Article

Understanding Negotiation: A Text-Mining and NLP Approach to Virtual Interactions in a Simulation Game

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Abstract: Negotiation constitutes a fundamental skill that applies to several daily life contexts; however, providing a reliable assessment and definition of it is still an open challenge. The aim of this research is to present an in-depth analysis of the negotiations occurring in a role-play simulation between users and virtual agents using Natural Language Processing. Users were asked to interact with virtual characters in a serious game that helps practice negotiation skills and to complete a psychological test that assesses conflict management skills on five dimensions. The dialogues of 425 participants with virtual agents were recorded, and a dataset comprising 4250 sentences was built. An analysis of the personal pronouns, word context, sentence length and text similarity revealed an overall consistency between the negotiation profiles and the user verbal choices. Integrating and Compromising users displayed a greater tendency to involve the other party in the negotiation using relational pronouns; on the other hand, Dominating individuals tended to use mostly single person pronouns, while Obliging and Avoiding individuals were shown to generally use fewer pronouns. Users with high Integrating and Compromising scores adopted longer sentences and chose words aimed at increasing the other party's involvement, while more self-concerned profiles showed the opposite pattern.

Keywords: natural language processing; negotiation; text mining; assessment; serious game

1. Introduction

Negotiation and conflict management are soft skills that are increasingly becoming a requirement on the job and they are pervasive in many interpersonal domains pertaining to personal and professional life. Assessing soft skills represents a challenging task, especially because these abilities cannot be evaluated on the basis of a commonly agreed and inclusive definition. Rather, a whole pattern of user characteristics and behavior needs to be taken into account to provide a correct user assessment, and the resulting profile is usually strictly context-specific and difficult to generalise. Domains such as conflict management and negotiation, deeply grounded on linguistic and behavioral variables, are defined by theoretical models and characteristics that can overlap or be ambiguous. Natural language, in particular, is a crucial variable in the domain of conflict management, since linguistic choices can reflect environmental aspects such as context, the characteristics of the individual or the interpersonal attitude of the agents involved in the negotiation [1].

Paper-and-pencil psychological tests are currently the only validated methodologies that can be used to provide a standardised quantitative and qualitative measure of negotiation and conflict management skills. Generally, however, the disadvantages of these traditional methodologies to assess and research upon negotiation are many, from the fact that these tests are based on self-report and declarative statements that poorly reflect practical situations to the fact that they greatly suffer from experimental biases such as repeatability and recall. Additionally, the results of these tests are difficult to interpret, since it is particularly challenging to translate these psychological profiles into behavioural

profiles and thus predict the actions and/or daily verbal interactions that are distinctive of each negotiation style. Technology-enhanced platforms for soft skills assessment are usually designed in the form of virtual environments [2–4], where simulated agents can help assess the individual's skills in a realistic situation using role-play techniques [5–7] (for a review see [8]). However, in most serious games and game-based simulations, data provided by the user is collected in the form of multiple choices [9], non-verbal information such as eye-gaze and gestures [10] or facial expression [11], with little or no attention given to verbal aspects. While natural language processing techniques have been used to generate human-like negotiations, via Wizard-of-Oz or machine learning algorithms, e.g., [12], the information about the sentences provided by the user has rarely been included in the user model and used as variables to provide an assessment of soft skills, and in particular negotiation abilities.

Additionally, while the widespread adoption of serious games allows us to better investigate and analyse the behavioural profiles of users using role-play in daily-life situations, there is rarely a theoretical match between the profiles provided by these game-based platforms, which are not standardised, and those provided by a validated psychological assessment.

The present study has a two-fold aim: on one hand, it proposes a natural language processing model that uses statistical inference to map the features of each user sentences and utterances used during a virtual negotiation to the predominant conflict management style; on the other hand, it wishes to provide a bridge towards the validation of a language-based serious game by defining a mapping between the linguistic characteristics of the users and their corresponding psychological profile. Such novel perspective on negotiation that makes use of linguistic and semantic features and is grounded on a specific daily-life context can be then expanded to all domains and settings where a conflict management assessment is needed. To pursue such aims, we will present the analyses conducted investigate the statistical relationship between the users' predominant negotiation style and the structure of the sentences they are likely to use by text-mining a corpus of documents collected during simulated negotiations.

The Concept of Negotiation as Conflict Management

The platform used for the collection of the negotiation sentences and described in the next section is based on the conceptualization of negotiation as conflict management and in particular on Rahim and Bonoma's model [13,14]. The authors distinguish five styles that stem from the combination of two dimensions: concern for self and concern for others. Concern for self (high or low) represents a person's attempt to satisfy his or her own needs. Concern for others (high or low) represents how much a person attempts to satisfy the needs of others. The resulting five styles are [1,15]:

- Integrating style (high concern for self and others), is defined by the attempt to find a solution that can be acceptable for both the negotiation parties and that maximizes the parties' satisfaction. This is achieved trying to involve the other party in the discussion as much as possible;
- Obliging (or accommodating) style (low concern for self and high concern for others) can be viewed as a strategy aimed at maximizing the other parties' satisfaction and needs during the negotiation;
- Dominating style (high concern for self and low concern for others) is defined as an attempt to maximize personal needs trying to force a solution on the other party. Negotiations often include the use of "you statements" in order to consolidate a position of power;
- Avoiding style (low concern for self and others) is defined by an avoidance behavior and a general attempt to postpone the negotiation;
- Compromising style (intermediate in concern for self and others) can be defined as the attempt to find a quick solution by finding a fair outcome for the negotiation without taking into account all of the details, possibilities and unique interests of the parties.

According to this model, the predominance of each user negotiation style can be measured with the Rahim Organizational Conflict Inventory II (ROCI-II), a 28-items test developed by Rahim and Bonoma [14] that provides an independent score from 1 to 5 for each of the five negotiation styles.

2. State-of-the-Art and Related Work

Analyzing utterances and natural language occurring during negotiation in terms of conflict handling is a hard task which is still open [16,17]. The most common approach requires the analysis of the parties' behaviour in terms of linguistic blocks, which can help interpret the concern and the power of one party on the other [18]. These blocks that can describe stalling or making threats, as well as demands [19,20] or persuasion [21,22], or relational versus rational power [23]. The occurrence of these coding blocks can be measured with statistical models [24] such as Markov chain [25]. Other works focused on the outcome of the negotiation, constituting instead a training ground [26].

However, a more molecular and traditional approach to explore negotiation utterances, especially in relation with Rahim and Bonoma's five style model, is personal pronoun analysis. In literature, previous pioneering work investigated the relationship between personal pronoun use and the level of engagement in the negotiation among the parties involved, e.g., [27,28]. The level of engagement and detachment is related to concern for self and for others in the interaction. As per Rahim and Bonoma's dimensions, highly engaged agents are cognitively involved with the other agent of the negotiation, while low-engaged agents show detachment from their own as well as others' conversation subject and arguments. In particular, one pioneering study in communication [29] takes into account three types of pronouns (first person, second person and relational pronouns) and uses the ratios second/first person and relational/first person pronouns to estimate the level of cognitive and communicative involvement the speaker has with the other party. The theory hypothesises that second/first person ratio indicates the position of the conversation on a continuum from "concern for the other" to "concern for self", while the relational/first person ratio indicates how integrative the approach is. Finally, other recent studies confirmed first person pronouns and second person pronouns as indicators of concern in the negotiation [30,31]. It has to be highlighted, however, that all the mentioned studies operated on limited datasets.

Among the many game-based e-learning technologies for the assessment of soft skills that make use of virtual agents, Holohan recently proposed a scenario-based role-play serious game for training communication, gender awareness and cultural awareness in peacekeeping missions aimed at police officers, civilians and the military [32]. Eutopia [33], instead, is a multiplayer platform that provides role-play simulations focused on the development of soft skills. The aim of this tool is to represent a training system able to promote the improvement of mediation skills. In particular, the goal of the training is to allow users to get in touch synchronously in verbal and non-verbal modes within a predefined simulated scenario and test their communication strategies. A game-based platform for the assessment of leadership skills and styles was also developed recently by Sousa and Rocha [34] in order to promote motivation, facilitation, coaching, mindset changing, and communication.

All the previously mentioned e-learning tools can provide valid scenarios for the learners to practice their skills, either individually or within peer groups; however, although some interactions can be made via natural language, none of them analyzes and makes use of the sentences expressed by the users during the interactions with virtual characters as variables to identify user profiles and provide an accurate assessment. Additionally, the limitations of the existing platforms lie in the absence of a theoretically sound interpretation of the assessment and training provided. The progress and the evaluation achieved with these technologies, in fact, cannot be reconciled with a validated and standardised assessment provided by traditional methodologies. The present research wishes

to overcome these limits, by providing a natural language processing model that is able to map the dialogues of the agents with an established negotiation theory.

In the present work, a methodology for collecting natural language negotiations is presented; a statistical perspective to investigate the similarities and the differences in the patterns of negotiation dialogues, word position and frequencies, sentence length and width of vocabulary and a focus on the use of personal pronouns will be taken, as explained in the next sections. The hypothesis is that it is possible to identify unique linguistic features belonging to each negotiation style that can help provide a more accurate assessment on the basis of natural language, and in particular using virtual agents-to-human dialogues. Other than that, we hypothesize that the distribution of words is also influenced by the style displayed by the virtual agent the user negotiated with.

The present work aims to provide theoretical and applied advances to the understanding— and assessment—of negotiation. Concerning the theoretical advances, we wish to explore the semantic and linguistic differences across the negotiation profiles as defined by Rahim and Bonoma's model, so as to ground the assessment provided by the platform. Concerning the applications, the identification of a clear negotiation dialogue pattern identified by pronouns usage, words and sentence length provides a new mean to provide an assessment of negotiation skills that can be embedded not only in the Enact simulation game, but that can be adopted for the assessment of negotiation skills in any natural language-based serious game to provide a standardised evaluation. To test our hypotheses, the following analyses are conducted and the results are presented:

- analysis to investigate the relationship between the negotiation scores obtained by the participants to the validated negotiation test and their pronoun usage and frequency in the simulation platform;
- analysis to investigate the relationship between the pronoun usage and frequency and the other words used in the sentences within the platform with their predominant negotiation style assessed with the validated test;
- analysis of the differences in sentence length and word usage across the different negotiation styles and profiles;
- analysis of the text similarity between the sentences written by all users according to their negotiation style.

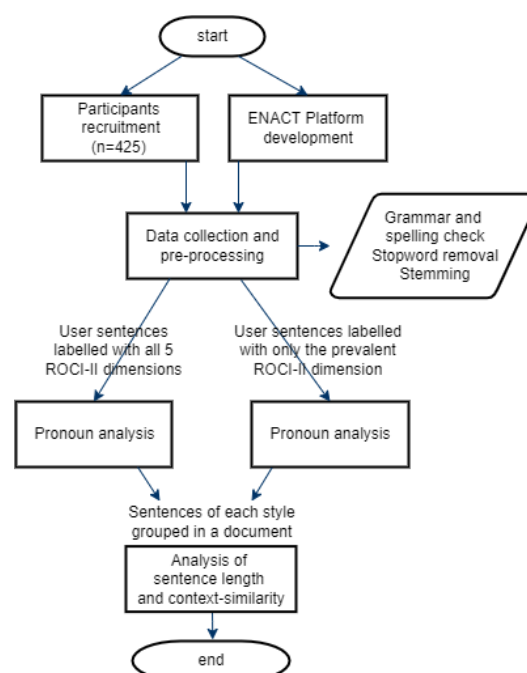The flow diagram of the study is also summarized in Figure 1.


Figure 1. Flow diagram of the study.

3. Materials and Methods

3.1. Simulation Environment

The simulation environment used within this experiment is taken from the serious game Enact [35] and developed within the ENACT (Enhancing Negotiation skills through online Assessment of Competencies and interactive mobile Training) Project (EACEA Erasmus + 54330l-LLP-l-2013-l-UK-KA3-KA3MP) . The Enact platform is a mobile and PC free 3D game-based simulation in which a dialogue between two agents in a negotiation setting is displayed; one agent is played by a bot and the other is played by the user. The game is organized in five scenarios, each independent from the others, where the user can play a different character and negotiate in everyday life conflict situations involving peers represented by an artificial agents . For each of the five scenarios a different situation is introduced, providing the roles that the virtual agent and the user will take. The scenarios invite the user to discuss with the bot on the decision about whether to go to a Chinese or Italian restaurant, about who will take the motorbike between two siblings, what TV show will be watched on the TV, who will design the logo for a sports team and who will buy the last autographed copy of a CD. In each of the five scenarios, the virtual agent behaves according to one of the five theorized negotiation styles (Integrating, Dominating, Compromising, Obliging and Avoiding) . In the experiment, scenarios are presented by two introductory scenes, where the story behind the two characters and the matter of the negotiation is explained, and then other scenes involving turns of speech between the agents. An example of the interface is shown in Figure 2.

The experiment aimed at collecting the natural language utterances between the users and the virtual agents was designed as follows: in the first part, after the consent form was filled, four screenshots for each of the five Enact scenarios were presented to each participant (two introductory and two interactive) for a total of 20 images. The two scenes were extracted randomly among the five possible for each scenario. Under the images of the interactive scenes a box was placed, and the user was asked to write one or more sentences that he or she would say in that situation, for a maximum of 100 characters.

In the second part, the user was asked to complete the ROCI-II psychological test. The whole procedure lasted about 30 min. The inclusion criteria for participating to the experiment was the ability to speak fluent English.
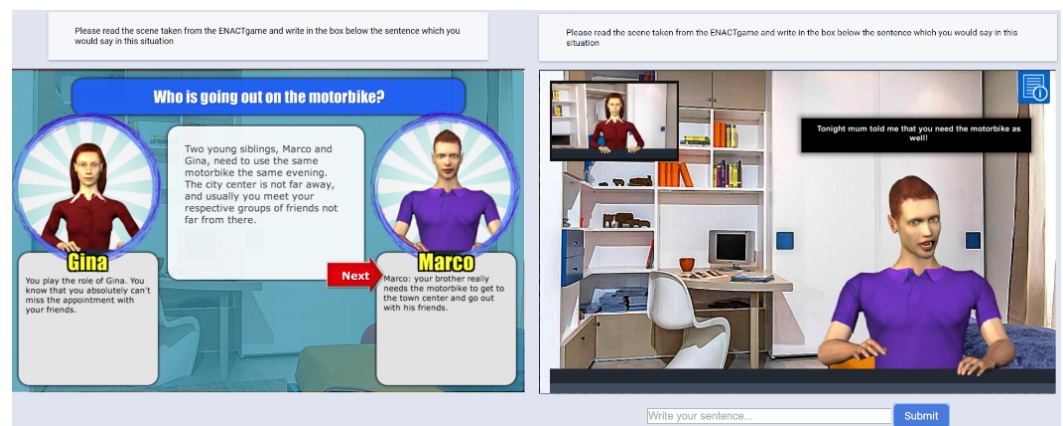
Figure 2. Sequence of the scenes in the natural language experiment. From the left, screenshot of the first introduction scene and screenshot of one interaction state of the first scenario.

3.2. Participants

A total of 425 participants (age mean = 22.84, st.d. = 7.47) took part in the experiment with valid responses and 4250 sentences were collected. The dataset is currently freely available upon request. A reliability test on the ROCI-II items' scores was conducted to confirm that the validity of the test administered to the sample is comparable to that obtained by Rahim's ROCI-II validation (Cronbach's alpha = 0.776). The distributions

of the original scores of the ROCI-II questionnaire obtained by the participants for each style dimension is shown in the boxplots in Figure 3. No significant difference among the distributions of words across the group of users assigned to each seed of screenshots was found.
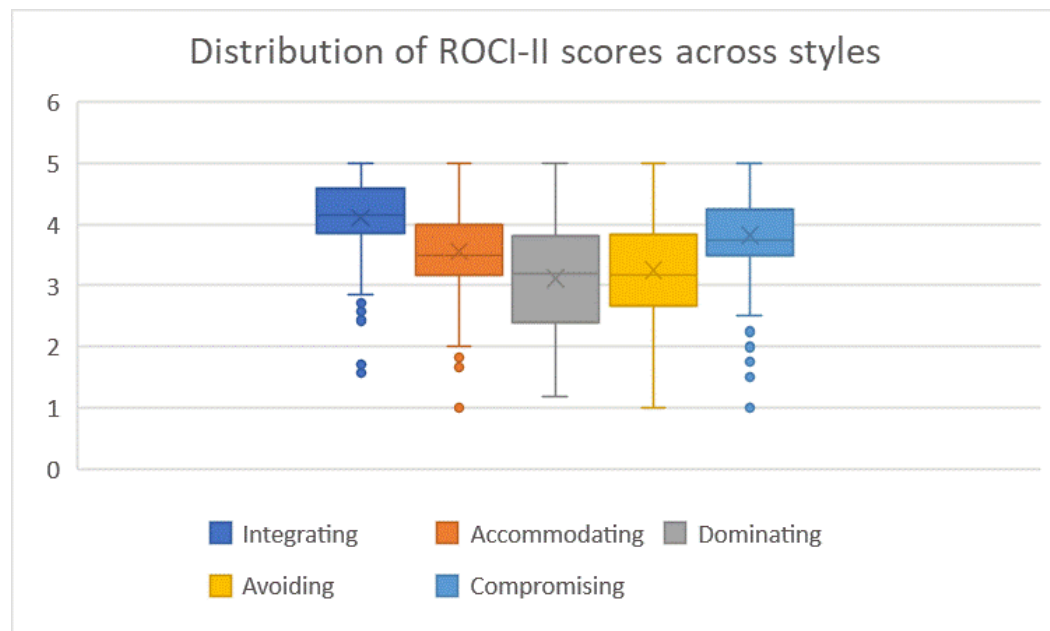
Figure 3. Distribution of the ROCI-II scores obtained by the participants for each negotiation style.

3.3. Statistical Analysis

Pearson or Spearman (as appropriate) correlations were used to investigate the relationship between the pronouns frequencies and the ROCI-II scores of each user. ANOVA with LSD post-hoc analysis was used to investigate the differences in the pronouns frequencies among the negotiation profiles as well as the differences in the sentence length. Context—defined as semantic concordance—similarity was evaluated between words with the Leacock–Chodorow algorithm [36]. Cosine similarity was used to evaluate the similarity between the documents generated by joining all sentences categorised by each users' prevalent negotiation style. For all analyses, a *p*-value < 0.05 was considered statistically significant. All analyses were performed using Python and R statistical software version 4.0.3.

3.4. Data Preparation and Pre-Processing

The sentences were pre-processed as follows:

1. Grammar and spelling check. In order to improve the accuracy of the categorization and of the data analysis, and considering the dataset size, all the sentences were subjected to a spelling and grammar correction. The corrections only included typical misspellings and grammar mistakes and did not aim to achieve a perfect British English (for example, juvenile and slang expressions were maintained) or to alter the content in any way;

2. Stopword removal. In text-mining and information retrieval, stopwords are the most common words that do not help extract features from the dataset—since their frequency, usage and meaning remain the same across all documents—and could therefore negatively affect the results. Prior to the analysis that considered the frequency of the words in the dictionary, the common stopwords were excluded. The list is taken from the Natural Language ToolKit (NLTK) open source library, which is based on the results of [37], with the exception of personal pronouns, which were deleted from

the list so to be included in the analysis. The complete list of the stopwords excluded is shown in Table 1.

3. Stemming. In information retrieval, stemming is the process of reducing all derived or declined words to their base or root form. The Porter stemmer was used in the present work [38].

Table 1. List of stopwords used to pre-process the dataset.

List of Stopwords
what, which, who, whom, this, that, these, those, am, is, are, was, wer, be, been, being, have, has, had, having, do, does, did, doing, a, an, the, and, but, if, or, because, as, until, while, of, at, by, for, with, about, against, between, into, through, during, before, after, above, below, to, from, up, down, in, out, on, off, over, under, again, further, then, once, here, there, when, where, why, how, all, any, both, each, few, more, most, other, some, such, no, nor, not, only, own, same, so, than, too, very, s, t, can, will, just, don, should, now

4. Results

This section is split into three subsection to show the results of the analyses on the difference dataset arrangement they were performed on. In particular, the following results will be presented:

*   the results on the analysis of the pronouns distribution in correlation with the five ROCI-II scores obtained by the users (all sentences are labelled with the five test scores);
*   the results on the difference on the pronouns usage according to the prevalent negotiation style obtained by the user (all sentences are labelled with only one negotiation class, that is the one with the highest score);
*   the results on the similarity and sentence length of the documents created by joining all sentenced labelled with the same style.

4.1. Analysis of the Relation between ROCI-II Scores, Enact Scenarios and Personal Pronouns

This section reports the correlation analysis between the frequency of personal pronouns and the ROCI-II dimensional scores obtained by the user in the whole dataset of sentences. All the personal pronouns considered for this analysis are listed in Table 2. The analysis of personal pronouns (in all their forms, i.e., nominative, objective, possessive and reflexive), is crucial to investigate the level of engagement and concern shown by parties during negotiations [29].

Table 2. List of pronouns used for the natural language analysis.

Type	Pronouns
1st Person	I, Me, Mine, My, Myself
2nd Person	You, Yours, Yourself, Yourselves
3rd Person	He, Him, His, Himself, It, Itself Her, Hers, Herself, She, Their, Theirs Them, Themself, Themselves, They
Relational	Our, Ours, Ourselves, Us, We

Each sentence of the dataset was labelled with the five continuous values indicating the five negotiation styles obtained by its author. ROCI-II scores for each style can have values between 1 and 5, and were normalized to a range between 0 and 1.

The results of the Pearson (or Spearman, where appropriate) correlation between the use of first person, second person, third person and relational pronouns with the ROCI-II

scores are shown in Figure 4. All ROCI-II dimensions show a very distinctive correlation pattern, and in particular Integrating and Dominating display correlations with a single sign, respectively positive and negative. The significance level indicates that the Dominating score obtained in the ROCI-II negatively correlates with the use of all pronouns, and significantly with the use of the first personal pronouns. This result is particularly meaningful if compared with the pronoun use of the "opposite" negotiation style, Integrating, with a high concern for self and concern for other. In fact, the Integrating component, instead, positively correlates with the frequency of all pronouns and significantly with the frequency of relational pronouns.

	Int	Obl	Dom	Avo	Com
first person	0.060	-0.022	-0.126*	-0.019	0.009
second person	0.062	-0.061	-0.062	-0.082	0.009
third person	0.042	0.038	-0.061	-0.022	0.047
relational	0.177*	0.038	-0.064	-0.010	0.078

Figure 4. Correlation coefficients between the use of first person, second person, third person and relational pronouns on the y axis, and the ROCI-II scores of the user, placed on the x axis. (*) Significant values ($p < 0.05$) are marked with asterisks.

Since in each of the five scenarios the bot displayed a different negotiation style, we conducted an analysis to account for this variable. Thus, a deeper per-scenario analysis was conducted considering the type of Enact scenario the user was interacting in to investigate the relationship between the negotiation style scores of the participant and the frequency of the pronouns according to the negotiation style of the virtual agent he or she was negotiating with. The results for each pronoun type are presented in Figures 5–9. Significance levels show that the frequencies of relational pronouns used during the interaction with an Avoiding, Compromising and Obliging virtual agent significantly correlates with the Integrating score obtained by participants in the ROCI-II.

The frequency of first person pronouns used during the interaction with an Integrating virtual agent negatively correlates with the Dominating score obtained at the ROCI-II.

Avoiding Agent

	Int	Obl	Dom	Avo	Com
first person	0.039	-0.020	-0.051	-0.006	-0.047
second person	0.171*	0.026	-0.103	-0.003	0.138*
third person	0.044	0.011	-0.049	-0.014	0.054
relational	0.105*	0.029	-0.005	-0.022	0.026

Figure 5. Correlation coefficients between first person, third person and relational pronouns used during the interaction with the Avoiding virtual agent and the ROCI-II scores. (*) Significant values ($p < 0.05$) are marked with asterisks.

Dominating Agent

	Int	Obl	Dom	Avo	Com
first person	0.041	0.039	-0.082	0.039	0.011
second person	-0.009	-0.081	-0.090	-0.014	-0.007
third person	0.052	0.027	-0.039	-0.023	0.070
relational	0.041	-0.010	-0.026	0.032	-0.035

Figure 6. Correlation coefficients between first person, third person and relational pronouns used during the interaction with the Dominating virtual agent and the ROCI-II scores.

Compromising Agent

	Int	Obl	Dom	Avo	Com
first person	0.019	-0.018	-0.077	-0.008	-0.011
second person	0.013	-0.093	0.079	-0.077	-0.027
third person	-0.048	-0.037	-0.072	-0.036	-0.045
relational	0.098*	-0.001	-0.062	-0.045	0.032

Figure 7. Correlation coefficients between first person, third person and relational pronouns used during the interaction with the Compromising virtual agent and the ROCI-II scores. (*) Significant values ($p < 0.05$) are marked with asterisks.

Integrating Agent

	Int	Obl	Dom	Avo	Com
first person	0.052	-0.022	-0.118*	-0.022	0.034
second person	0.023	-0.016	0.018	-0.015	0.022
third person	0.010	0.024	-0.024	0.019	-0.008
relational	0.083	0.066	-0.054	-0.048	0.056

Figure 8. Correlation coefficients between first person, third person and relational pronouns used during the interaction with the Integrating virtual agent and the ROCI-II scores. (*) Significant values ($p < 0.05$) are marked with asterisks.

Figure 9. Correlation coefficients between first person, third person and relational pronouns used during the interaction with the Obliging virtual agent and the ROCI-II scores. (*) Significant values ($p < 0.05$) are marked with asterisks.

4.2. Analysis on the Sentences Classified by the User's Highest Negotiation Style Dimension

The relation between ROCI-II negotiation classification (i.e., the prevalent style, represented by the highest score) and the use of the four types of pronouns, means and standard deviations were analysed and then a ANOVA with LSD post-hoc was conducted for each of the pronoun type to investigate the significant differences. Means and standard deviations are shown in Table 3. Results of the ANOVA for each of the pronoun types are shown in Table 4 and show that:

- Integrating individuals use first person pronouns significantly more than the others, while Obliging and Avoiding significantly less. In general, as defined by Rahim's negotiation theory, styles with a high concern for self show a use of first person pronouns overall greater than styles with a low concern for self;
- Concerning the use of second person pronouns, the highest mean frequency is still achieved by Integrating individuals, while Avoiding individuals, with a low concern for self and for others, show significantly lower values;
- Third person pronouns are generally much less frequently used than the first and second person pronouns, and results show that Dominating and Obliging use them significantly less, since these are styles that are particularly prone on reaching an agreement without switching the subject of the negotiation. Individuals with a prevalent Avoiding style, instead, which showed a significantly lower frequency of personal pronouns in the other considered cases, show a general greater frequency of third person pronouns;
- Relational pronouns, used much less than the others, show even more significant differences in their frequencies among the different ROCI-II prevalent styles: Integrating displays the highest mean frequency, while both Obliging and Dominating, had the lowest frequency, followed by Avoiding. Across all types of pronouns the Compromising style, consistently with its definition, shows a frequency that is a value in the middle between all the other styles, displaying few significant differences.

The five ROCI-II scores obtained by every participant represent a unique pattern of style dimensions independent from each other. However, the previous analyses clearly evidenced that the quality of each of these dimensions is meaningful, i.e., the dimensions and their relational proportions are consistent with their theoretical definition and participants can be compared across dimensions after normalization. Since participants with high values on one style showed unique words and pronouns frequencies regardless of their scores on the other styles, an assumption that can be made on the dataset is therefore that the prevalent negotiation style measured by the ROCI-II—that will now be referred to as "class"—can be a robust measure and can be meaningfully used to group into categories all the participants. Hence, for the analysis of the personal pronouns that follows, rather

than labelling the sentences with all five dimensional scores from the ROCI-II classification, sentences are labelled just with the negotiation class of the user—i.e., the prevalent style—obtained in the ROCI-II.

Table 3. Means and standard deviations between the number of personal pronouns and the ROCI-II style class.

		Avo	Com	Dom	Int	Obl
1st person	Mean	5.518519	5.518519	6.022727	6.306818	4.861111
	St.D.	3.289438	3.574632	3.372175	3.574059	2.641999
2nd person	Mean	4.962963	5.670886	5.727273	5.948864	5.472222
	St.D.	2.801367	3.058077	3.949469	3.151906	3.056479
3rd person	Mean	3.666667	3.696203	3.568182	3.744318	3.388889
	St.D.	2.44949	2.967147	2.296587	2.198044	1.916511
Relational	Mean	1.851852	2.037975	1.613636	2.392045	1.583333
	St.D.	1.709103	1.931142	1.587977	1.88217	1.518928

Table 4. Post-hoc significance level between the number of pronouns and the ROCI-II prevalent style. Estimated mean differences and *p*-values are reported. (*) Significant differences ($p < 0.05$) are marked with asterisks.

		First Person		Second Person		Third Person		Relational	
I	J	I−J	p	I−J	p	I−J	p	I−J	p
avo	com	−0.4038 *	0.000	0.0376	0.631	0.4038 *	0.000	−0.1197 *	0.016
	dom	−0.1854 *	0.020	0.2606 *	0.001	0.3803 *	0.000	−0.1995 *	0.000
	int	0.3357 *	0.000	0.8216 *	0.000	0.7606 *	0.000	−0.2770 *	0.000
	obl	0.0657	0.408	−0.9343 *	0.000	−0.1667 *	0.008	−0.1714 *	0.001
com	avo	0.4038 *	0.000	−0.0376	0.631	−0.4038 *	0.000	0.1197 *	0.016
	dom	0.2183 *	0.006	0.2230 *	0.004	−0.0235	0.706	−0.0798	0.107
	int	0.7394 *	0.000	0.7840 *	0.000	0.3568 *	0.000	−0.1573 *	0.001
	obl	0.4695 *	0.000	−0.9718 *	0.000	−0.5704 *	0.000	−0.0516	0.297
dom	avo	0.1854 *	0.020	−0.2606 *	0.001	−0.3803 *	0.000	0.1995 *	0.000
	com	−0.2183 *	0.006	−0.2230 *	0.004	0.0235	0.706	0.0798	0.107
	int	0.5211*	0.000	0.5610 *	0.000	0.3803 *	0.000	−0.0775	0.117
	obl	0.2512*	0.002	−1.1948 *	0.000	−0.5469 *	0.000	0.0282	0.569
int	avo	−0.3357 *	0.000	−0.8216 *	0.000	−0.7606 *	0.000	0.2770 *	0.000
	com	−0.7394 *	0.000	−0.7840 *	0.000	−0.3568 *	0.000	0.1573 *	0.001
	dom	−0.5211 *	0.000	−0.5610 *	0.000	−0.3803 *	0.000	0.0775	0.117
	obl	−0.2700 *	0.001	−1.7559 *	0.000	−0.9272 *	0.000	0.1056 *	0.033
obl	avo	−0.0657	0.408	0.9343 *	0.000	0.1667 *	0.008	0.1714 *	0.001
	com	−0.4695 *	0.000	0.9718 *	0.000	0.5704 *	0.000	0.0516	0.297
	dom	−0.2512 *	0.002	1.1948 *	0.000	0.5469 *	0.000	−0.0282	0.569
	int	0.2700 *	0.001	1.7559 *	0.000	0.9272 *	0.000	−0.1056 *	0.033

This further categorization allows us to split the dataset into five different documents. Since, according to the structure of the ROCI-II, the dimensions are independent, partici-

pants could be classified as having two or more predominant styles. These cases (*n* = 37) were excluded from the dataset.

4.3. *Analyses on the Five Documents Obtained by Joining All the Sentences with the Same Class*

A series of analyses were conducted to mine the semantic differences between the documents. The distribution of the users' prevalent ROCI-II style is summarized in Figure 10. The complete dataset consisted of documents is distributed as specified in Table 5. It is interesting to underline the difference in the average number of words per sentence (average sentence length) as shown in Table 5. In order to investigate the difference, an ANOVA with LSD post-hoc analysis was conducted on the distributions of the sentence lengths. Significant differences were found, and the summary of the results of the post-hoc analysis is shown in Figure 11. Participants classified as predominantly Avoiding, Dominating and Obliging produced significantly shorter sentences than Integrating ones, while sentences classified as Compromising did not significantly differ than the other styles' sentences. Avoiding, Dominating and Obliging sentence lengths all resulted with a very similar average length, as can be seen with the *p* level of 1.0 in the table.

Table 5. Number, number of words, sentence length and vocabulary of each document.

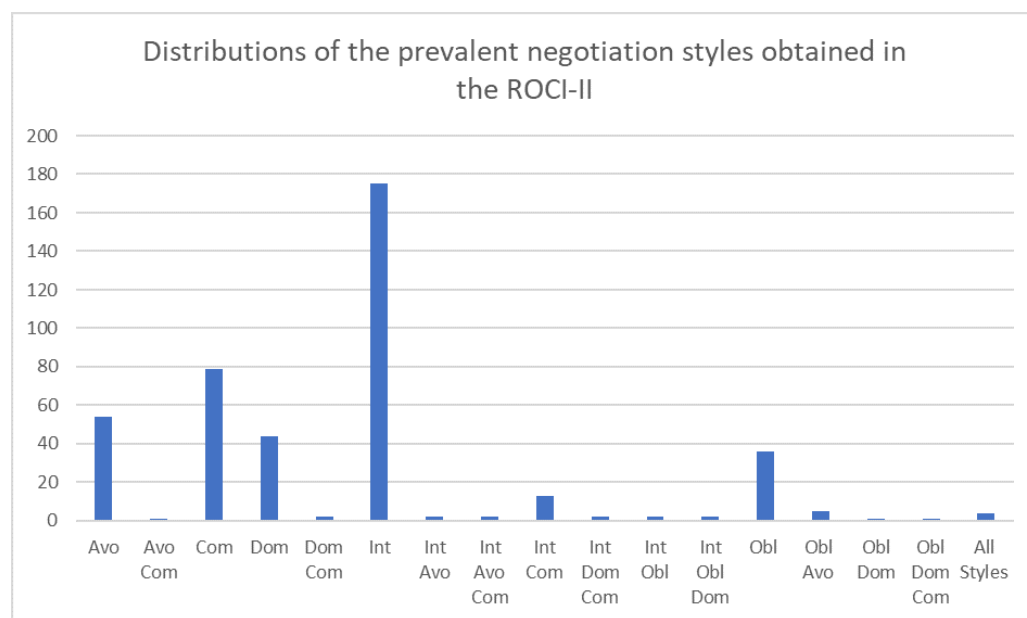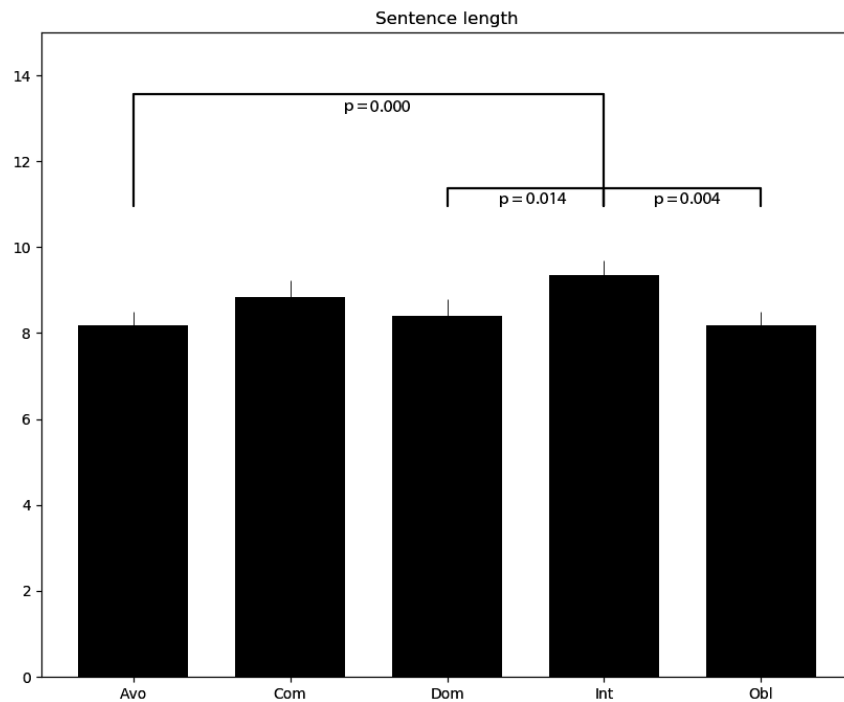|	Avo	Com	Dom	Int	Obl
N	540	790	440	1760	360
Tot words	4421	6978	3690	1761	2949
Tot words (no stopwords)	4146	6556	3466	15,645	2771
Avg. sentence length (words)	8.19	8.83	8.39	9.34	8.19
Vocabulary	796	1074	780	1745	642

Figure 10. Distribution of the negotiation class obtained by the participants in the ROCI-II.

Figure 11. Mean , standard deviations and ANOVA post-hoc analysis of the sentence length among the documents. Significant results are marked and annotated on top with the *p* level.

Concerning the term frequency, an analysis of the occurrences of the words and pronouns was performed. All the results from this section were processed from stemmed tokens excluding the stopwords. Table 6 displays the most frequent words in their absolute counts that occurred in each of the documents and their relative occurrence regarding their proportion on the whole dataset (normalized from 0 to 1). Table 7 displays the most frequent personal pronouns and their absolute counts and normalized frequency.

As shown , "You" was by far the most frequent pronoun in each document, while the occurrence of "It" and "I" is similar in proportion across the documents, not showing any significant difference. The most frequent terms, instead, were verbs connected to the specific scenario they were used in ("watch" in reference to a TV program within the scenario in which the virtual agent was Dominating, "take" in reference to the specific objects of the negotiation). The differences among the documents, instead, is evidenced by the third most frequent term. Avoiding and Compromising, the negotiation styles that are less engaged and motivated to continue the negotiation, show a higher frequency of the verb "Go", that is semantically related to a tendency to put off the discussion or take an immediate decision, while Dominating, Integrating and Obliging styles show "Let" as the third most frequent term, a word associated with a direct proposal and therefore a wish to continue negotiating.

Table 6. Most frequent personal pronouns (absolute counts and normalized by the total number of words) that occurred in each of the documents.

Most Frequent Pronouns (Abs. Count)			
Avo	You (192)	It (152)	I (138)
Com	You (314)	I (231)	It (200)
Dom	You (193)	It (134)	I (120)
Int	You (743)	I (535)	It (531)
Obl	You (135)	I (100)	It (92)
Most Frequent Pronouns (Normalized)			
Avo	You (0.068)	It (0.054)	It (0.054)
Com	You (0.070)	I (0.051)	It (0.044)
Dom	You (0.079)	It (0.055)	I (0.049)
Int	You (0.070)	I (0.050)	It (0.050)
Obl	You (0.071)	I (0.053)	It (0.049)

Table 7. Most frequent terms (absolute counts and normalized by the total number of words) that occurred in each of the documents.

Most Frequent Pronouns (Abs. Count)			
Avo	You (0.068)	It (0.054)	It (0.054)
Com	You (0.070)	I (0.051)	It (0.044)
Dom	You (0.079)	It (0.055)	I (0.049)
Int	You (0.070)	I (0.050)	It (0.050)
Obl	You (0.071)	I (0.053)	It (0.049)
Most Frequent Pronouns (Normalized)			
Avo	Watch (0.021)	Take (0.017)	Go (0.013)
Com	Watch (0.022)	Take (0.015)	Go (0.013)
Dom	Watch (0.021)	Take (0.019)	Let (0.016)
Int	Watch (0.022)	Take (0.020)	Let (0.014)
Obl	Watch (0.023)	Let (0.021)	Take (0.015)

Considering that the personal pronouns with the highest frequencies, as shown in Table 6, were "You" and "I", we investigated whether their use was similar across documents. For this purpose, the context—defined as semantic concordance, i.e., the tokens that are more frequently associated and used before or after each word [39]—in which these personal pronouns were used in each document was measured with the Leacock-Chodorow algorithm [36]. The pronoun "It" was not included since it is semantically ambiguous [29]. The results of the analysis are presented in Table 8. While Avoiding, Compromising and Integrating display the use of "You" and "I" similarly with each other and with the pronoun "We", a peculiar difference is with the styles Obliging and Dominating. In the Dominating document, in fact "You" is used in context with imperative verbs or proposals ("Could", "Go" and "Take"), while "I" is associated with "Help" and, more importantly, with "Pizza", that is the object of negotiation in the scenario in which the user deals with an Integrating agent.

Table 8. Words that are used in similar contexts as the pronouns "You" and "I" across the documents measured with the Leacock–Chodorow algorithm.

	Context Similarity "You"	Context Similarity "I"
Avo	I, We, Together	You, Early, We
Com	We, I, Me	You, We, It
Dom	Could, Go, Take	You, Help, Pizza
Int	I, We, It	You, We, It
Obl	Me, That, I	Let, We, Upon

Finally, Table 9 shows whether there are shared similar contexts between the pronouns "I" and "You" across the documents.

Finally, a natural language processing analysis of the dictionary and of the five documents containing the sentences in relation with the ROCI-II prevalent dimension (class) of each negotiation style of the participant was conducted. The similarity between the documents and the term frequency–inverse document frequency (TF-IDF) scores were calculated [40]. The TF-IDF can be measured for each word w in a document d with vocabulary V_d and weighs the frequency of that word in a document by the occurrence of it across all documents D, as shown below:

$$TF = \frac{count(w \in d)}{V_d} \tag{1}$$

$$IDF = \log \frac{N_D}{count(d \in D : w \in d)} \tag{2}$$

$$TFIDF = TF * IDF. \tag{3}$$

Table 9. Words that are used in shared similar contexts as the pronouns "You" and "I" across the documents.

	Contexts Shared by "I" and "You"
Avo	Know, Get, Good, Time
Com	Happy, Watch, Need, Yeah, Say
Dom	Don't, Take
Int	Want, Don't, Think, Could, Please
Obl	Yeah, Need

The TF-IDF value, performed on all words of each document, allows us to obtain a vectorized form of each document, that can be used to measure the similarity with standard geometrical operations such as cosine similarity. Cosine similarity can be used to find the width of the angle θ between the two vectors representing the documents [41], regardless of their length, and is defined as:

$$cos\theta = \frac{\vec{d_1} \cdot \vec{d_2}}{|d_1||d_2|}, \tag{4}$$

where d_1 and d_2 are the TF-IDF values of two documents.

TF-IDF was used to vectorize each term in the vocabulary of the documents. TF-IDF matrices were computed for all the terms in each of the five documents and were compared using cosine similarity. Results of the computations are shown in Table 10. As shown , the highest similarity values stand between the document containing the sentences classified as Integrating and all the other documents.

Table 10. Cosine similarity values between each of the TF-IDF matrices generated from the documents

	Avo	Com	Dom	Int	Obl
Avo	1	0.9664	0.9541	0.973	0.9437
Com	0.9664	1	0.958	0.9799	0.9546
Dom	0.9541	0.958	1	0.9688	0.9472
Int	0.973	0.9799	0.9688	1	0.9613
Obl	0.9437	0.9546	0.9472	0.9613	1

5. Discussion

Overall, the results support the main hypothesis of the study, i.e., that it is possible to delineate a clear pattern of pronoun usage that is distinctive for each of the Rahim and Bonoma's negotiation styles. These results also support the idea that the theoretical model reflects a specific difference in the language adopted in real daily-life contexts by negotiating individuals.

The correlation analysis between the pronoun frequency and the ROCI-II scores showed that Integrating individuals use overall the highest amount of personal pronouns. This is consistent with the theory that highly Integrating individuals try to increase the level of mutual engagement in the negotiation and highlight possible decisions that can satisfy both parties, therefore proposing and involving both self and other's centred solution. An example of this strategy in the dataset is the following sentence extracted from an individual with a high Integrating dimension:

"We can share. Bikes can handle two people and we can coordinate our simultaneous return".

The lack of pronoun's usage shown by individuals with a high Dominating component can instead be viewed as the consequence of not discussing different approaches to solve the situation that involves the two parties nor trying to balance the person's own will and aim with the one of the other. Examples taken from highly Dominating individuals in the dataset are:

"Let's settle it now."

or

"Eat your pizza with chopsticks."

The second example also highlights the use of a typical Dominating "You statement", i.e., a statement that dictates something similar to an order in a highly assertive manner. Individuals with a high Avoiding and Obliging dimensions also use fewer pronouns than those with a higher Compromising and Integrating dimension, leading to a further step in the interpretation: styles with a theoretical high concern for self and for others show a generally high frequency in the use of personal pronouns, while styles with a low concern show the opposite pattern. The following sentence displays a highly Avoiding individual's strategy taken from the dataset:

"Okay whatever floats your boat."

while highly Obliging participants, for example, proposed

"Sure thing!"

and

"Sounds like a good idea!"

In agreement with the definition of Integrating style, highly Integrating individuals try to balance between self and other's interests during a negotiation, and the frequent use of relational pronouns is the most evident linguistic expression of this attempt, regardless of the style of the virtual agent. Even though, as it is observed, Compromising individuals may decide to solve the situation proposing a deal that is very similar to that of Integrating ones, the depth of the interest they have in others' is largely different, as displayed by the following sentence in the dataset:

"I can watch Masterchef with you. You should allow me to watch Report later on."

The frequency of relational pronouns only correlates with the Compromising score when interacting with an Obliging virtual agent, and this could be explained by the fact that the Obliging style is the one that has the lowest concern for self, and a highly Compromising peer may wish to equally split the resources, feeling uncomfortable if the other party ended up with an unbalanced deal. The sentence below, extracted from the dataset, can support this interpretation:

"It will be good for us to work together."

As shown, highly Dominating individuals show a scarce use of first person pronouns, and this can be interpreted as an effect that the integrative approach used by the other party influences—and decreases—the need to impose one's interest in general, as the Dominating individual may feel that his or her interests are already taken into account. Examples of highly Dominating participants responses to Integrating agents, showing highly assertive utterances, are:

"Why do you want Chinese?"

and

"Do you hate Italian restaurants so much?"

A particular case, instead, concerns the use of second person pronouns. As shown in the tables, the frequency of second person pronouns with an Avoiding virtual agent strongly correlates with the Integrating and Compromising scores in the ROCI-II and, in accordance with the results of the relational pronouns, this could be explained by an attempt of the party to discuss the deal further and to increase the other's interest, as in the example below:

"Are you sure there isn't a shop in South Africa that also has the CD?"

The frequency of second person pronouns in scenarios with an Avoiding virtual agent, instead, negatively correlates with a Dominating score, and this can be interpreted as a retreat of the Dominating individual on their position and deal, rather than attempting what can be felt as an unnecessary involvement of the other.

Concerning sentence length, the results support the hypothesis that while predominantly Compromising and Integrating styles will tend to integrate the perspectives of both the parties during the negotiation and consider multiple options using a higher number of words per sentence, a highly Dominating party will try to reach his or her objective in the shortest time possible, as well as Obliging and Avoiding parties will not explore all the possible outcomes and will have a reduced concern towards the object of the negotiation and/or self or other's interest. This is also consistent with the idea of Integrating and Compromising styles being the negotiation styles that require a higher depth of the negotiation to reach a mutual decision.

The results on the words used in the same context as "You" and "I" across all the documents highlight that predominantly Avoiding participants again make references to a temporal dimension ("Time") while negotiating, aiming to postpone the discussion, as in

"Next time this comes up I'll give it to you."

while Obliging classified sentences (and largely less Compromising) shows "Yeah" as a shared context, which confirms the theory that sees it as accommodating the other parties' proposals, as in

"Anything to make you happy, yeah.".

Regarding the analysis of the documents formed by joining all the sentences labelled with the same style, the Dominating document shows only two words that are shared between the contexts of "You" and "I", the most prevalent being "Don't", which clearly shows the attempt to impose one's will on the other party. Integrating, instead, consistently with the theoretical definition, also shows words that are semantically related to proposals and exploration, such as "Think", "Could" or "Please".

Concerning document similarity, the Integrating sentences were shown to be the most dissimilar from all the other documents. This can be partly explained by the fact that the Integrating style is the one that tries to include all the perspectives and holds both a high interest for self and for other. , This could also be a consequence of the fact that, as previously evidenced, sentence length was higher, and so was the number of words in the vocabulary. The couple with the highest similarity stands, confirming the initial hypothesis, between the documents containing Compromising and Integrating sentences—and this is in accordance with the theoretical definitions of these styles—while, still consistent with Rahim's theory, the couple of documents classified as predominantly Dominating and Obliging holds the lowest score in terms of cosine similarity, since these styles are placed opposite in the concern for the self's and concern for others' conflict handling spectrums.

6. Conclusions

A natural language analysis of the pronouns, word frequency and term usage was conducted to investigate the interaction between linguistic features and negotiation styles. Sentences used by participants during virtual negotiations were collected and labelled with the ROCI-II dimension scores representing the negotiation styles. An analysis of the frequency and usage of the first person, second person, third person and relational pronouns was performed on the dataset, taking into account the style of the virtual agent the user negotiated with. In general, the Integrating dimension has been found to correlate positively with the frequency of all pronouns, and significantly with relational pronouns. The Dominating component has been found to positively correlate with second person pronouns and negatively with relational pronouns. Highly Avoiding and Obliging individuals were those that displayed the lowest frequency of pronouns where Avoiding ones showed a higher frequency of third person pronouns. The pronouns frequencies of individuals with a high Compromising dimension are very close to all the other styles across all the pronouns, holding middle values. The results were consistent with the theoretical definitions of Rahim's negotiation styles, and in particular, Integrating style sought to engage the other party using personal pronouns with a predominance of relational ones; highly Dominating individuals and styles less involved in the negotiation such as Avoiding and Obliging used fewer relational and more third person pronouns. Then, sentences were grouped into five documents labelled with the prevalent ROCI-II dimension obtained by the participant and the documents were analysed applying text mining methods. Differences among the sentence length, vocabulary and words frequency in the styles consistently with the theoretical framework were found.

Overall, the results strongly support our hypothesis that the validated negotiation profiles theorized by Rahim and Bonoma can actually be identified by their distinctive usage of pronouns, term frequency and number of words. This result opens up the possibility of evaluating soft skills in a standardised manner solely on the basis of natural language features, adopting game-based platforms that are grounded on contextual situations and without the need for paper-and-pencil tests. The present study not only provides a novel mean for a quick and reliable assessment of negotiation skills, but also helps to highlight the most important features and characteristics of each negotiation style, which can be useful

for the assessment and training of individuals across all domains that involve negotiation, from professional to personal lives.

The limitations of the present work are several. First of all, the Enact platform was not originally built to provide a textual response that was in line and/or perfectly consistent with the conversation provided by the participant. In fact, the virtual agent was not able to adapt its response according to the answer provided by the participant. Additionally, since the recruitment was conducted both online and offline, age and gender of the participants could not be fully controlled and balanced. Although in the literature there is no proven difference in the way negotiation styles are expressed across these two demographical variables, more attention must be paid to these two important aspects in subsequent experiments. Another important limitation concerns the type of analyses that were carried out on the dataset. Even if the dataset is currently highly imbalanced in terms of negotiation class distributions and only moderately large, text-categorization machine learning models, such as recurrent or convolutional neural networks, could be used for a more robust comparison across negotiation profiles.

The present work has given rise to many possible future research questions that concern both the improvement of the current model and the development of other psychological assessment-based serious games. The model architecture, in particular, could be improved in the following ways:

- The statistical analysis of the natural language sentences could target not only personal pronouns but also other parts-of-speech;
- The developed natural language architecture could be used to generate sentences that could be added to the model of the virtual agents, to allow a more adaptive flow of the dialogues inside the scenarios.

In the future, the aim is to foster the development of other technology-enhanced platforms for the assessment and training of soft skills that could also look at the interaction among several psychological aspects and factors. Possible future implementations concern, among others, leadership skills, problem solving abilities and time management.

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