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Assessing Persuasion in Argumentation through Emotions and Mental States

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Abstract

Argumentative persuasion usually employs one of the three persuasion strategies: Ethos, Pathos or Logos. Several approaches have been proposed to model persuasive agents, however, none of them explored how the choice of a strategy impacts the mental states of the debaters and the argumentation process. We conducted a field experiment with real debaters to assess the impact of the mental engagement and emotions of the participants, as well as of the persuasiveness power of the arguments exchanged during the debate. Our results show that the Pathos strategy is the most effective in terms of mental engagement.

Introduction

In everyday life situations like online discussions and political debates, "the aim of persuasion is for the persuader to change the mind of the persuadee" (Hunter 2016). This process, called *persuasive argumentation*, may employ different strategies. In the Ethos strategy, persuasion relies on the authority of the persuader with respect to the topic of the debate. The Logos strategy is grounded on logical arguments leading to a sound inference process to derive conclusions, while the Pathos strategy solicits the emotions of the interlocutors to generate empathy. These strategies have been used to define formal models of persuasion, e.g., (Hunter 2016), to be employed by intelligent agents to persuade the others to change their beliefs. However, analyzing how these strategies are perceived by humans when they argue, and what is the impact of these strategies on the humans' mental states like *engagement* and *emotions* has not been explored. Yet, this would be of valuable importance for argumentative agents to be able to apply persuasion strategies as humans do, resulting in more effective interactions with people.

In this paper, we answer the following research question: *what is the impact of persuasion strategies on the mental states and emotions of the debaters?* To answer, we conducted a field experiment with users, starting from three hypotheses to be validated. We raised a number of debates in which, together with the participants of the experiment, a *persuader* was involved to convince the other participants about the goodness of her viewpoint, applying one of the three persuasion strategies. The persuader is a person who has been provided with particular argumentation frameworks but appears to the other participants as just another participant, e.g., she does not dominate the debate. Every participant was equipped with an Electroencephalography (EEG) Headset to detect mental engagement, and cameras to detect facial emotions. The collected data was synchronized to assess the validity of our hypotheses. Results highlight the higher persuasion impact of the Pathos strategy.

Preliminaries

Argumentative persuasion. In computational models of argument (Rahwan and Simari 2009), arguments are linked to each other by *attacks*, indicating that an argument is incompatible with another one, and *supports*, indicating an argument provides some backing to another. Three kinds of argumentative persuasion exist: *Ethos*, *Logos*, and *Pathos* (Ross and Roberts 2010). Ethos deals with the character of the speaker, whose intent is to appear credible. The main influencing factors for Ethos encompass elements such as vocabulary, and social aspects like rank or popularity. Logos is the appeal to logical reason: the speaker wants to present an argument that appears to be sound to the audience. Pathos encompasses the emotional influence on the audience.

Mental states and emotions. To assess both participants' mental condition and their involvement in the argumentation, we adopt the *engagement index* (Chaouachi and Frasson 2012). Engagement is defined as the mental vigilance and alertness while accomplishing a task (Berka et al. 2004). This index was first defined in (Pope, Bogart, and Bartolome 1995), and relies on neuroscientific research on attention and vigilance. It is computed from three EEG bands: $\Theta(4-8Hz)$, $\alpha(8-13Hz)$ and $\beta(13-22Hz)$, and it obeys to this equation (Chaouachi and Frasson 2012): $Engagement = \frac{\beta}{\alpha+\theta}$. In this paper, we investigate also the distribution of engagement among the brain lobes (Teplan 2002; Vuilleumier 2005): the *Frontal lobe* has two key functions, i.e., controlling motor activities (including speech), and human "executive functions" (e.g., planning, reasoning, making decision); the *Temporal lobe* controls visual and auditory memories; the *Parietal lobe* is responsible for processing sensory information, comprehending oral and writing language, and controlling working memory; the *Occipital lobe* is responsible for vision. We consider the brain lobe reaction to an argu-

ment within 10 sec. to characterize the persuasive strategy effect. Emotions have an important role in decision making and can manifest wrt. three levels, namely, *experiential*, *behavioral* and *physiological*. For example, during conversations, when someone attacks an argument, she could experience the anger emotion, her behavioral reaction is shown by the angry facial expression or aggravated voice tone, and the physiological response consists in an increasing heart rate. To improve the emotion recognition accuracy, multimodal techniques by combining different sensors to capture these different emotional reactions are used. We combined physiological sensors (EEG) with facial expression analysis system (FaceReader 6.1).[1] By analyzing the user's face streamed via webcam, the FaceReader software is able to recognize six basic emotions: happy, sad, angry, surprised, scared and disgusted. The FaceReader model reaches 87% accuracy by extracting and classifying in real-time 500 key points in facial muscles. As output, FaceReader provides the probability of the presence of these six emotions, as well as the probability of the neutral state.

Experimental setting

The goal of our experiment was to investigate how the argumentative persuasion process in debates is affected by the mental states and emotions of the participants, and vice-versa. In each debate, besides the participants equipped with the EEG Emotiv EPOC devices, there is a participant who plays the role of the *persuader*, called the PP in the remainder of the paper. The PP adopts and maintains a predefined viewpoint in the debate (i.e., pro or con), together with an argumentation strategy (i.e., Logos, Pathos or Ethos). PP intends to persuade other debaters of her viewpoint on the debated issue. The goal is to evaluate the following hypotheses:

H1: Argumentation strategies trigger negative emotions and engagement having an impact on the persuasion.

H2: Specific brain lobes are activated when a Logos or an Ethos argument is proposed by the PP, while other lobes are solicited when the PP puts forward a Pathos argument.

H3: Pathos arguments activate a higher empathy, triggering a number of arguments put forward by the other participants to support PP's arguments. Pathos arguments have a more effective persuasive power in the debate.

Participants and roles: 4 participants aged from 19 to 45 were involved in each of the 5 debate sessions, and each participant received a compensation of 20$ at the end of the session. In total, we collected data from 20 participants (7 women, 13 men). The size of the experiment is driven by the complexity of the experimental setting (devices, protocol). Debaters were preselected after filling an online form that collects their initial opinions about all the debate subjects, data is anonymized and kept confidential. This step was necessary to ensure possibly conflicting initial opinions in the debates. The ideal configuration includes 2 participants in favor and 2 against the debated topic. When not possible, a random assignment has been carried out. Each participant was kept separate from the others to avoid interactions out of the debate platform. In addition to the four participants and the PP, a *moderator* who proposes the debated issue and solicits unresponsive participants participated too. Each group of participants was involved in two debates. All participants (including the PP) were identified in the debate platform through a nickname. The PP cannot be identified by her nickname. No personal information about participants was disclosed during the debates.

Protocol: *Phase 0*: Participants fill in the self-reporting questionnaire about their initial opinions on the debate topics. They are associated to the debate sessions.

Phase 1: Familiarization of the participants with the Internet Relay Chat debate platform, the EEG headset, the camera for emotion recognition, and signature of a consent form.

Phase 2: The debate starts. Participants are involved in two debates for a maximum of 20 minutes each. The moderator provides the debaters with the topic to be discussed, and asks each participant to provide a general statement about her opinion on the topic. Each participant writes her viewpoint to the others, then the others are asked to comment on the expressed opinions. The PP plays the predefined persuasion strategy to convince the others with a different opinion, meaning that all arguments put forward by the persuader apply only the selected strategy. No turn taking was applied. Participants were free to propose their arguments, and the PP participates in the debate with the same amount of arguments as the other participants. The debaters were free to put forward generic arguments about the debated topic, or to explicitly refer to the other participants' argument to attack or support them. Arguments proposed by the PP were pre-instantiated arguments retrieved on online debate platforms[2], and categorized with the three persuasion strategies we identified. These arguments allowed us to provide a fixed stimulus in the debate. When necessary, the PP slightly adapted the pre-defined argument to precisely refer to another participant's argument, e.g., "I don't agree with you Participant1 because `predefined argument`". After about 15 minutes of debate, the moderator asked to provide their final viewpoint on the topic, and the debate is closed. Strategies have not been randomized. For each debate session, the PP applies the logos strategy for one debate, and either Pathos or Ethos for the second debate to compare for each set of debaters a more rational strategy (i.e., Logos) vs a more empathic one (either Ethos or Pathos). The contingency table below shows the correlation of the strategy adopted by the persuader and her stance in the 10 debates.[3]

Phase 3: Participants are asked to fill a second self-reporting questionnaire on their experience in the debate.

Post-processing phase: we synchronized the textual argument collected during the debates, with the engagement index and the emotions.

[1] www.noldus.com/human-behavior-research/products/facereader

[2] www.debate.org/, www.createdebate.com/

[3] The Pathos strategy has not been used with a Pro stance because *i)* we had 6 debate sessions but the EEG data of the first session, where we considered Pathos/Pro, was corrupted, and *ii)* the stance depends also on the arguments used on the debate platforms we collected to construct PP's ones.

Strategy	Stance		
	Pro	Con	Total by Strategy
Pathos	0	3	3
Logos	4	1	5
Ethos	1	1	2
Total by Stance	5	5	10

We are aware that field experiments, as the one proposed in this paper, suffer from the possibility of contamination, and we agree about the fact that experimental conditions can be controlled with more precision in a constrained experimental setting. However, field experiments have the advantage that outcomes are observed in a natural setting rather than in a contrived environment, thus showing higher external validity than "laboratory" experiments. For instance, the reader may argue about our choice of an experimental setting where 5 persons are involved at the same time, instead of a more controlled setting with a 1:1 face-to-face exchange. However, our interest is not in studying the effect of a single strategy on a single person with respect to a single dialogue move, but in considering a more realistic setting where several persons interact, like on social media.

Dataset. Two annotation tasks have been carried out offline on the collected data[4] by two annotators. Each argument is annotated with debate identifier, argument identifier, participant, and timestamp.In total, 791 arguments, and 162 argument pairs (74 linked by an attack and 88 by a support) were annotated. We computed the inter-annotator agreement for the relation annotation task on 1/3 of the pairs of the dataset (54 randomly extracted pairs), obtaining a satisfactory agreement: $\kappa = 0.83$.

Experimental results

This section reports on the obtained results for our hypotheses. We divided the debate into three phases: the introduction (INTRO) where the PP states her own opinion on the topic of the debate; the argumentation (ARG) includes the reformulation, the refutation and the contribution of new ideas according to the strategy adopted by the PP; the conclusion (CONC) where the PP recalls her position and final opinion. This structure is inspired from the conversation structure in pragmatics, where conversations have a linear structure, i.e., initiation, maintenance and termination (Kellermann et al. 1989). For data synchronization, we considered the participants' physiological reactions during 10 seconds after each intervention of the PP (Lee and Hsieh 2014), and we computed the average emotion values of the 10 seconds after each argument proposal. We considered the anger scores in the result analysis because it was the most predominant emotion during the debates (Rozin and Royzman 2001).

H1 - Persuasion vs. emotions and engagement

In this first hypothesis, we verified for each strategy, the means of anger generated throughout the different phases of the debate. To verify the impact of anger and engagement on persuasion, we ran a repeated ANOVA measure.

[4]The corpus is available at https://goo.gl/xSykTi.

There is a significant correlation between the persuasion strategy and the participants' emotions	NO	H1
Engagement in supporters and anger in opponents grow in an inversely proportional way	YES	H1
Logos activates language comprehension and situations correlation	YES	H2
Logos activates planning and decision making	NO	H2
Ethos leads to the higher percentage of attacks wrt. PP's arguments	YES	H3
Pathos leads to the higher percentage of supports wrt. PP's arguments	YES	H3

Table 1: Experiments finding at a glance.

As within-subjects factors, we consider the debate phases (INTRO, ARG, CONC). As between-subjects factors, we consider $PP\_strategy$ (Ethos, Logos, Pathos), measure (anger, engagement), and participant's final position (Neutral, Opponent, Supporter). We validate the repeated ANOVA measures with (Mauchly 1940) test for sphericity on the dependent variable Deb_phases (sig=.013) (we assess the significance of the corresponding F with (Greenhouse and Geisser 1959)'s correction). For the within-subject effect test, we have a significant effect of debate phases and $PP\_strategy$ on measuring (engagement and anger) with p=0.016 and F(8.857, 113.372)=2.405. The between-subject effects results show that there are significant main effects of the $PP\_strategy * Final\_Position$, F(8,64)=2.178, p=0.041, meaning a significant effect of the persuasion strategy, anger and engagement on persuasion. Fig. 1 presents the corresponding engagement to compare the effect of emotions on the engagement. Note that if anger decreases, the engagement increases in all persuasion strategies.

For the Logos strategy (Fig. 1-B), participants who stayed *Neutral* all over the debates had low negative emotions and their engagement was high. So participants who have not decided about the PP's opinion were more engaged in looking for logical reasons to support opinions. This can be interpreted as follows: neutral participants follow the arguments deployed by Logos and show a high engagement in trying to be persuaded. The opponents show a clear increase of negative emotions and loss of engagement. They are more engaged in the ARG phase in refuting the PP's arguments (*emotional resistance*) whereas the supporters were less engaged because they already accepted PP's logic. Hence, for the Logos strategy, neutral participants show decreasing negative emotions and engagement growth, whereas opponents are mostly subject to negative emotions and disengaged to follow the logical reasoning.

For the Ethos strategy (Fig. 1-A), opponents rejected the credibility of the PP and were not engaged in following her opinion. Their position does not change during the debates end where the negative emotion is higher. The neutrals were less engaged throughout the debate phases compared to the other participants. This can be due to the lack of interest in the subject of the debate and even disengagement in taking a position face to an expert opinion. We may notice that the supporters' engagement is higher in the INTRO phase, and continues to decrease at the ARG and CONC phases

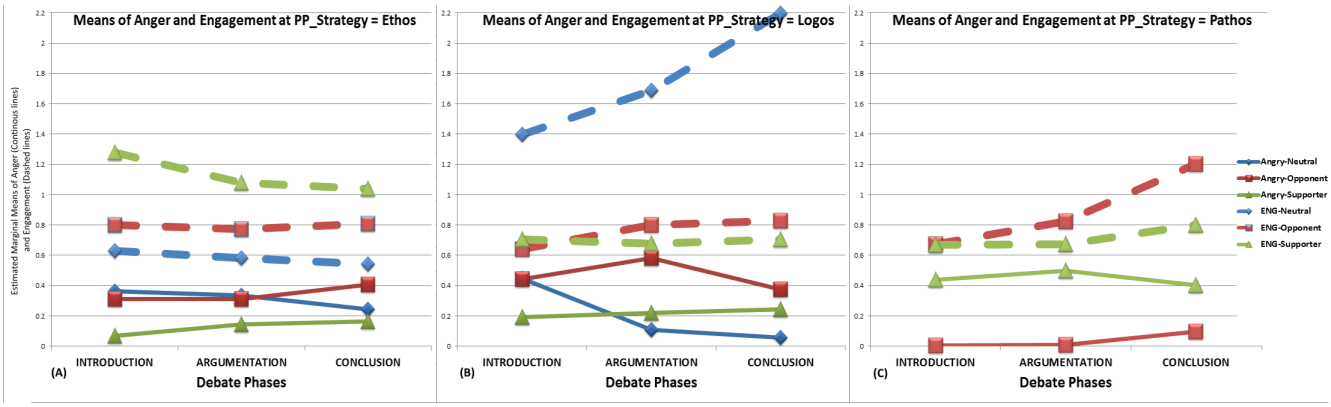

Figure 1: Means of anger (continuous lines) and engagement (dashed lines) (y axis) by debates' phases (x axis) for the different persuasion strategies. Blue, red and green colors correspond, respectively, to the participants' final position (Neutral, Opponent, and Supporter) to PP's opinion.

while their negative emotion is the lowest through the debate phases compared to other participants, indicating their satisfaction towards the expert's opinion.

For the Pathos strategy (Fig. 1-C), there are no neutral participants. We have opponents with increasing engagement related to the resistance to the emotional examples proposed by the PP. They were suppressing their negative emotion elicited by the Pathos strategy so their anger is low. Supporters were affected by Pathos, so their negative emotions are higher and their engagement is lower compared to the opponents because of the emotional effect of this strategy.

H2 - Brain solicitation vs. strategies

To verify the second hypothesis, we compute the differences in terms of engagement of each brain region for each participant, running a repeated ANOVA measure. The goal is to measure the effect of persuasion strategies on the engagement of each participant, considering both the different brain lobes that are activated, and the debate phases (the latter is the *within-subject* factor). As *between-subjects factors*, we consider the strategies and the brain lobes. Considering the resulting correlations among the strategy applied and the brain lobes activated in the participants in the different phases of the debate, we found $F(1.243, 30.683)$=4.495 and p=0.027. The factor Deb_phases has a significant effect on the participant's engagement. We also have a significant interaction of the factors $Deb\_phases * PP\_strategy$ with $F(2.486, 30.683)$=4.059 and p=0.012, meaning a significant effect on engagement[5]. The between-subject effects results show that there is a significant main effect of $PP\_strategy$ on the engagement, $F(2, 148)$=3.885, p=0.023.

For the Logos strategy, the most activated brain region is the parietal. Fig. 2-(B) shows that there is a significant difference between the INTRO and ARG phases for the parietal, which is the most activated lobe. By looking at the simple effect comparison, we found that the only significant mean difference is of parietal engagement between the ARG and INTRO phases with the Logos strategy (Mean difference= .115, p = .019). This result was unexpected, as we know that the frontal lobe is normally in charge of the planning, and rational decisions. By analyzing Logos arguments, we find that the PP used examples to justify her point of view, and imagination, residing in the parietal lobe, was triggered.

For the Ethos strategy, we have found that the parietal region was also activated. Looking at Fig. 2-(A), we see that the engagement in the parietal is high in the INTRO phase and decreases in the ARG phase. By looking at the simple effect comparison, we found that the only significant mean difference is of parietal engagement between the ARG and INTRO phases with the Ethos strategy (Mean difference = $-.174$, p = .024). For the CONC phase, the engagement remains similar to the ARG phase both with the Logos and Ethos strategies. Engagement is related to the resistance towards the persuader's arguments: the more there is a resistance, the more there is engagement. For the Ethos strategy, as the PP is assimilated to an expert, the engagement is decreasing in the ARG phase. Parietal lobes play a role in interpreting sensory information and orientation, meaning that the participant tries to establish new rules to take decisions. Recent studies discuss the correlation between this region and the process of decision making (Huk and Meister 2012), and other studies have shown the role of right temporal-parietal junction for thinking about thoughts, e.g., people's belief, desires and emotions (Saxe and Wexler 2005).

For the Pathos strategy, the PP tried to induce empathy in participants. This resulted in the generation of strong emotions, and the circuit of emotions starts from the frontal to reach, through the cingulate Cortex, amygdala and hippocampus in the limbic system. The most important difference of engagement between the INTRO and ARG phases is indeed in the frontal lobe (see Fig. 2-(C)). In the simple effect analysis, the mean difference of the frontal engagement between INTRO and ARG with the Pathos strategy is the most important compared to the other brain lobes, even if it is not statistically significant (Mean diff.=0.61, p = 0.332).

[5]Complete SPSS's results: http://bit.ly/2nmbygV.

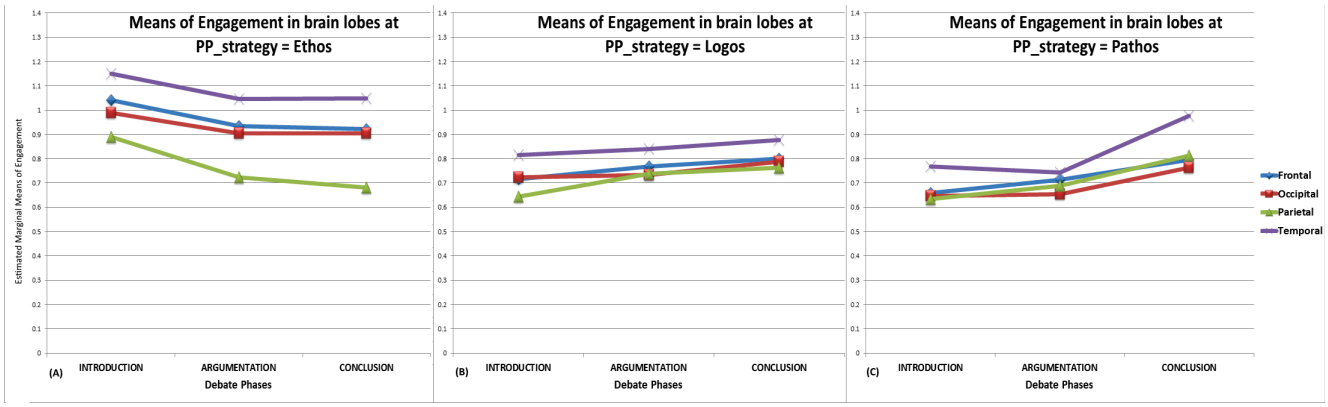

Figure 2: Estimated marginal means of engagements (*y* axis) in brain lobes by debates' phases (*x* axis) for the different persuasion strategies. Blue, red, green and violet lines correspond to the Frontal, Occipital, Parietal and Temporal brain lobes.

H3 - Pathos persuasiveness

We hypothesize (H3) that the Pathos strategy impacts more than the other strategies in terms of persuasive power, and consequently it gathers more support towards the PP's arguments than the others. Table 2 reports about the changes of opinion of participants by comparing their initial opinion, and the final opinion after the debate. Since self-reporting is not predictive (Stock, Guerini, and Pianesi 2016), the table reports also about participants who have changed their opinions but did not disclose this change in the questionnaire.

Debate	Strategy	PP position	P1	P2	P3	P4
DeathPenalty	Pathos	Con	Y	N	N	Y
Torture	Logos	Pro	N	Y	N	*Y*
Suicide	Ethos	Pro	N	N	N	*Y*
Profiling	Logos	Con	N	N	Y	*Y*
Nuclear	Logos	Pro	N	N	N	Y
Religion	Pathos	Con	N	N	*Y*	Y
Vaccines	Logos	Pro	N	N	N	N
GunRights	Ethos	Con	N	N	N	Y
Schools	Logos	Pro	N	N	*Y*	N
Organs	Pathos	Con	N	N	*Y*	*Y*

Table 2: Participants' changes of opinion. Y: an opinion change occurred; N: no change; *underlined*: change from neutral; *italic*: a change not reported by the participant (detected by comparing his initial and after-debate opinions).

To verify this hypothesis, we first need to normalize the number of attacks and supports for each debate wrt. the different strategies. Fig. 3 shows that the number of attacks and supports significantly changes depending on the strategy employed by the PP: Ethos is the strategy leading to the higher percentage of attacks in the argumentation, much more than the Logos and the Pathos strategies, while Pathos is the strategy leading to the higher percentage of supports wrt. the arguments proposed by the PP. Logos is in-between, as it is the most balanced strategy wrt. the percentage of attacks and supports. These results confirmed from the argumentation perspective what we already observed in H1 and

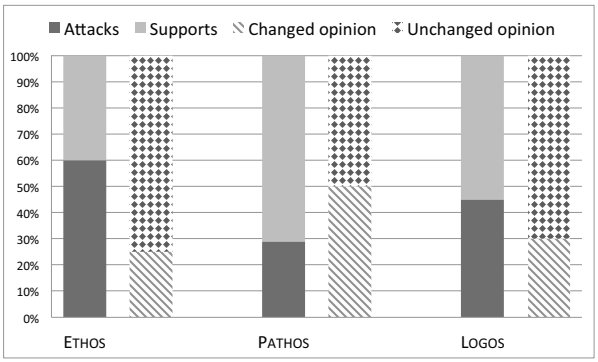

Figure 3: Percentage of attacks and supports for and against PP's arguments (1st columns), and percentage of participants with changed/unchanged opinion (2nd columns).

H2: Pathos leads to the higher empathy leading to more supports than the other strategies. Note that these supports come even from those participants who do not agree with the PP, but they "cannot" attack the Pathos arguments she proposes, so they tend to agree on minor points related to the main topic. Ethos leads to more attacks than Logos: this can be explained by the fact that when an Ethos argument is proposed, the other participants do not evaluate the source as reliable, and tend to attack these arguments asking for evidences. Given that participants do not know each other, this behavior makes sense as authority is assessed by reputation and recommendation, and not only by claims.

The validation of H3 is confirmed by analyzing the percentage of participants who changed/did not change their opinions wrt. the persuasion strategies (see Figure 3). On the one side, Pathos is the most effective strategy wrt. the percentage of participants who actually changed their mind after the debate, in line with the fact that participants tend to support Pathos arguments in the debate. On the other side, Logos and particularly Ethos are the less effective strategies with few participants persuaded by the PP.

Related work

Very few approaches in persuasive argumentation involve humans in the loop. Among them, (Rosenfeld and Kraus 2016) evaluate a methodology for human persuasion through argumentative dialogs, with human users. The huge difference wrt. (Rosenfeld and Kraus 2016) is that we do not analyze the argumentation style, but we capture the emotions and mental states directly on human participants through sensors. In (Benlamine et al. 2015), we studied the connections between emotions and argumentation, but we do not consider persuasion. In (Benlamine et al. 2017), we studied the correlation of the engagement index in brain hemispheres with the persuasion strategies. The difference with H2 is twofold: *i)* here, we provide a more fine grained analysis of the correlation of theengagement wrt. the four lobes instead of the left and right sides, *ii)* we concentrate on the correlation with the persuasion strategies, while in (Benlamine et al. 2017) we correlated with the neutral vs. opinionated (pro/con) stance of the participants. To the best of our knowledge, in neuroscience (Cacioppo, Cacioppo, and Petty 2017), no other work investigates the correlation between persuasive argumentation and mental states captured from users' brain through sensors. Usually, these factors are studied based on questionnaires with the participants.

Conclusions

The main contributions of this paper are: *i)* the first field experiment to study the correlation of persuasion strategies, argumentation and emotions using EEG headsets and cameras, *ii)* an annotated dataset of arguments characterized by a persuasion strategy, and *iii)* the first steps towards the definition of human-like empathic argumentative agents.

The analysis of the results allowed us to highlight some drawbacks of our experimental setting to be addressed: *i)* more fine grained persuasion strategies may be considered, as these categories are highly general and sometimes difficult to be evaluated; *ii)* the strategies adopted by the other participants should be taken into account to expand the scenario (here, to overcome this issue, we consider them as random and we focus on the punctual reactions of the participants to PP's arguments); *iii)* the binary variable (pro/con) expressing the stance of the participants wrt. the debated issue may not fully capture the effect of a strategy, so allowing the expression of degrees of pro/con could be preferable.

Acknowledgments

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