

comparisons ranged from .18 to .76. Figure 2 provides a summary of our quantitative findings for all trials.

4.5.1 Function: Question

A's Dominance and Friendliness. The analyses revealed a main effect of Type on A-Dom ($F(2, 34) = 9.1, p < .001$). As the amount of overlap increased the perceived A's dominance increased (*none*: $M=.48, SE=.04$; *short*: $M=.53, SE=.03$; and *long*: $M=.64, SE=.04$), therefore **H.A-Dom is supported**.

Type also had a main effect on A-Friend ($F(2, 34) = 3.6, p < .05$). In this case an increasing overlap decreased the perceived A's friendliness (*none*: $M=.74, SE=.04$; *short*: $M=.71, SE=.03$; and *long*: $M=.66, SE=.04$), thus the hypothesis **H.A-Friend is supported**.

B's Dominance and Friendliness. We found a main effect of Type on B-Dom ($F(2, 34) = 4.0, p < .05$), therefore **H.B-Dom is rejected**. When the agent interrupted in silence (i.e. no overlap) it was perceived significantly less dominant ($M=.70, SE=.04$) compared to the two other interruption types (*short*: $M=.78, SE=.04$; *long*: $M=.78, SE=.03$).

For friendliness we discovered two main effects of Type ($F(2, 34) = 7.9, p < .005$) and Strategy ($F(1, 17) = 11.9, p < .005$) but no significant interaction effects, thus **H.B-Friend is partially supported**. We decomposed these effects and discovered that in general a cooperative Strategy accounts for higher friendliness ($M=.53, SE=.04$) compared to a disruptive one ($M=.42, SE=.04$). However, when using a disruptive Strategy, the agent was perceived significantly more friendly when interrupting in silence ($M=.53, SE=.05$) in comparison with the other two Types (*short* overlap: $M=.32, SE=.05$; *long*: $M=.39, SE=.04$).

A's Engagement and Involvement. We did not find any significant effect on A-Eng. However, we found a significant interaction effect between Type and Strategy on A-Inv ($F(2, 34) = 4.4, p < .05$). More specifically, when interrupted in silence (i.e. no overlap), A is considered more involved in the interaction when B's strategy is cooperative ($M=.60, SE=.04$) compared to disruptive ($M=.70, SE=.03$).

B's Engagement and Involvement. We found two main effects of Type ($F(2, 34) = 5.5, p < .05$) and Strategy ($F(1, 17) = 17.0, p < .005$) on B-Eng, but no significant interaction effects, thus **H.B-Eng is partially confirmed**. The decomposition of these effects revealed that, in general, B was more engaged when it used the cooperative Strategy ($M=.61, SE=.05$) compared to the disruptive one ($M=.45, SE=.05$). However, when using a disruptive Strategy, it was perceived significantly more engaged when interrupting in silence ($M=.54, SE=.05$) in comparison with the other two Types (*short* overlap: $M=.41, SE=.05$; *long*: $M=.40, SE=.06$).

Strategy had a main effect on B-Inv ($F(1, 17) = 12.5, p = .003$). Cooperative interruptions made B more involved ($M=.59, SE=.04$) than disruptive ones ($M=.40, SE=.06$). Therefore, **H.B-Inv is supported**.

4.5.2 Function: Opinion

A's Dominance and Friendliness. We did not find significant effects on A-Dom (**H.A-Dom rejected**). However, we found a significant interaction effect on A-Friend ($F(2, 34) = 3.8, p < .05$), thus **H.A-Friend is partially supported**. In particular, for silent Type of interruptions

(i.e. A not overlapping), when the other agent interrupted with a cooperative Strategy, A was perceived less friendly ($M=.66, SE=.05$) compared to the case when a disruptive strategy was used ($M=.74, SE=.03$).

B's Dominance and Friendliness. We did not find significant effects on B-Dom (**H.B-Dom rejected**). We found a main effect of Strategy on B-Friend ($F(1, 17) = 54.8, p < .001$), therefore **H.B-Friend is supported**. B was more friendly when doing cooperative interruptions ($M=.52, SE=.04$) compared to disruptive ones ($M=.26, SE=.03$).

A's Engagement and Involvement. No significant effects were found.

B's Engagement and Involvement. We discovered a main effect of Strategy on B-Eng ($F(1, 17) = 26.0, p < .001$) and B-Inv ($F(1, 17) = 23.8, p < .001$), thus **H.B-Eng and H.B-Inv are supported**. In particular, interrupting with a cooperative Strategy led to higher engagement ($M=.46, SE=.04$) and involvement ($M=.46, SE=.04$) compared disruptive ones ($M=.22, SE=.02$ and $M=.23, SE=.04$).

4.5.3 Function: Partner

A's Dominance and Friendliness. We found a main effect of Strategy on A-Dom ($F(1, 17) = 12.8, p < .005$). When B adopted a cooperative Strategy, A was perceived significantly more dominant ($M=.60, SE=.03$) compared to when a disruptive Strategy was used ($M=.55, SE=.03$). Therefore, **H.A-Dom is rejected**. We did not find significant main effects or interactions on A-Friend (**H.A-Friend is rejected**).

B's Dominance and Friendliness. We found a main effect of Type on B-Dom ($F(2, 34) = 5.3, p < .05$), therefore **H.B-Dom is rejected**. B's dominance was significantly higher when A suddenly stopped its utterance in reaction to the interruption (Type=*simple*: $M=.75, SE=.03$), compared to the case where A took a pause in its utterance (Type=*silent*: $M=.67, SE=.03$).

For friendliness (B-Friend) we discovered two main effects of Type ($F(2, 34) = 8.6, p < .005$) and Strategy ($F(1, 17) = 30.8, p < .001$) but no significant interaction effects, thus **H.B-Friend is partially supported**. We decomposed these effects and discovered that for all interruption Types a cooperative Strategy accounts for higher friendliness ($M=.52, SE=.04$) compared to a disruptive one ($M=.27, SE=.03$). However, this effect is more remarked when Type is *silent* (*cooperative*: $M=.62, SE=.05$; *disruptive*: $M=.33, SE=.04$).

A's Engagement and Involvement. No significant effects were found.

B's Engagement and Involvement. The analysis revealed a main effect of Strategy on B-Eng ($F(1, 17) = 30.7, p < .005$) and B-Inv ($F(1, 17) = 15.5, p < .001$), therefore **H.B-Eng and H.B-Inv are supported**. In both cases a cooperative Strategy led to higher B's engagement ($M=.42, SE=.04$) and involvement ($M=.43, SE=.03$) compared to a disruptive one, respectively ($M=.18, SE=.04$) and ($M=.21, SE=.04$).

4.5.4 Function: Topic

For this trial we only found a significant main effect of Type on B-Friend ($F(2, 34) = 7.9, p < .005$). In particular, B's friendliness was significantly higher when A took a pause in its utterance (Type=*silent*: $M=.47, SE=.05$), compared to the other two interruption Types (Type=*overlap*: $M=.38, SE=.03$, Type=*simple*: $M=.35, SE=.03$).

| Function | INTERRUPTEE AGENT (A) | | | INTERRUPTER AGENT (B) | | |
|----------|-------------------------------|---------------------------------------|---|-----------------------------|---|---|
| | Type (↗ <i>overlap</i>) | Strategy (<i>disr. to coop.</i>) | Type AND Strategy (<i>disr. to coop.</i>) | Type (↗ <i>overlap</i>) | Strategy (<i>disr. to coop.</i>) | Type OR Strategy (<i>disr. to coop.</i>) |
| QUESTION | ↗ Dominance ↘ Friendliness | <i>n.s.</i> | ↗ Involvement (when type: <i>no overlap</i>) | ↗ Dominance | ↗ Involvement | ↗ Friendliness ↗ Engagement (particular cases: see Section 4.5.1) |
| OPINION | <i>n.s.</i> | <i>n.s.</i> | ↗ Friendliness (when type: <i>no overlap</i>) | <i>n.s.</i> | ↗ Friendliness ↗ Engagement ↗ Involvement | <i>n.s.</i> |
| PARTNER | <i>n.s.</i> | ↗ Dominance | <i>n.s.</i> | ↗ Dominance | ↗ Engagement ↗ Involvement | ↗ Friendliness (more remarked when type: <i>no overlap</i>) |
| TOPIC | <i>n.s.</i> | <i>n.s.</i> | <i>n.s.</i> | ↘ Friendliness | <i>n.s.</i> | <i>n.s.</i> |

Figure 2: Summary of results for all functions examined. IVs are listed in the header. Inclined arrows indicate effects directions for the DVs in the cells. In the QUESTION trial, for example, changes in interruption Type (an increasing ↗ *overlap*) decreased A’s perceived Friendliness ↘. For OPINION, by changing interruption Strategy from *disruptive* to *cooperative* B’s perceived Engagement increased ↗.

5. DISCUSSION AND FUTURE WORK

Type and strategy of interruption had main and interaction effects on the mutual attitudes of the agents. Contrary to our expectations, type had greater importance compared to strategy on user’s perceived dominance and friendliness of both A (interruptee) and B (interrupter).

In the “Question” trial, A’s dominance increased (and friendliness decreased) as the amount of overlap with B increased. B was perceived less dominant during silent interruption types. This would suggest that no matter how disruptive/cooperative is a question, the amount of overlap between interactants has higher impact on users’ perception of their dominance and friendliness.

For “Opinions” (i.e. disagreement vs. agreement), strategy had greater impact but only on friendliness. In particular, a cooperative strategy increases B’s friendliness. However, for A this effect also depended on the type of interruption (i.e. *silent*). When B used a cooperative strategy in silent type interruptions, A’ friendliness decreased and vice-versa for disruptive ones. We think that B has been perceived very hostile while placing a disruptive strategy (strong disagreement), making A looking more friendly in comparison. The lack of differences in dominance levels can be explained by the tendency of opinions (i.e. A’s utterance when interrupted was “It tells an amazing story. . .”) to elicit a (dis) agreement, thus both strategies seemed appropriate.

In the “Partner Communication” trial, B’s strategy had effects on A’s dominance (B’s disruptive strategy led to lower A’s dominance compared to the cooperative one), whereas the type had impact on B’s dominance as found in other trials. The first outcome can be explained by the notion introduced in [22] about complementarity of interpersonal attitudes in dyads, and stating that dominant behavior induces submissive responses.

Strategy had an effect on B’s level of friendliness (more friendly when cooperative). In particular, this effect was more pronounced when the interruption happened after A’s silence.

As for the engagement and involvement assessments, A’s engagement was never influenced by B’s interrupting behavior. Even if A stopped/continued its utterance in reaction. A’s involvement was influenced by type and strategy only in the “Question” trial. A possible explanation is that a misunderstanding/clarification question is the only interruption in

this study that can reveal something about A’s quality of interacting. In the “Question”, “Opinion”, and “Partner Communication” trials cooperative strategies led to higher B’s engagement and involvement levels compared to disruptive ones. This reflects the nature of cooperative interruptions as less face-threatening compared to disruptive ones [18], and displays of joint involvement [14].

The overall lack of significant effects in the “Topic” trial (except for a main effect of type on B’s friendliness) can be explained by difficulties in capturing differences among the stimuli, as also reported by participants’ feedback (6 out of 18).

In sum, the **turn-taking** mechanism (i.e. **type** of **interruption**) had more impact on the users’ perception of **interpersonal attitudes** of both agents, though changing from a disruptive to a cooperative strategy increased interrupter’s friendliness and reduced its dominance. We believe that for silent interruption types, when no overlap occurred, the content of the interrupter’s utterances became more noticeable, thus increasing the effect of the two different strategies. On the other hand, the **strategy** had important main effects on **engagement** and **involvement** of the interrupter. These results have implications for the design of autonomous conversational agents that can be interrupted and can interrupt human users in a mixed-initiative incremental dialogue. When a cooperative interruption occurs, for example, the agent’s mental model of the user (i.e. *Theory of Mind*) can be updated with the perceived user’s intention of being friendly and subsequent agent’s communicative intents can be (re)planned and adapted accordingly.

Future work should be considered. In human-human interaction personal characteristics such as the gender and status of the interactants can play a role in their interruption behavior [36, 4]. While we kept such variables stable in our study, they form interesting concepts to be considered in future work on interruptions in human-agent interaction. We also kept important factors, such as the timing of the interruption, constant across conditions to avoid further biases. However, we believe that manipulating the moment when the interruption occurs during the interruptee’s turn might reveal interesting outcomes on the perceived interrupter’s attitude. Finally, we are working on an agent able to manage interruptions (i.e. implementing different handling strategies in response to a user’s interruption) or proactively interrupt the user by deploying a specific interruption strategy.

Acknowledgments

This work was supported by the European project H2020 ARIA-VALUSPA and the French ANR project MOCA. It was partially performed within the Labex SMART (ANR-11-LABX-65) supported by French state funds managed by the ANR within the Investissements d’Avenir programme under reference ANR-11-IDEX-0004-02.

REFERENCES

- [1] M. Argyle. *Bodily communication*. Methuen, New York, 2nd ed. edition, 1988.
- [2] M. Aylett and C. Pidcock. The cerevoice characterful speech synthesiser sdk. In C. Pelachaud, J.-C. Martin, E. André, G. Chollet, K. Karpouzis, and D. Pelé, editors, *Intelligent Virtual Agents*, volume 4722 of *Lecture Notes in Computer Science*, pages 413–414. Springer Berlin Heidelberg, 2007.
- [3] B. S. Bamallem, A. J. Wodehouse, G. M. Mair, and G. A. Vasantha. The impact of head movements on user involvement in mediated interaction. *Computers in Human Behavior*, 55, Part A:424 – 431, 2016.
- [4] G. W. Beattie. Interruption in conversational interaction, and its relation to the sex and status of the interactants*. *Linguistics*, 19(1-2):15–36, 1981.
- [5] J. V. Bradley. Complete counterbalancing of immediate sequential effects in a latin square design. *Journal of the American Statistical Association*, 53(282):525–528, 1958.
- [6] J. K. Burgoon and J. L. Hale. The fundamental topoi of relational communication. *Communication Monographs*, 51(3):193–214, 1984.
- [7] J. Cassell. *Embodied conversational agents*. MIT press, 2000.
- [8] N. Crook, D. Field, C. Smith, S. Harding, S. Pulman, M. Cavazza, D. Charlton, R. Moore, and J. Boye. Generating context-sensitive eca responses to user barge-in interruptions. *Journal on Multimodal User Interfaces*, 6(1-2):13–25, 2012.
- [9] N. Crook, C. Smith, M. Cavazza, S. Pulman, R. Moore, and J. Boye. Handling user interruptions in an embodied conversational agent. In *Proceedings of the AAMAS International Workshop on Interacting with ECAs as Virtual Characters, Toronto*, pages 27–33, 2010.
- [10] N. Ferguson. *Interruptions: speaker-switch nonfluency in spontaneous conversation*. PhD thesis, University of Edinburgh, 1975.
- [11] D. C. Funder, R. M. Furr, and C. R. Colvin. The riverside behavioral q-sort: A tool for the description of social behavior. *Journal of Personality*, 68(3):451–489, 2000.
- [12] N. Glas and C. Pelachaud. Definitions of engagement in human-agent interaction. In *Workshop on Engagement in Human Computer Interaction (ENHANCE) at ACII 2015*, pages 944–949, 2015.
- [13] N. Glas and C. Pelachaud. User engagement and preferences in information-giving chat with virtual agents. In *Workshop on Engagement in Social Intelligent Virtual Agents (ESIVA) at IVA 2015*, pages 33–40, 2015.
- [14] J. A. Goldberg. Interrupting the discourse on interruptions: An analysis in terms of relationally neutral, power-and rapport-oriented acts. *Journal of Pragmatics*, 14(6):883–903, 1990.
- [15] A. Gravano and J. Hirschberg. A corpus-based study of interruptions in spoken dialogue. In *INTERSPEECH, 13th Annual Conference of the International Speech Communication Association*, pages 855–858, 2012.
- [16] C. W. Kennedy and C. T. Camden. A new look at interruptions. *Western Journal of Communication (includes Communication Reports)*, 47(1):45–58, 1983.
- [17] S. C. Levinson. *Pragmatics (Cambridge textbooks in linguistics)*. Cambridge University Press, 1983.
- [18] H. Z. Li. Cooperative and intrusive interruptions in inter-and intracultural dyadic discourse. *Journal of Language and Social Psychology*, 20(3):259–284, 2001.
- [19] M. Lombard and T. Ditton. At the heart of it all: The concept of presence. *Journal of Computer-Mediated Communication*, 3(2):0–0, 1997.
- [20] M. Lombard, T. B. Ditton, D. Crane, B. Davis, G. Gil-Egui, K. Horvath, J. Rossman, and S. Park. Measuring presence: A literature-based approach to the development of a standardized paper-and-pencil instrument. In *Third international workshop on presence, delft, the netherlands*, volume 240, 2000.
- [21] M. T. Maat, K. P. Truong, and D. Heylen. How turn-taking strategies influence users’ impressions of an agent. In J. Allbeck, N. Badler, T. Bickmore, C. Pelachaud, and A. Safonova, editors, *Intelligent Virtual Agents*, volume 6356 of *Lecture Notes in Computer Science*, pages 441–453. Springer Berlin Heidelberg, 2010.
- [22] P. M. Markey, D. C. Funder, and D. J. Ozer. Complementarity of interpersonal behaviors in dyadic interactions. *Personality and Social Psychology Bulletin*, 29(9):1082–1090, 2003.
- [23] H. J. Mazeland. *Inleiding in de conversatieanalyse*. Coutinho, 2003.
- [24] K. Murata. Intrusive or co-operative? a cross-cultural study of interruption. *Journal of Pragmatics*, 21(4):385–400, 1994.
- [25] S. H. Ng, M. Brooke, and M. Dunne. Interruption and influence in discussion groups. *Journal of Language and Social Psychology*, 14(4):369–381, 1995.
- [26] I. Poggi. *Mind, hands, face and body: a goal and belief view of multimodal communication*. Weidler, 2007.
- [27] B. Ravenet, A. Cafaro, B. Biancardi, M. Ochs, and C. Pelachaud. Conversational behavior reflecting interpersonal attitudes in small group interactions. In W.-P. Brinkman, J. Broekens, and D. Heylen, editors, *Intelligent Virtual Agents*, volume 9238 of *Lecture Notes in Computer Science*, pages 375–388. Springer International Publishing, 2015.
- [28] E. A. Schegloff. Accounts of conduct in interaction: Interruption, overlap, and turn-taking. In *Handbook of sociological theory*, pages 287–321. Springer, 2001.
- [29] E. A. Schegloff. *Sequence organization in interaction: Volume 1: A primer in conversation analysis*, volume 1. Cambridge University Press, 2007.

- [30] W. C. Schutz. *FIRO: A Three-dimensional Theory of Interpersonal Behaviour*. Rinehart books in the assessment of personality. Holt, Rinehart and Winston, 1958.
- [31] C. L. Sidner, C. Lee, C. D. Kidd, N. Lesh, and C. Rich. Explorations in engagement for humans and robots. *Artificial Intelligence*, 166(1):140–164, 2005.
- [32] D. Tannen. Gender differences in topical coherence: Creating involvement in best friends’ talk. *Discourse Processes*, 13(1):73–90, 1990.
- [33] K. R. Thórisson, O. Gislason, G. R. Jonsdottir, and H. T. Thorisson. A multiparty multimodal architecture for realtime turntaking. In *Intelligent Virtual Agents*, pages 350–356, 2010.
- [34] J. S. Wiggins, P. Trapnell, and N. Phillips. Psychometric and geometric characteristics of the revised interpersonal adjective scales (ias-r). *Multivariate Behavioral Research*, 23(4):517–530, 1988.
- [35] J. Youngquist. The effect of interruptions and dyad gender combination on perceptions of interpersonal dominance. *Communication Studies*, 60(2):147–163, 2009.
- [36] D. H. Zimmermann and C. West. Sex roles, interruptions and silences in conversation. *Amsterdam Studies in the Theory and History of Linguistic Science Series 4*, pages 211–236, 1996.