

EFFICIENT COMMUNICATION THROUGH ATTENTIVE SPEAKING

Hendrik Buschmeier & Stefan Kopp

Social Cognitive Systems Group · CITEC · Bielefeld University

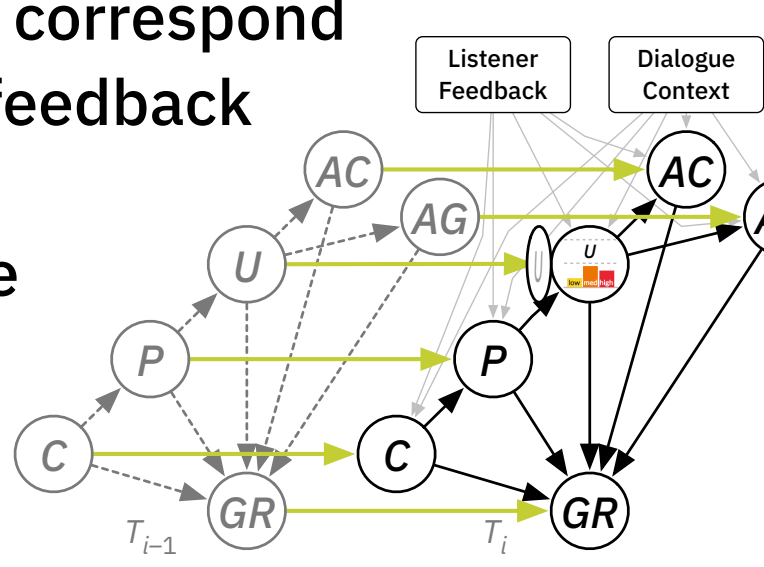
FEEDBACK & ATTENTIVE SPEAKING

Communicative listener feedback is an important coordination mechanisms for efficiently reaching understanding in dialogue. Based on feedback, speakers reason about listeners' mental state of listening and adapt ongoing utterances to their needs.

A computational model of attentive speaking:

Feedback interpretation as listener state attribution (Buschmeier & Kopp, SemDial 2012/2014)

- Listening-related mental states correspond to communicative functions of feedback (perception, understanding, ...)
- Tracking the user's mental state with a dynamic Bayesian network, which represents the *attributed listener state (ALS)*



Adaptive behaviour generation

- Decisions in dialogue management can be based on ALS
- Incrementally adaptive natural language generation, using ALS (Buschmeier et al., SigDial 2012)

Feedback elicitation cue generation

- Feedback is elicited based on the agent's information needs (Buschmeier & Kopp, IVA 2014)

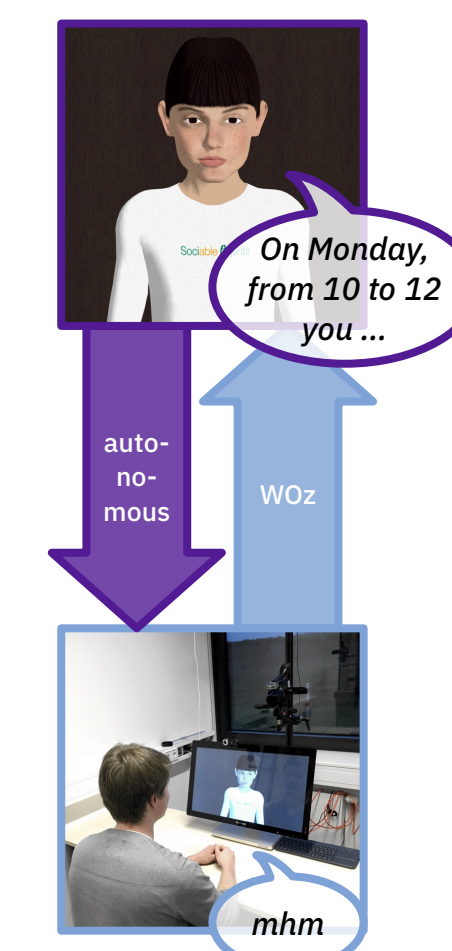
INTERACTION STUDY

¿Do participants reach understanding with an attentive speaker agent more efficiently than with conversational agents that are not attentive to their interlocutors' needs?

Information presentation task (calendar)
Semi-autonomous Wizard-of-Oz paradigm

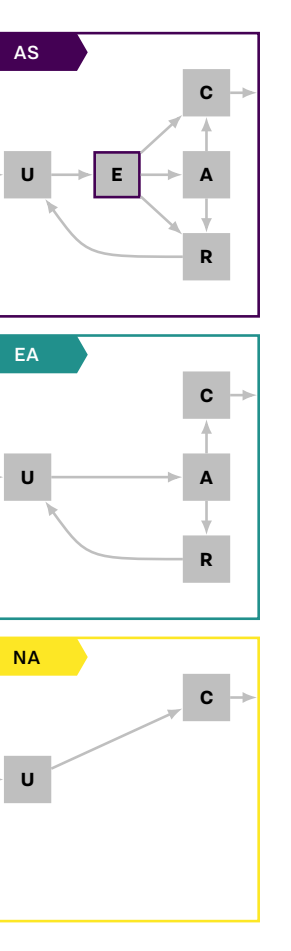
- Wizard observes participants and 'annotates' feedback in real-time
- Attentive speaker agent autonomously processes feedback, adapts its behaviour, and produces feedback elicitation cues

Instruction: participants *can* only provide feedback, the agent *may* take this information into account in its own behaviour



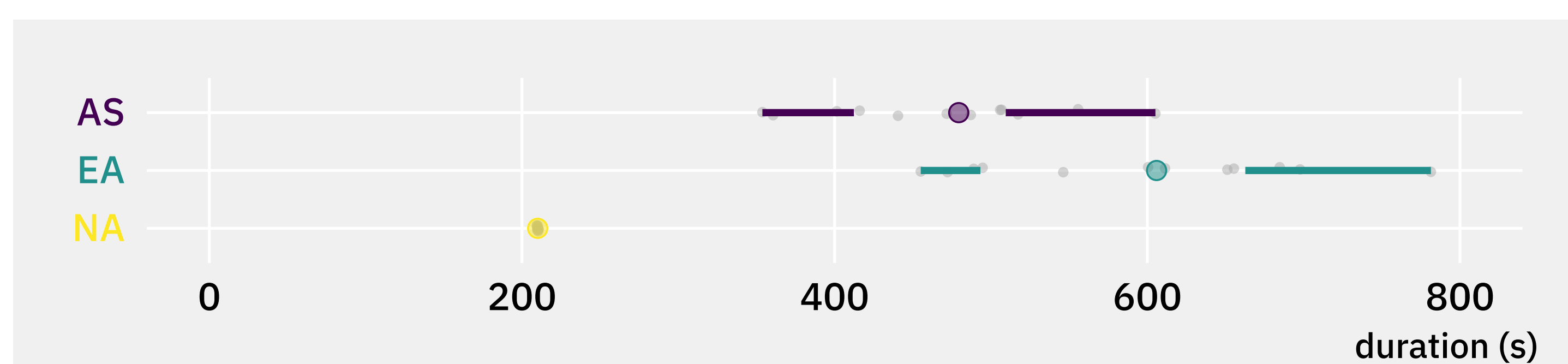
Three exp. conditions (between subject)

- AS: attentive speaking**
 - AS-models, ask if uncertain, target
- EA: explicit asking**
 - ignore feedback, always ask, upper-bound control
- NA: no adaptation**
 - ignore user, lower-bound control



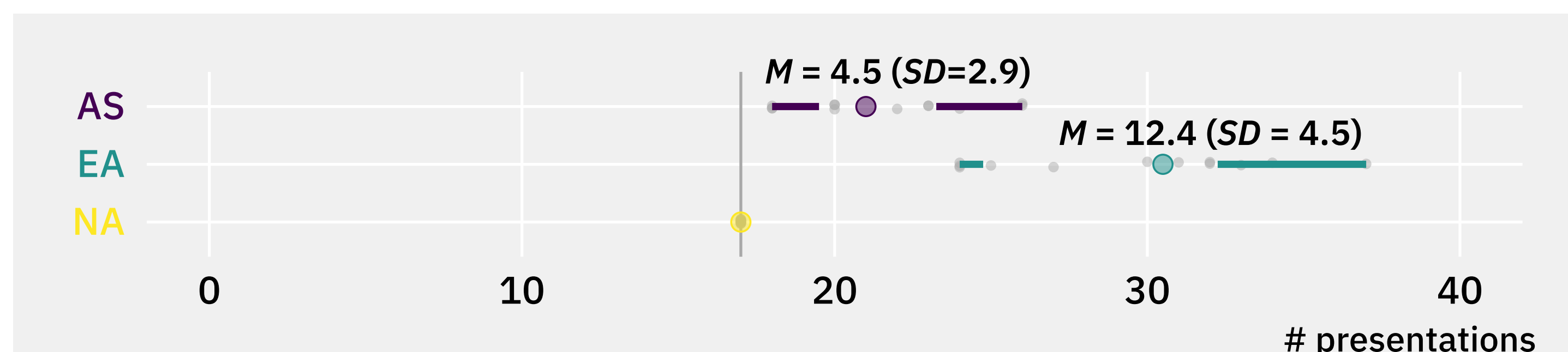
QUALITY OF THE INTERACTION

Costs of interacting (duration, number of presentations/repetitions) with the 'attentive speaker agent' fall in between the two baseline conditions (**NA** < **AS** < **EA**).



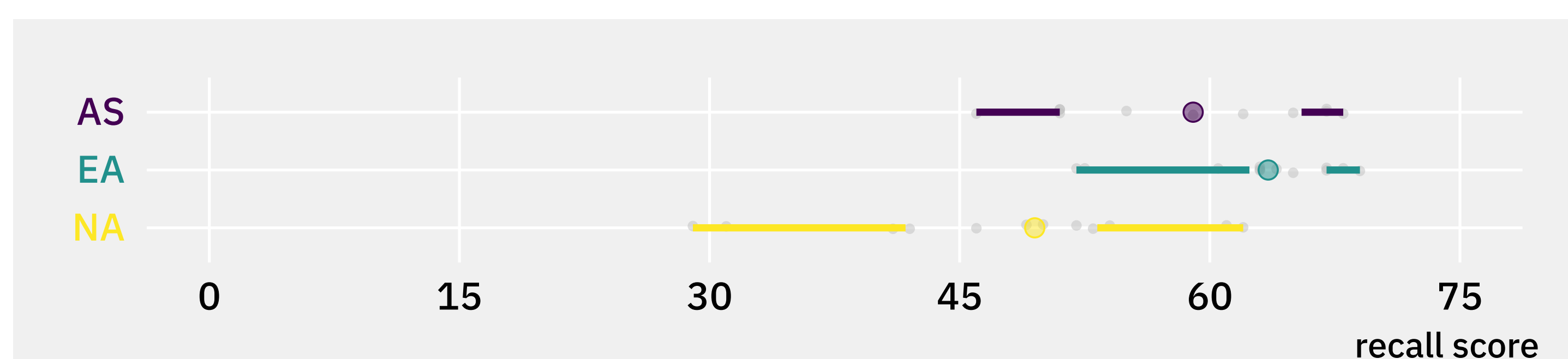
BayesFactor ANOVA: BF10 = 3.8e10, 'decisive'

Post-hoc BayesFactor t-tests with default prior ('medium'-scaled, $r = 0.707$):
– AS<NA: BF<0 = 28.3, 'strong'
– AS<EA: BF<0 = 1.5e8, 'decisive'
– NA<EA: BF<0 = 8.4e8, 'decisive'
– NA<AS>EA: BFR0 = 2.3e11, 'decisive'



BayesFactor t-tests with default prior ('medium'-scaled, $r = 0.707$): AS<EA: BF<0 = 892.9, 'decisive'

Participants' performance (understanding in terms of recall) when interacting with the 'attentive speaker agent' also falls in between the two baseline conditions (**NA** < **AS** < **EA**).



BayesFactor ANOVA: BF10 = 160.7, 'decisive'

Post-hoc BayesFactor t-tests with default prior ('medium'-scaled, $r = 0.707$):
– AS>EA: BF>0 = 4.7, 'substantial'
– AS>NA: BF>0 = 1.5e8, 'decisive'
– EA>NA: BF>0 = 261.7, 'decisive'
– EA>AS>NA: BFR0 = 849.3, 'decisive'

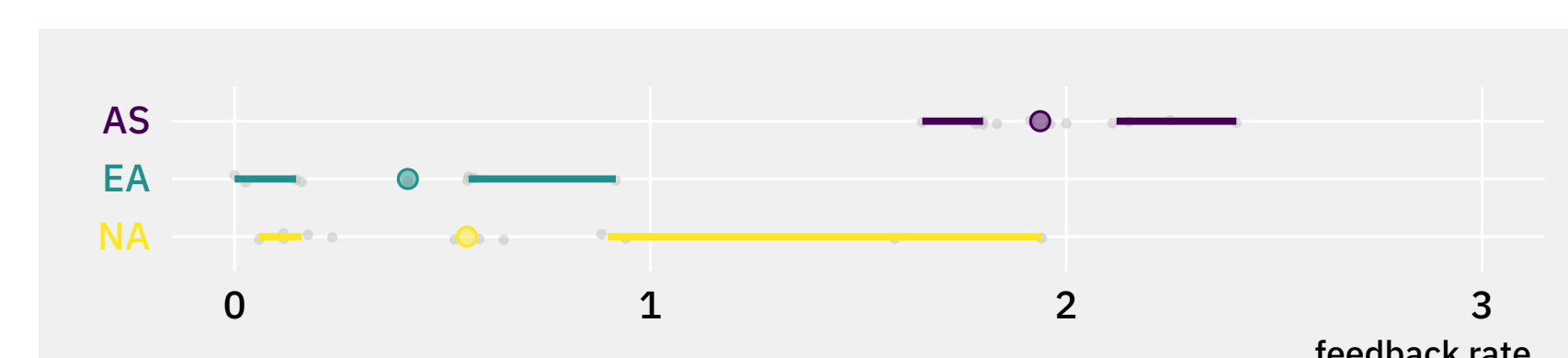
Interactions with the attentive speaker agent (**AS**) were more efficient (ratio of performance/duration [presentations]) than interactions in condition **EA** (factor 1.18 [1.28]), but less efficient than interactions in condition **NA** (factor 0.55 [0.98]).

BayesFactor ANOVA: BF10 = 1.6e7, 'decisive'

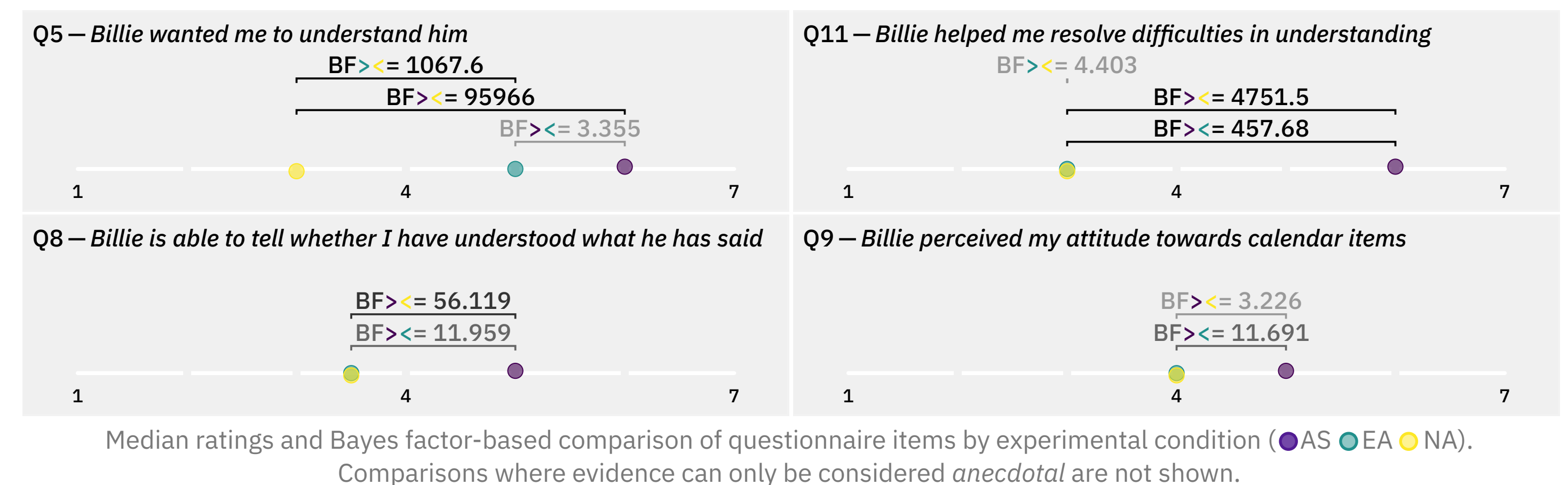
Post-hoc BayesFactor t-tests with default prior ('medium'-scaled, $r = 0.707$):
– AS>EA: BF>0 = 4.7, 'substantial'
– AS>NA: BF>0 = 1.5e8, 'decisive'
– NA>EA: BF>0 = 2.5e5, 'decisive'

REACTIONS & PERCEPTION

Participants provided more, natural feedback to the 'attentive speaker' than to the baselines.



Participants more strongly attested the attentive speaker agent a desire to be understood, agreed more that it helped them in resolving difficulties in understanding, and clearly noticed that it had the ability to interpret their communicative feedback behaviour.



Median ratings and Bayes factor-based comparison of questionnaire items by experimental condition (● AS ● EA ● NA). Comparisons where evidence can only be considered *anecdotal* are not shown.

CONCLUSIONS

- Taking user feedback into account in human-agent interaction and adapting to it makes communication more efficient than when explicitly ensuring users' understanding.
- Not adapting was even more efficient, but found to be less helpful and cooperative.

→ Being able to speak *attentively* can be regarded an important step towards natural, smooth, and efficient interaction with artificial conversational agents.

FURTHER READING

- Buschmeier, H. (2018). *Attentive Speaking. From Listener Feedback to Interactive Adaptation*. PhD thesis, Bielefeld University, Bielefeld, Germany. <http://doi.org/10.4119/unibi/2918295>
- Buschmeier, H. & Kopp, S. (2018). Communicative listener feedback in human-agent interaction: artificial speakers need to be attentive and adaptive. In *Proceedings of the 17th International Conference on Autonomous Agents and MultiAgent Systems*, pp. 1213–1221 Stockholm, Sweden.

