9]. Indeed, in this article are identified four implicit roles on *Social Networking* (SNet), namely physical, emotional, mental and spiritual. Integrates human beings daily life chores into their *Social Interactions*, which leads to new questions as well as to a reinterpretation of some currently accepted roles in the position of men [10], and to investigate the possibility of using the underlying *MVL* to express more general preferred enquiries, viz.

- *Do you use social networks to socialize?*
- *Do you use social networks to get job-related information?*
- *Do you use social networks to create your social identity?*
- *Do you use social networks to reduce academic and organizational stress?*
- *Do you use social networks for collaborative learning?*
- *Do you use social networks to watch the funny sharing?*

It was also assumed that there is a significant correlation between the networking scale and the measures that may be considered given the people answers to questionnaires like *Entertainment*, *Constraints*, *Academic and Organizational Strain*, and *Socialization*. This study was carried out in northern Portugal. A total of 30 (thirty) workers took part in this study. The ages ranged from 20 to 60 years old, with 60% women and 40% men. The questionnaires were divided into two sections, the first containing general questions (e.g., age, gender, and academic and organizational qualifications), while the second included statements on working conditions, interpersonal relationships and emotional feelings.

The article is divided into five sections. Following the introduction, a new section is presented that examines the basics used in this work, namely the concept of *Entropy* and how it potentiates the use of *LP* for *KRR* [8, 9, 11, 12]. Section 3 presents the methods followed in this work and address the thematic of a thermodynamics approach to *SN* and introduces the computational models to assess organizational performance. Then conclusions are drawn, and future work outlined.

## 2 Preliminaries

### 2.1 Entropy vs. Knowledge Representation and Reasoning

The problem-solving method presented in this article is based on the *Laws of Thermodynamics* and aims to describe the practices of *Knowledge Representation and Reasoning (KRR)* as a process of energy degradation. This means that energy can be converted in a system but cannot be created or destroyed. It is measured in terms of entropy, a property that quantifies the ordered state of a system and its evolution, whose universe of discourse is expressed here as logic theories or logic programs [9].

On the other hand, it is undeniable that expressing *KRR* practices as logic theories as logic programs has become more natural and general as the field of *Logic Programming (LP)* matured and other arenas began to use its tools and results. Theories are typically uttered as a series of patterns (rules) and facts that make it possible to infer non-logical consequences using logical inference. In writing such rules and facts, both explicit (strong) negation or negation by failure and explicit declarations may be used to reinforce knowledge. Since the most common situation in the real world is incomplete and updateable, any system that makes serious attempts to deal with real-world situations must cope with such complexities [13].

Therefore, and in order to collect information about a *MVL* assessment of *SN* in the workplace it was considered the questionnaires *Entertainment Questionnaire Four-Item (EQ-4)*, *Constraints Questionnaire Four-Item (CQ-4)*, *Academic and Organizational Strain Questionnaire-Six-Item (TQ-6)*, and *Socialization Questionnaire-Four-Item (SQ-4)*. The former one encompasses the statements, viz.

- E1 – I use social networking sites for sharing pictures;*
- E2 – I use social networking sites to look at funny sharing;*
- E3 – I use social networking sites for watching movies; and.*
- E4 – I use social networking sites to get relief from academic and organizational stress.*

They denote all possible occurrences in the discourse universe, the purpose of which is to evaluate the general feelings of the workforce about their behavioral relationships in the workplace. To make the process understandable, it is shown graphically. The scale used was based on an extension of the Likert scales expanded to cover the concept of entropy, viz.

*always agree (4), sometimes agree (3), rarely agree (2), never agree (1), rarely agree (2), sometimes agree (3), always agree (4)*

Moreover, it is included a neutral term, *neither agree nor disagree*, which stands for *uncertain or vague*. The reason for the individual’s answers is in relation to the query, viz.

*As a member of an organization, how much would you agree with each one of EQ – 4 referred to above?*  
 leading to Table 1.

**Table 1.** A workforce member answers to *EQ – 4*.

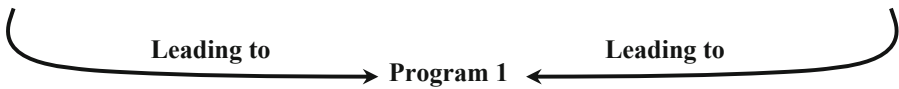
<i>Questions</i>	<i>Scale</i>							<i>Vagueness</i>
	(4)	(3)	(2)	(1)	(2)	(3)	(4)	
<i>E1</i>		×	×					
<i>E2</i>								×
<i>E3</i>				×				
<i>E4</i>					×			



Once the input for *EI* closely matches (3) → (2), meaning that the system tends to deteriorate; i.e., the input for *EI* (3) → (2) indicates that there is a tendency for system degradation. The inputs are read from *left to right* (e.g., from (4) → (1) (with increasing entropy) or from (1) → (4) (with decreasing entropy)). The markings on the axis correspond to one of the possible scaling options that can be used from *bottom* → *top* (i.e. from (4) → (1)), which indicates that the performance of the system decreases as the entropy increases, or becomes from *top* → *bottom* (i.e. from (1) → (4)), which indicates that the performance of the system increases with decreasing entropy. It is now possible to have an evaluation of the entropic state of the system according to the individual answers of a person to the above questionnaire for the *Best* and *Worst scenarios* [8] (Table 2).

**Table 2.** The extent of the *eq - 4's relation* in terms of an individual answer to the *EQ - 4* questionnaire. The corresponding logical program for the *Best-case scenario* is now given as *Program 1*, below.

<i>EX</i>	<i>VA</i>	<i>AN</i>	<i>SNA</i>	<i>QoI</i>	<i>EX</i>	<i>VA</i>	<i>AN</i>	<i>SNA</i>	<i>QoI</i>
<i>BCS</i>	<i>BCS</i>	<i>BCS</i>	<i>BCS</i>	<i>BCS</i>	<i>WCS</i>	<i>WCS</i>	<i>WCS</i>	<i>WCS</i>	<i>WCS</i>
0.45	0.33	0.30	0.89	0.55	0.78	0	0.22	0.63	0.22



- The *SNA*, in general, is given as  $\sqrt{1 - (EX + VA)^2}$ ; it stands for the sum of social, emotional and cognitive skills that enable the workforce to face the challenges of and to adapt to the demands of the organization (i.e., a *MVL* value that ranges in the interval 0... 1 (Fig. 1)), viz.

$$SNA_{BCS} = \sqrt{1 - EX^2} = \sqrt{1 - (0.45)^2} = 0.89$$

$$SNA_{WCS} = \sqrt{1 - (EX + VA)^2} = \sqrt{1 - (0.78 + 0)^2} = 0.63$$

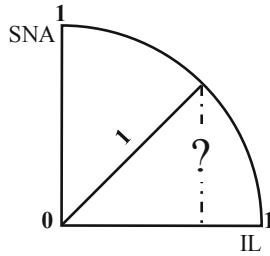
- *QoI* values are evaluated, in general, in the form, viz.

$$QoI \text{ values} = 1 - (EX + VA)/Interval \text{ Lenght} (IL)$$

that stand for the *SNA*'s sustainability degrees, i.e., it shows how the workforce was identified and adapted to the organizational environment, i.e., an *MVL* value that ranges in the interval  $0 \dots 1$ , viz.

$$QoI_{values_{BCS}} = 1 - (EX + VA)/1 = 1 - (0.45 + 0) = 0.55$$

$$QoI_{values_{WCS}} = 1 - (EX + VA)/1 = 1 - (0.45 + 0.33) = 0.22$$



**Fig. 1.** *SNA* evaluation.

{

$\neg eq - 4 (EX, VA, AN, SNA, QoI)$

$\leftarrow not eq - 4 (EX, VA, AN, SNA, QoI),$

*not exception* <sub>$eq-4$</sub>   $(EX, VA, AN, SNA, QoI)$

$eq - 4 (0.45, 0.33, 0.30, 0.89, 0.55).$

}

**Program 1.** The extent of the relation  $eq - 4$  for the *Best-case scenario*.

On the other hand, by looking at Table 1, it is possible not only to adjust but also to quantify the tendency for system deterioration and / or system improvement. In fact, the partition originating from (4)  $\rightarrow$  (1) tends to set the system deterioration tendency, while the partition originating from (1)  $\rightarrow$  (4) determines the system improvement. Looking now at Table 2 it is possible to measure the entropy associated with each partition. For the *Best-case scenario* one may have, viz.

$$\text{entropy}_{(4)\rightarrow(1)} = E_1 + E_2 + E_3 + E_4 = 0.06 + 0 + 0.25 + 0 = 0.31$$

$$\text{entropy}_{(1)\rightarrow(4)} = E_1 + E_2 + E_3 + E_4 = 0 + 0.25 + 0.25 + 0.14 = 0.64$$

Therefore, and once  $0.31 < 0.64$ , the system tends to develop positively. To evaluate the *Worst-case scenario*, the following procedures are similar.

### 3 A Declarative Knowledge Theory for Evaluating Organizational Performance Using Workforce Social Networking

A social unit consists of one or more people who live in a community or prefer to live rather than alone. It is characterized by commitment, joint decision-making and goal achievement. Looking at society in this way, one can take into account different attitudes and arrangements that exist in humanity today. Indeed, understanding its structure, function and process is of paramount importance in characterizing it and how it can contribute to the good of the individual or group. This understanding is addressed here in the form of questionnaires to assess entertainment, limitations, academic and organizational burdens, and the socialization practices referred to above.

#### 3.1 Constraints

Today, time and cognitive constraints put an upper limit on the number of social relationships an individual can maintain at a given level of intensity. Similar restrictions may have worked throughout hominin evolution, affecting the size and structure of social networks. In order to decide in which extension this is the case, one can answer questions such as, viz.

*C1– I face difficulty in finding exact information for academic via social networking sites;*

*C2 – Compulsive usage of social networking sites is a problematic issue;*

*C3 – I usually postpone my academic task for spending more time on the social networking sites; and*

*C4 – While using social networking sites it is difficult for me to concentrate on my studies.*

once it is of the utmost importance to obtain as much information on the subject as possible. They represent the *Constraints Questionnaire Four Item (CQ – 4)*, whose answers in terms of qualitative and quantitative values of consumed energy are shown in Tables 3 and 4, respectively.

### 3.2 Academic and Organizational Strain

Academic and organizational social networks enhance the ability to share knowledge and this can be the final stepping stone to scientific research and organizational practices at both levels. Given their target audience and the product they offer, it is worth taking a closer look at the mission of social networks in an academic and organizational context and their most common uses, their effects on intellectual and organizational performance and their benefits. The value of this communication model also lies in its role as a strong emotional resource, as it creates a special atmosphere in the academic and organizational community by modeling groups of people with similar interests who are ultimately supposed to develop a sense of belonging and differentiation, therefore serving as a channel for creativity in the educational and organizational sectors. In consequence, to know if someone is feeling happier, more relaxed, or healthier, answer questions like, viz.

*A1 – I use social networking sites to solve my academic, research and organizational problems;*

*A2 – I use social networking sites for online academic and organizational group discussion;*

*A3 – I communicate with my friends via social networking sites for preparation of group work;*

*A4 – I use social networking sites for collaborative learning and organizational practices;*

*A5 – I use social networking sites to learn about my curricular aspect; and*

*A6 – I use social networking sites to seek help from my peers and colleagues.*

which stand for the *Academic and Organizational Strain Questionnaire-Six-Item (AOSQ – 6)*, whose answer by a worker is given in terms of its qualitative and quantitative values in Tables 3 and 4, respectively.

### 3.3 Socialization

Socialization is a process that introduces people to social norms and customs, i.e., a person learns to become a member of a group, community or society. To know how people feel about this process, answer questions such as, viz.

*S1 – I use social networking sites to become more sociable;*

*S2 – I use social networking sites to create my social identity;*

*S3 – I prefer using social networking sites to attending social gathering; and*

*S4 – I used social networking sites for strengthening interpersonal relationships.*



that make the *Socialization Questionnaire-Four-Item (SQ – 4)*, whose answers in terms of qualitative and quantitative values are shown in Tables 3 and 4, respectively.

**Table 3.** An individual answers to the *CQ – 4*, *AOSQ – 6* and *SQ – 4* questionnaires.

Questionnaires	Questions	Scale				Vagueness
		(4)	(3)	(2)	(1)	
<i>CQ – 4</i>	Q1				×	
	Q2		×			
	Q3					×
	Q4					×
<i>AOSQ – 6</i>	A1					×
	A2				×	
	A3		×	×		
	A4					×
	A5					×
	A6		×	×		
<i>SQ – 4</i>	S1		×	×		
	S2					×
	S3	×	×			
	S4				×	×



**Table 4.** The extent of relations *eq – 4*, *cq – 4*, *aosq – 6* and *sq – 4* stand for an individual answers to the questionnaires *EQ – 4*, *CQ – 4*, *AOSQ – 6* and *SQ – 4* for the *Best* and *Worst-case scenarios*.

Questionnaires	<i>EX</i>	<i>VA</i>	<i>AN</i>	<i>SNA</i>	<i>QoI</i>	<i>EX</i>	<i>VA</i>	<i>AN</i>	<i>SNA</i>	<i>QoI</i>
	<i>BCS</i>	<i>BCS</i>	<i>BCS</i>	<i>BCS</i>	<i>BCS</i>	<i>WCS</i>	<i>WCS</i>	<i>WCS</i>	<i>WCS</i>	<i>WCS</i>
<i>EQ – 4</i>	0.45	0.33	0.30	0.89	0.55	0.78	0	0.22	0.63	0.22
<i>CQ – 4</i>	0.27	0.36	0.48	0.96	0.73	0.63	0	0.37	0.78	0.37
<i>AOSQ – 6</i>	0.23	0.30	0.60	0.97	0.77	0.53	0	0.47	0.85	0.47
<i>SQ – 4</i>	0.10	0.50	0.66	0.99	0.90	0.59	0	0.41	0.81	0.41



### 3.4 A Computational Make-Up

The computational framework forms the basis for a symbolic rating of the level of *Social Networking (SNA)* for an individual or group of people, measured by the *Quality-of-Information* used in their rating, which in relation to *MVL* stands for a set of truth

values that lie in the interval  $0...1$ . The corresponding logical program for the *Best-case scenario* is given as Program 2 [8], viz.

```

{
/* The extent of eq - 4, cq - 4, aosq - 6 and sq - 4 predicates for the Best-case
scenario */
  ¬ eq - 4 (EX, VA, AN, SNA, QoI truth values)
                                     ← not eq - 4 (EX, VA, AN, SNA, QoI),
                                     not abducibleeq-4 (EX, VA, AN, SNA, QoI).
  eq - 4 (0.45, 0.33, 0.30, 0.89, 0.55).

  ¬ cq - 4 (EX, VA, AN, SNA, QoI)
                                     ← not cq - 4 (EX, VA, AN, SNA, QoI),
                                     not abduciblecq-4 (EX, VA, AN, SNA, QoI).
  cq - 4 (0.27, 0.36, 0.48, 0.96, 0.73).

  ¬ aosq - 6 (EX, VA, AN, SNA, QoI)
                                     ← not aosq - 6 (EX, VA, AN, SNA, QoI),
                                     not abducibleaosq-6 (EX, VA, AN, SNA, QoI).
  aosq - 6 (0.23, 0.30, 0.60, 0.97, 0.77).

  ¬ sq - 4 (EX, VA, AN, SNA, QoI)
                                     ← not sq - 4 (EX, VA, AN, SNA, QoI),
                                     not abduciblesq-4 (EX, VA, AN, SNA, QoI)
  sq - 4 (0.10, 0.50, 0.66, 0.99, 0.90).
}

```

**Program 2.** A Formal Description of the Universe of Discourse for the *Best-case scenario*.

It is now possible to generate the data sets in order to train an ANN (Fig. 2) which, for the *Best-case scenario*, may be obtained by proving the theorem [14, 15], viz.

$$\forall (EX_1, VA_1, AN_1, SNA_1, QoI_1, \dots, EX_4, VA_4, AN_4, SNA_4, QoI_4),$$

$$(eq-4 (EX_1, VA_1, AN_1, SNA_1, QoI_1)),$$

$$? (cq-4 (EX_2, VA_2, AN_2, SNA_2, QoI_2),$$

$$aosq-6 (EX_3, VA_3, AN_3, SNA_3, QoI_3),$$

$$sq-4 (EX_4, VA_4, AN_4, SNA_4, QoI_4))$$

i.e., generate in all conceivable ways the sequences that combine the extent of predicates *eq-4*, *cq-4*, *aosq-6*, and *sq-4* [14, 15] (where the symbols “ $\forall$ ” and “?” stands for “for all” and “falsity”, respectively), leading to Table 5.

**Table 5.** ANN’s inputs for the *Best-case scenario*.

---

$\{ \{ (eq-4 (0.45, 0.33, 0.30, 0.89, 0.55), cq-4 (0.27, 0.36, 0.48, 0.96, 0.73),$

$aosq-6 (0.23, 0.30, 0.60, 0.97, 0.77), sq-4 (0.10, 0.50, 0.66, 0.99, 0.90)), \dots \}$

---

For the *Worst-case scenario* the procedure is analogous. The corresponding logical program is given as Program 3 [8], viz.

{

*/\* The extent of eq - 4, cq - 4, aosq - 6 and sq - 4 predicates for the Worst-case scenario \*/*

$\neg eq - 4 (EX, VA, AN, SNA, QoI \text{ truth values})$

$\leftarrow not eq - 4 (EX, VA, AN, SNA, QoI),$

$not abducible_{eq-4} (EX, VA, AN, SNA, QoI).$

$eq - 4 (0.78, 0, 0.22, 0.63, 0.22).$

$\neg cq - 4 (EX, VA, AN, SNA, QoI)$

$\leftarrow not cq - 4 (EX, VA, AN, SNA, QoI),$

$not abducible_{cq-4} (EX, VA, AN, SNA, QoI).$

$cq - 4 (0.63, 0, 0.37, 0.78, 0.37).$

$\neg aosq - 6 (EX, VA, AN, SNA, QoI)$

$\leftarrow not aosq - 6 (EX, VA, AN, SNA, QoI),$

$not abducible_{aosq-6} (EX, VA, AN, SNA, QoI).$

$aosq - 6 (0.53, 0, 0.47, 0.85, 0.47).$

$\neg sq - 4 (EX, VA, AN, SNA, QoI)$

$\leftarrow not sq - 4 (EX, VA, AN, SNA, QoI),$

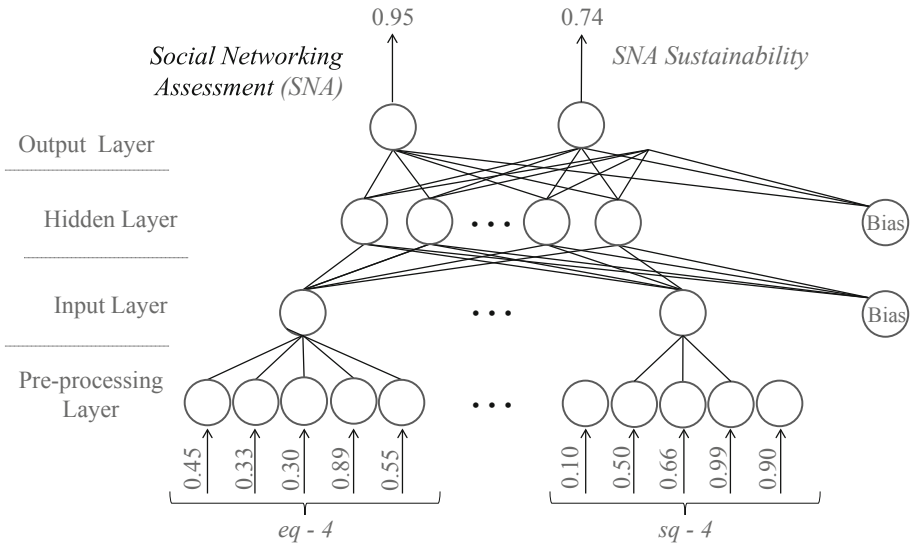
$not abducible_{sq-4} (EX, VA, AN, SNA, QoI)$

$sq - 4 (0.59, 0, 0.41, 0.81, 0.41).$

}

**Program 3.** A Formal Description of the Universe of Discourse for the *Worst-case scenario*.

It is now possible to generate the data sets in order to train an ANN (Fig. 3) which, for the *Worst-case scenario*, may be obtained by proving the theorem [14, 15], viz.



**Fig. 2.** A creative view of the ANN topology for SNA assessment and a measure of its Sustainability for the Best-case scenario.

$$\forall (EX_1, VA_1, AN_1, SNA_1, QoI_1, \dots, EX_4, VA_4, AN_4, SNA_4, QoI_4),$$

$$(eq-4 (EX_1, VA_1, AN_1, SNA_1, QoI_1)),$$

$$? (cq-4 (EX_2, VA_2, AN_2, SNA_2, QoI_2),$$

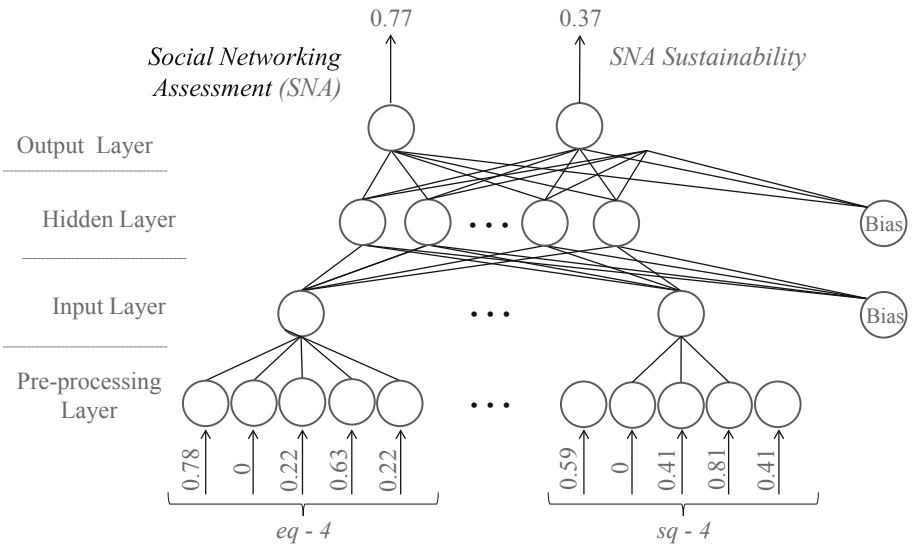
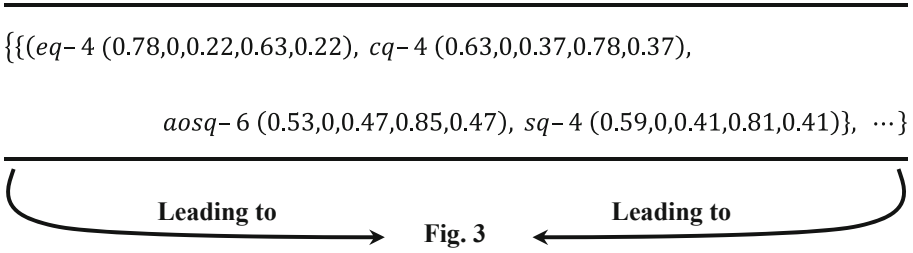
$$aosq-6 (EX_3, VA_3, AN_3, SNA_3, QoI_3),$$

$$sq-4 (EX_4, VA_4, AN_4, SNA_4, QoI_4))$$



leading to Table 6.

**Table 6.** ANN’s inputs for the *Worst-case scenario*.



**Fig. 3.** A creative view of the ANN topology for SNA assessment and a measure of its Sustainability for the *Worst-case scenario*.

The output of the ANNs in Figs. 2 and 3 shows that the relationships between two people should not be viewed as dyadic ties, but rather as embedded in a larger network of relationships between network members; indeed  $|SNA_{BCS} - SNA_{WCS}| = |0.95 - 0.77| = 0.18$  ( $0.18 \neq 0$ ), which shows that there are a greater number of relationships between network members, which emphasizes its impact on *Organizational Performance*.

### 4 Conclusions and Future Work

*Social Networking* according to the results so far obtained (Figs. 2 and 3) proves that relationships between two individuals should not be viewed as dyadic ties, but as embedded within a larger network of relations between network members. However, a network can act as a scaffold to the dyadic tie, reducing the time and cognitive costs of maintaining the relationship. Together with affairs based on empathy, this scaffolding will allow for

larger groups to exist among hominins, what would not be possible if such networks were based purely on dyadic ties between individuals. These results show that one may have to change the way of living, accept new challenges, adapt to new experiences, develop new behavioral, cognitive, or emotional responses, a range of subjects that will be the subject of future work, matters for future work.

**Acknowledgments.** This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020.

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