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Using the Affect Grid to Measure Emotions in Software Requirements Engineering

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Abstract: Computer systems are designed and used by humans. And human being is characterized, among other things, by emotions. Giving this fact, the process of designing and developing computer systems is, like any other facet in our lives, driven by emotions. Requirements engineering is one of the main phases in software development. In Requirements engineering, several tasks include acceptance and negotiation activities in which the emotional factor represents a key role. This paper presents a study based on the application of affect grid by Russell in requirements engineering main stakeholders: developers and users. Results show that high arousal and low pleasure levels in the process are predictors of conflictive requirements.

Keywords: Software engineering, Software requirements, Software psychology, Emotions
Categories: D.2.1, D.m, K.6.1

1 Introduction

Information Technology work is highly intensive in human capital ([Casado-Lumbreras, 11]; [Colomo-Palacios, 10]; [Trigo, 10]). In the software engineering (SE) scenario, the human dimension sometimes has greater importance than the technical dimension [Constantine, 01]. Its importance is due to the fact that SE is essentially based on intellectual and social activities [Sommerville, 96]. However, the management of people in software development projects is particularly critical [Liu, 11] and because of that, [Hazzan, 08] stated that there is abundant empirical evidence which proves that human aspects are the source of the main problems associated with software development projects.

Software requirements express the needs and constraints placed on a software product that contributes to the solution of some real-world problem [Kotonya, 98].

The term Requirements Engineering (RE) is widely used in the field to denote the systematic handling of requirements. There are other terms, e.g. “requirements definition”, “requirements gathering”, “requirements elicitation”, with the common meaning of “to figure out what to build” [Holtzblatt, 95]. The importance of human factors in RE is reflected in the fact that regardless of the methods and tools employed, the success of requirements analysis depends on how well users and analysts communicate and collaborate [Safayeni, 08]. Thus, it can be said that requirements engineering is a multidisciplinary human-centred process, although we can benefit from some tools and techniques in addition to human expertise [Nuseibeh, 00]. Many authors have highlighted the influence of the human factor in this activity, arguing that the new system will change the modus operandi of the organization; thus, the RE needs to be sensitive to how people perceive and understand the world around them. Therefore soft issues, such as people’s feelings, are often cited as problems in the RE process and as key causes of system failure [Sutcliffe, 10].

In [Walia, 09] main requirement errors are identified and classified. In this work several people issues are identified including: misunderstanding or mistakes in resolving conflicts or lack of participation by all stakeholders in the requirements process to cite just some of the most relevant ones. Hence the errors in the requirements are costly and dangerous. However, the failure of software development projects is not only due to inadequate requirements [Ewusi-Mensah, 03] in general, but more specifically to the social [Hanisch, 01], political [Sommerville, 97] and cultural factors ([Damian, 03]; [Hanisch, 01]) associated with the project. These soft issues are often cited as problems in the RE process, and cannot be adequately addressed by computer science or SE research alone [Robertson, 99]. Therefore, RE should be studied using research methodologies and theories proceeding from the management and social science disciplines [Zowghi, 02].

Returning to the work of [Walia, 09], human errors in the requirements phase were identified and classified into the following categories: communication, participation, domain knowledge, specific application knowledge, process execution, and other cognition errors. In this paper we will focus on the “other cognition” errors, specifically in emotions. Given the importance of requirements and the influence of people issues in their management, the aim of this paper is to design and to test an instrument to analyze the influence of emotions in requirements management based on the use of the affect grid, one o the leading tools to measure human emotions.

The remainder of the paper is organized as follows. The next section shows the state of the art about the interaction of emotions and RE. This is followed by the description of the affect grid. Subsequently, the experimental setup is described and its main findings discussed. Lastly, the paper presents the principal conclusions and future work of the study.

2 Emotions and RE

Long before psychology as a science was born, great thinkers such as Aristotle and Darwin already acknowledged the pivotal role of emotional expression in social interaction [Van Kleef, 09] and, as a result of this, in human behaviour. More recently, several authors (e.g. [Etzioni, 88]; [Hochschild, 75]) stated that human behaviour is highly influenced by emotions.

Determining a unique definition of the term “emotion” represents a complicated task. The term “emotion” has defied definition mainly because it is multifaceted and not a unitary phenomenon or process. Use of the unqualified term “emotion” makes for misunderstandings, contradictions, and confusions in theory and research [Izard, 09]. Regarding the nature of emotions, in this paper, following the works of [Russell, 91], authors have adopted the universality of emotions. Leaving aside the discussion concerning the concreteness and universality of emotion concept, [Izard, 77] claimed that emotion is composed of three aspects: a) the experience or conscious feeling of emotion, b) the processes that occur in the brain and nervous system, and c) the observable extensible patterns of emotion.

[Russell, 89] proposed a measure of affect which had a profound impact on social psychology. They termed the measure the affect grid, a scale designed as a quick means of assessing affect along pleasure-displeasure and arousal-sleepiness dimensions on a 1-9 scale. According to the studies of these authors, the affect grid is potentially suitable for any study that requires judgments about affect of either a descriptive or a subjective kind (e.g. [García-Crespo, 10a], [García-Crespo, 11]).

Focusing on the interaction between requirements and emotions, the field is not unexplored. Thus, [Ramos, 05a] stated that changes that computer systems bring interact with the users’ values and beliefs and trigger emotional responses which are sometimes directed against the software system and its proponents. This analysis is rooted on two main reasons. Firstly, the transformation that involves the use of a new system to users [Ramos, 2005b], and secondly, the difficulty in defining the requirements in ways that are beneficial for developers and users, i.e. establishing a win-win relationship [Boehm, 96]. The result of their studies confirms the importance and validity of the emotional factor in RE. This factor must be taken into consideration together with other classic factors, such as personnel performance or cost.

Other efforts seek to integrate Soft Issues in RE Process [Thew, 08] including users’ values, motivations and emotions. Emotions integration is made using the OCC model [Ortony, 88], which distinguishes 22 emotional categories. However, this effort, which is a very valid antecedent, is not considered to be one which pursues the same objectives of this study. The approach proposed in this paper focuses on the evolution of requirements and the parallel evolution of the emotions throughout the various stages of RE.

Another issue that has to be considered is emotional bias. Emotional bias is a distortion in cognition and decision making due to emotional factors [Turner, 00]. Therefore, the relation to cognition and cognitive bias has to be considered, despite the fact that they are present in different areas of the human brain [Ortony, 88]. Considering that the processing of emotions tends to be biased, and that these biases affect our perception, judgment, and behaviour [Kahneman, 03], a method that enables the tracking of emotions through RE phases may shed light on the poorly understood processes of understanding human and organizational needs, and may improve the determination of requirements in order to meet user requirements and expectations [Vessey, 94].

Software requirements are not static and they evolve with time. Throughout the requirements management processes emotions are present from elicitation to negotiation, from modelling to prioritizing. RE is a knowledge and human capital intensive activity and emotions are key aspects of the process. Thus, an overall picture of emotions and requirements should provide the starting point for a better RE process. In the next section the main aspects of the proposal are depicted.

3 Using the affect grid to characterize emotions in RE

This paper proposes using the affect grid psychological tool created by [Russell, 89] to characterize requirements in software development processes. Using this mean, different stakeholders may express the emotion that a given requirement raise for them. This emotional assessment is intended to be discrete, but its changes over time serialize intake data, enabling the creation of patterns in projects or organizations. It is important to mention that the evolution of a given requirement means that the assessment must be repeated. This new assessment provides traceability to stakeholders' emotional states.

The emotional evaluation is conducted through the affect grid, which is a single-item scale of pleasure and arousal. The subject answers the question "What's your emotion regarding this requirement definition?" and places one checkmark somewhere in the grid, as shown in Figure 2. The overall process is as depicted in Figure 1:

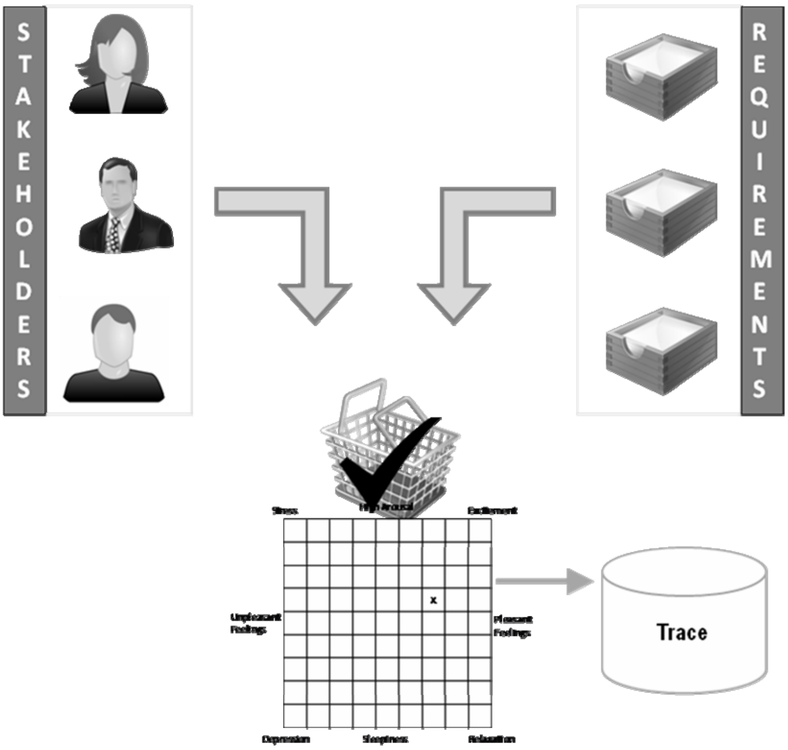

Figure 1: Assessment process

4 Evaluation

4.1 Research design

In order to test the applicability of the approach an evaluation was conducted in two different projects. The first project, Project A, is an adaptive maintenance of a legacy information system developed in the context of a software development organization. Project A lasted for 7 months. The project team collected a total of 28 user requirements that presented a total of 97 different versions. All these requirements were identified and documented according to the methodology employed in the project.

On the other hand, project B was focused on the design and construction of a touristic information system developed by a hired software development organization. The project team identified a total of 37 user requirements that, in sum, produced a total of 115 different requirements versions. This project lasted for 6 months.

Project stakeholders performed the emotional assessment of the requirements throughout the process including all requirements versions. All scores were codified using a 1-9 Likert Scale, with 1 meaning low arousal-pleasure, and 9 meaning high arousal-pleasure. Each score represents the pleasure (y axes) and arousal (x axes) as is depicted in Figure 2.

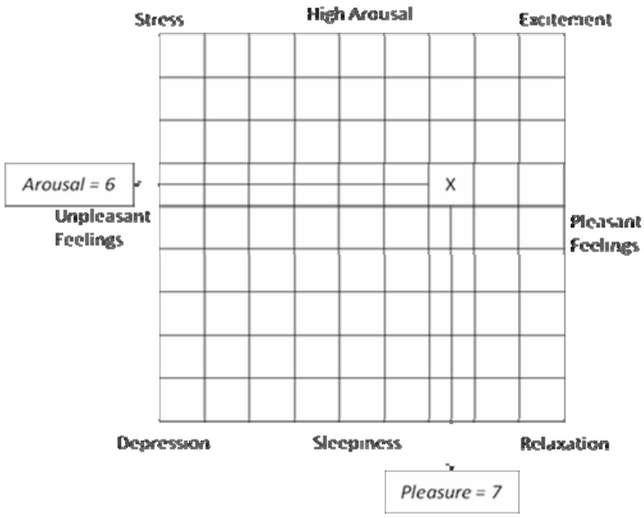

Figure 2: Example of an Affect Grid score

The aim of the experiment is to verify whether the emotional assessment responds to any pattern. In order to do so, some hypotheses are set. In the first place, with respect to the evolution of scores along the versions, two hypotheses are defined:

H1: Higher requirement versions’ scores present higher Pleasure scores.
H2: Higher requirement versions’ scores present lower Arousal scores.

These hypotheses are based on the premise that requirements finally have to fit users' needs on the one hand, and have to be carried out by developers on the other hand. The other set of hypothesis are related to the fact that initial contacts with requirements produce stress in both developers and users. Thus, hypothesis 3 and 4 are as follows:

H3: Pleasure scores for final requirements are higher than for non-final requirements.
H4: Arousal scores for final requirements are lower than for non-final requirements.

Final requirements are supposed to fit the user's needs and are accepted by all stakeholders; therefore these hypotheses specialize H1 and H2.

4.2 Sample

The sample was composed of 11 individuals: five of them belonging to project A (3 developers and 2 users), and 6 to project B (3 developers and an equal number of users). In relation to demographic characteristics, the group of subjects consisted of 4 women (36%) and 7 men (64%), with an average age of 32.7.

The sample choice was made according to the available projects. Within these projects, the subjects are those directly involved in the requirements process.

4.3 Sample

As a result of subjects' activities, a total of 1,175 emotional ratings were collected. Table 1 shows average and standard deviation of pleasure and arousal dimensions in different requirement versions. Firstly, the one corresponding to all emotional ratings; secondly, emotional ratings for each requirements version; and, finally, emotional ratings for requirements final versions. Requirements column indicate the total and final requirement for each scenario. The average and standard deviation of emotional ratings of requirements is calculated using the ratings related to all requirements in the scenario, namely final and not final.

	Requirements		**Ratings**		**Pleasure (Total)**		**Arousal (Total)**	
	Total	Final	**Total**	Final	Avg.	S.d.	Avg.	S.d.
All	**212**	65	**1175**	362	4.856	1.737	4.821	1.462
V1	**65**	14	**362**	79	4.738	1.947	5.229	1.582
V2	**51**	14	**283**	78	4.604	1.676	4.873	1.503
V3	**37**	13	**205**	74	4.654	1.566	4.634	1.368
V4	**24**	7	**131**	38	5.0382	1.605	4.496	1.349
V5	**17**	7	**93**	36	5.602	1.575	4.441	1.246
V6	**10**	4	**57**	24	5.404	1.412	4.421	0.9626
V7	**6**	4	**33**	22	5.606	1.435	4.273	0.876
V8	**2**	2	**11**	11	5.455	1.128	4.364	1.12
Final	**65**	65	**362**	362	5.718	1.517	4.602	1.299

Table 1: Average and standard deviation of emotional ratings of requirements

In order to see the trends of values shown in Table 1, a lineal regression model is presented in Figure 3.

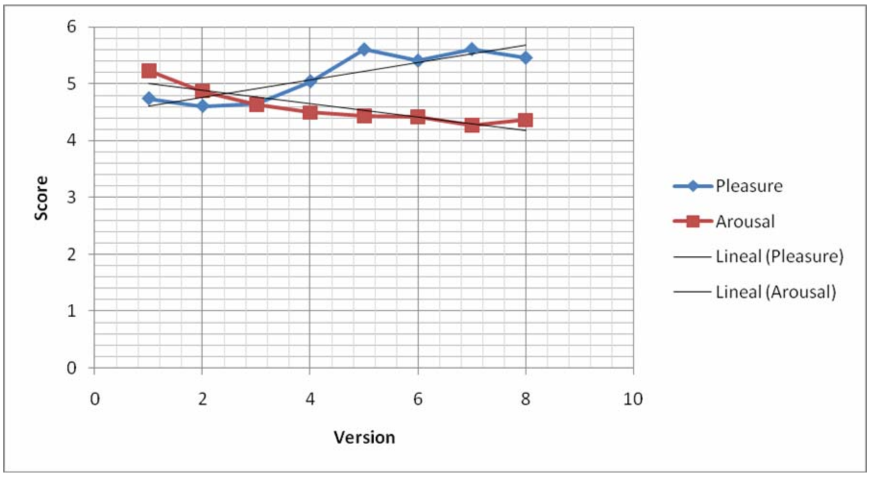

Figure 3: Average emotional ratings of requirements

Observing the results shown in Figure 3 and Table 1, a trend for each dimension is presented; pleasure dimension increases when requirement version increases, and arousal dimension goes in the opposite direction. In order to counteract the effect of the static requirement's, a complementary analysis must be performed. See Appendix, Table 1 in order to check the evolution of pleasure and arousal scores for final requirements. For further analysis, the values obtained by users and developers are included.

The data analysis of final requirements scores shows that there is a marked trend of pleasure and arousal scores in the case of final version requirements (see Appendix, Table 2 for more information). On the one hand, pleasure dimension remains constant while on the other hand, arousal decreases with time (Figure 4). Further analysis is needed to shed light on the differences of these results with those obtained for all versions scores, which points to an increase of pleasure along versions and a decrease of arousal.

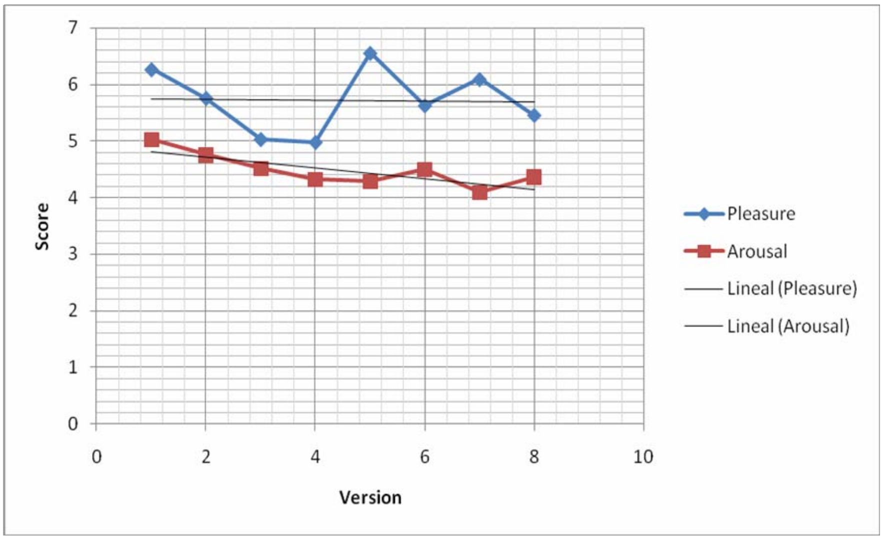

Figure 4: Arousal and Pleasure of final requirements in each version

These results support H1 and H2; the pleasure dimension score increases throughout versions, while the arousal dimension decreases. In order to identify when these hypotheses are not supported, a set of T student tests have been carried out between version x and x+1 (see Appendix, Table 3 for more information). From these tests, it can be concluded that there are not significant differences from one version to another except on Arousal from version 1 to 2, and on Pleasure from version 3 to 4 and 4 to 5. In order to check how many levels are needed for a significant change in arousal and pleasure dimension, other sets of T student tests have been carried out. In these cases, the tests are done between version x and x+2, version x and x+3, and version x and x+4 (see Appendix, Table 4, 5 and 6 for more information). The conclusion that emerges from these tests is the fact that the decrease in arousal and the increase in pleasure dimensions are not significant between versions but the significance of both changes increases when the distance between versions increases. Two questions arise from this conclusion and cannot be solved with the data used for this experiment. Firstly, is the temporal distance between versions influencing the emotional rating? And secondly, if it does influence it, how does it influence the significance between versions?

Summing up the change between versions, pleasure dimension points to an increase along versions (check Appendix, Table 2 for more exhaustive data). The data analysis of Figure 5 shows again the decrease of arousal detected in all requirements' and in final requirements' scores. This finding coherent with H1 and H2.

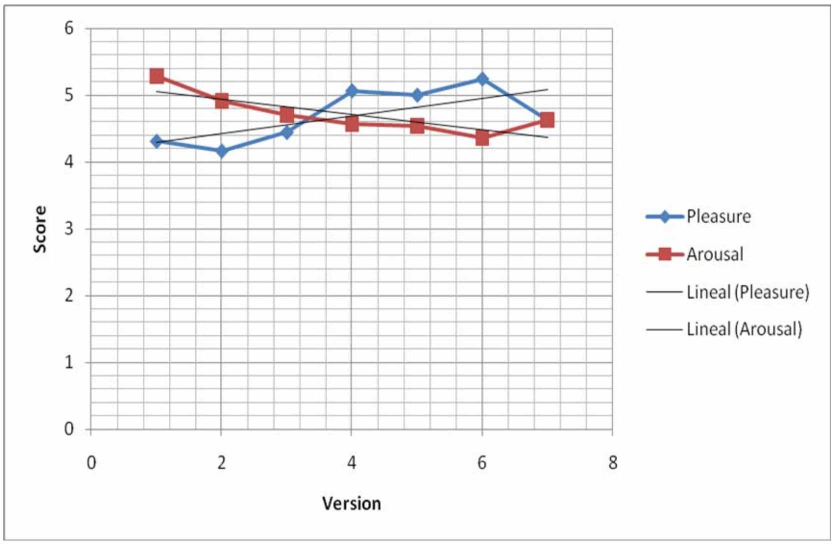

Figure 5: Arousal and Pleasure of non-final requirements in each version

To sum up the evolution of final requirements the following figure is included (Figure 6). It can be observed from this figure that scores follow a descending parabola along versions. This parabola is followed by non-final requirements' scores until version 7; but is not for final requirements' scores which seem to follow a downward grade.

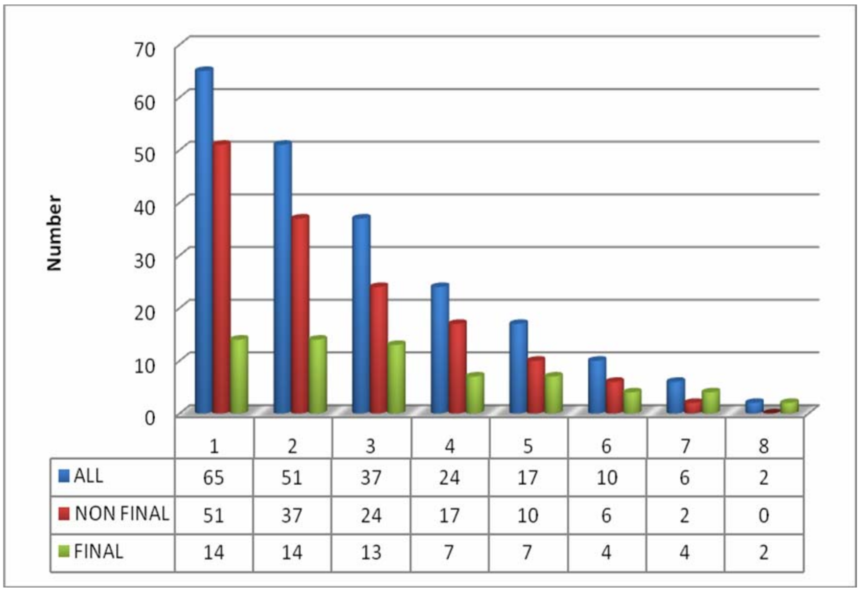

Figure 6: Requirements in each version

This trend points to an evolution of requirements until pleasure reaches a middle or high value. This trend is reversed in the arousal dimension. To check whether there are significant differences between non-final requirements' and final requirement's scores, the T-test has been carried out. For this test, the scores of first requirements that are final version requirements at the same time are considered only as final version requirements. The test results determine that there are differences in the pleasure dimension between final and non final requirements ($t(1175)=12.537$, $p < .05$)) assuming non-equal variances ($.012 < .05$), and in arousal dimension ($t(1175)=-3.656$, $p < .05$)) assuming non-equal variances ($.002 < .05$). With these results, H3 and H4 are proved; the pleasure dimension has an increase and arousal has a decrease between non-final and final requirements. That is, the final requirements, from the emotional point of view, fits best with stakeholder views, generating in them higher pleasure and lesser arousal levels than first versions. Thus, requirements evolve from the stress quadrant to relaxation and to a lesser extent, to excitement.

Figure 7 shows the occurrences of scores from requirements at the first version and at the final version of each requirement:

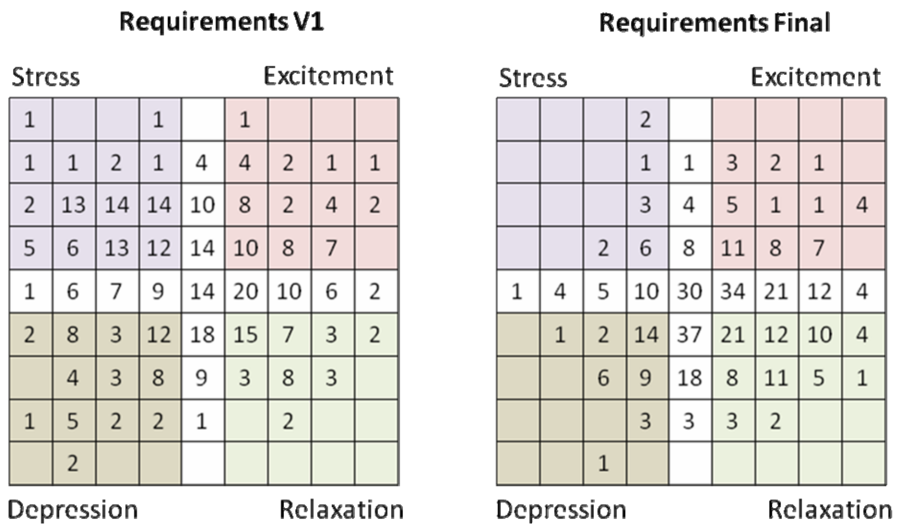

Figure 7: Emotional rating of requirements

In addition, to verify whether there are significant differences between the scores of users and developers, Student t test has been made for each dimension and each version (non-final and final versions). Thus, the comparative level of version one requirements shows that there are no significant differences for pleasure dimension, but there are significant differences for arousal ($t(362)=8.650$, $p < .05$) assuming equal variances ($.000 < 0.5$). This may indicate that the stress that developers are facing in the development is higher than the users'. On the other hand, users have somewhat higher values in the pleasure dimension, but there are not significant differences. In relation to the comparisons made in the final versions of requirements, there are no significant differences between user and developer ratings in pleasure and arousal dimensions. The explanation for this may be that at the end of the process, both developers and users have a comparable level of confidence. Thus, the level of stress decreases greatly and is distributed in a balanced way between both groups.

Regarding stress, the requirements scored by developers with high level of Arousal (>=7) and low Pleasure (<=3) are 40. None of them are final requirements. Expanding the range of this quadrant (maintaining arousal and pleasure less than or equal to 4) just 3 final requirements' scores are obtained from 62 scores. Increasing the level of Arousal to greater than or equal to 6 and maintaining the last limit for pleasure, there are only 5 final requirements from a total of 130 cases. Therefore, a practical conclusion of this finding is that requirements rated by developers with high level of arousal (>=6) and low pleasure (<=4) must be reviewed quickly and effectively. This policy is aimed to prevent that their development over time causing damage due to a late modification, as pointed out by [Boehm, 91].

Separate analysis of the results shows that the development team tends to suffer from stress in the early stages of development (see Figure 8 and 9). This stress undeniably affects their performance and their social competence. Good information given to the development team could be helpful to the developers in coping with that stress, thus, reducing problems of absenteeism, and increasing the effective subjects' contribution.

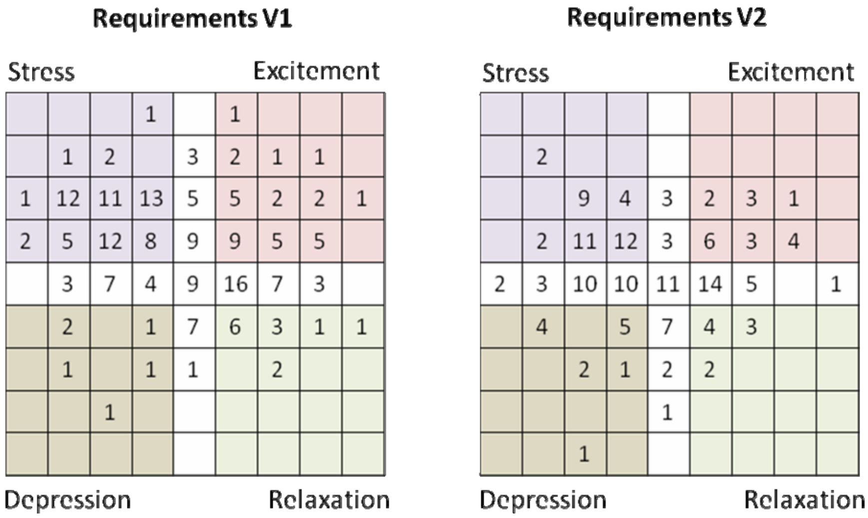

Figure 8: Developer's emotional rating of requirements for version 1 and 2

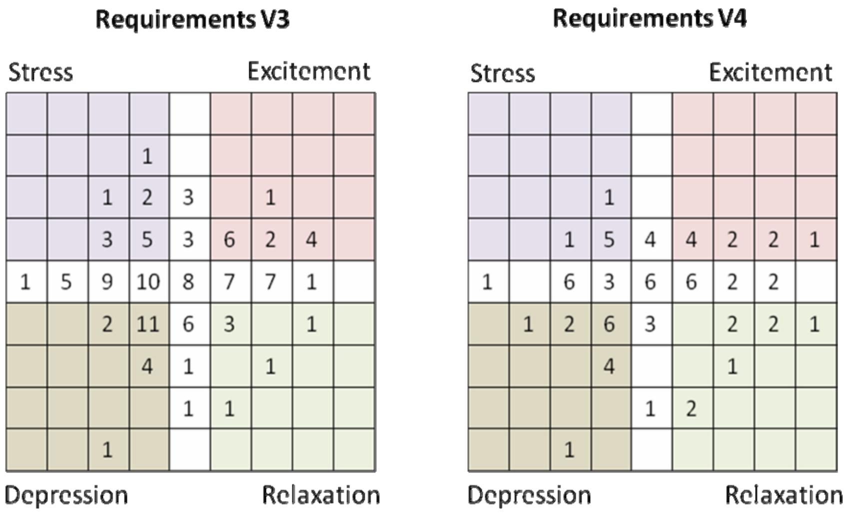

Figure 9: Developer's emotional rating of requirements for version 3 and 4

Finally, software project performance includes SE issues of efficiency [Jiang, 04]. Knowing the emotional state of the development team helps the manager to create an environment capable of combating the effects of "bad" emotions. Thus, training the development team on stress management, communication and assertiveness will improves the coping ability of the RE.

5 Conclusions

Emotions are key issues in people's behaviour. Taking into account that software engineering is a human capital intensive activity; the importance of emotions management in software profession is obvious. In this research field, this paper proposes the integration of emotions in RE processes by means of the use of the affect grid. This classic tool aimed at the analysis and evaluation of emotions is integrated into the categorization of the requirements. Results show that emotions are a factor to take into account in establishing requirements stability. Thus, knowing the stakeholder's emotions involves understanding the reliability and stability of the definition of those requirements. In addition, we must consider that there are no magical ways of solving RE problems because complexity is essential to the processes [Brooks, 87].

6 Future Work

Future works will focus on the extension of the model to deal with cross cultural scenarios. The increasing globalization in software development is changing the way software is produced ([Colomo-Palacios, 11]; [Hernández-López, 10]; [García-Crespo, 10]). Thus, in the current globalized working environment, where offshoring and nearshoring flood the agendas of CIOs around the world, having more data to address the RE process in the global environment is a challenge for both organizations and researchers. Indeed, although many researchers argue that emotions are universal, the characterization of emotions by different cultures is not, nor will it ever be the same …even in a globalized world.

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Appendix

	Ratings	**Pleasure**		**Arousal**	
Requirements + Final	**N**	Average	S.d.	Average	S.d.
Final	**362**	5.718	1.517	4.602	1.299
V1	**79**	6.266	1.639	5.025	1.339
Users	**37**	6.189	1.898	4.73	1.283
Developers	**42**	6.333	1.391	5.286	1.349
V2	**78**	5.756	1.107	4.756	1.331
Users	**36**	5.806	1.167	4.722	1.701
Developers	**42**	5.714	1.066	4.786	0.925
V3	**74**	5.027	1.544	4.514	1.23
Users	**35**	5	1.663	4.4	1.594
Developers	**39**	5.051	1.45	4.615	0.782
V4	**38**	4.974	1.585	4.316	1.454
Users	**17**	5.176	1.286	4.412	1.622
Developers	**21**	4.81	1.806	4.238	1.338
V5	**35**	6.556	1.403	4.278	1.301
Users	**15**	6.667	1.291	4.133	1.506
Developers	**21**	6.476	1.504	4.381	1.161
V6	**24**	5.625	1.096	4.5	1.022
Users	**12**	6.083	1.379	4.417	1.379
Developers	**12**	5.167	0.389	4.583	0.515
V7	**22**	6.091	1.411	4.091	0.921
Users	**10**	6	1.491	4	1.054
Developers	**12**	6.167	1.403	4.167	0.835
V8	**11**	5.455	1.128	4.364	1.12
Users	**5**	6	1	4.4	1.342
Developers	**6**	5	1.095	4.333	1.033

Table 1: Average and Standard Deviation of final requirements along versions

	Ratings	**Pleasure**		**Arousal**	
Non Final Requirements	**N**	Average	S.d.	Average	S.d.
V1	**283**	4.311	1.809	5.286	1.641
Users	**130**	4.354	1.916	4.462	1.735
Developers	**153**	4.275	1.718	5.987	1.17
V2	**205**	4.166	1.648	4.917	1.565
Users	**94**	4.181	1.678	4.223	1.667
Developers	**111**	4.153	1.63	5.505	1.198
V3	**131**	4.443	1.545	4.702	1.44
Users	**59**	4.254	1.469	4.169	1.487
Developers	**72**	4.597	1.598	5.139	1.248
V4	**93**	5.065	1.621	4.57	1.305
Users	**42**	4.905	1.543	4.119	1.452
Developers	**51**	5.196	1.685	4.941	1.047
V5	**57**	5	1.376	4.544	1.211
Users	**27**	4.889	1.553	4.185	1.21
Developers	**30**	5.1	1.213	4.867	1.137
V6	**33**	5.242	1.601	4.364	0.929
Users	**15**	5.2	1.568	4.333	1.047
Developers	**18**	5.2778	1.674	4.389	0.85
V7	**11**	4.636	0.924	4.636	0.674
Users	**5**	4.4	0.548	4.6	0.548
Developers	**6**	4.833	1.169	4.667	0.816

Table 2: Average and Standard Deviation of non final requirements along versions

		Arousal		Pleasure	
	N	T	Sig.	T	Sig.
V1 vs V2	645	2.902*	.004*	.917	.351
V2 vs V3	488	1.797	.073	-.330	.741
V3 vs V4	336	.907	.365	-2.174*	.030*
V4 vs V5	224	.312	.755	-2.612*	.010*
V5 vs V6	148	.109	.913	.779	.437
V6 vs V7	90	.728	.469	-.652	.516
V7 vs V8	44	-.278	.810	.318	.752

Table 3: T Student for Arousal and Pleasure dimensions between versions (x and x+1)

		Arousal		Pleasure	
	N	T	Sig.	T	Sig.
V1 vs V3	567	4.699*	.000*	.560	.576
V2 vs V4	424	2.447*	.015*	-2.843*	.013*
V3 vs V5	298	1.203	.231	-4.835*	.000*
V4 vs V6	188	.433	.666	-1.486	.139
V5 vs V7	126	.841	.403	-.13	.990
V6 vs V8	68	.176	.860	-.113	.910

Table 4: T Student for Arousal and Pleasure dimensions between versions (x and x+2)

		Arousal		Pleasure	
	N	T	Sig.	T	Sig.
V1 vs V4	493	5.081*	.000*	-1.732	.084
V2 vs V5	376	2.749*	.007*	-5.056*	.000*
V3 vs V6	262	1.338	.183	-3.264*	.001*
V4 vs V7	164	1.159	.250	-1.854	0.66
V5 vs V8	104	.196	.845	.301	0.764

Table 5: T Student for Arousal and Pleasure dimensions between versions (x and x+3)

		Arousal		Pleasure	
	N	T	Sig.	T	Sig.
V1 vs V5	455	4.461*	.000*	-3.962*	.000*
V2 vs V6	338	2.901*	.004*	-3.367*	.001*
V3 vs V7	238	2.009*	.049*	-3.493*	.001*
V4 vs V8	142	.371	.717	-1.132	.277

Table 6: T Student for Arousal and Pleasure dimensions between versions (x and x+4)