

Cognitive Planning for Persuasive Multimodal Interaction

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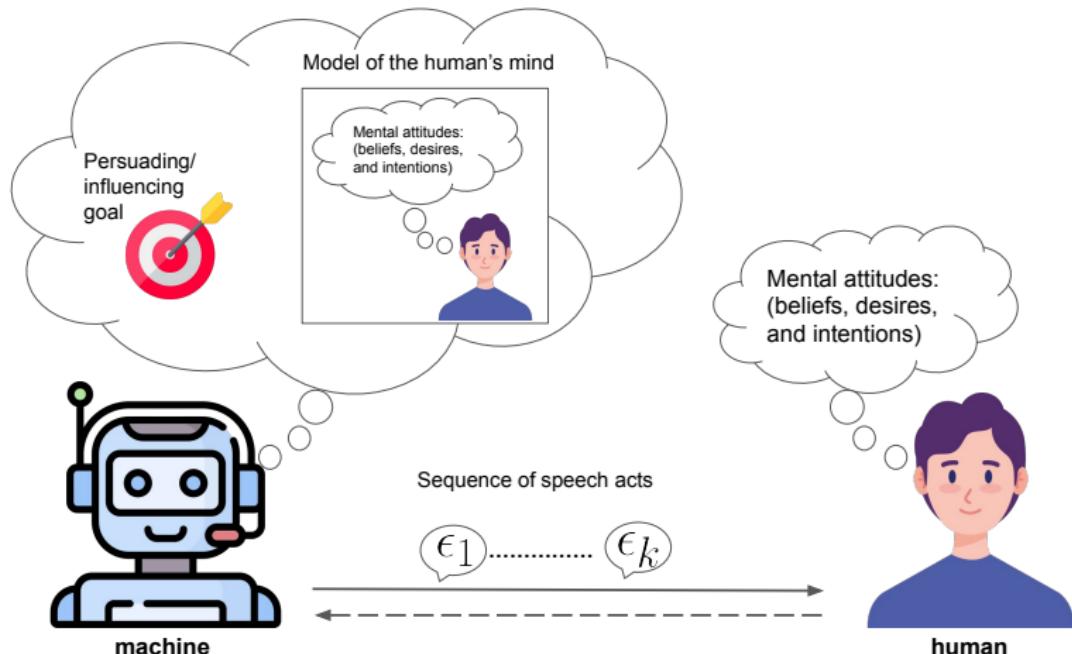
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EMAS 2024

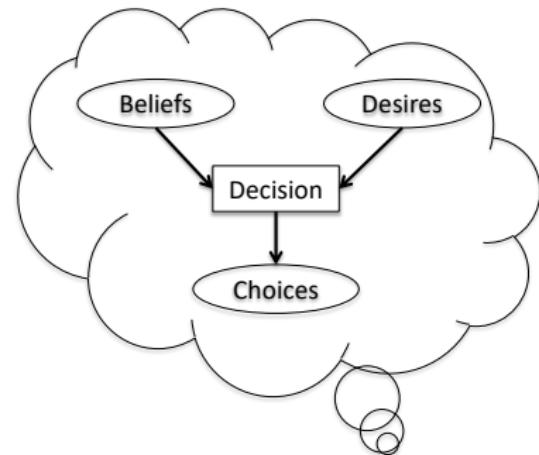
Cognitive planning (in one picture)



Cognitive planning for persuasion and influence

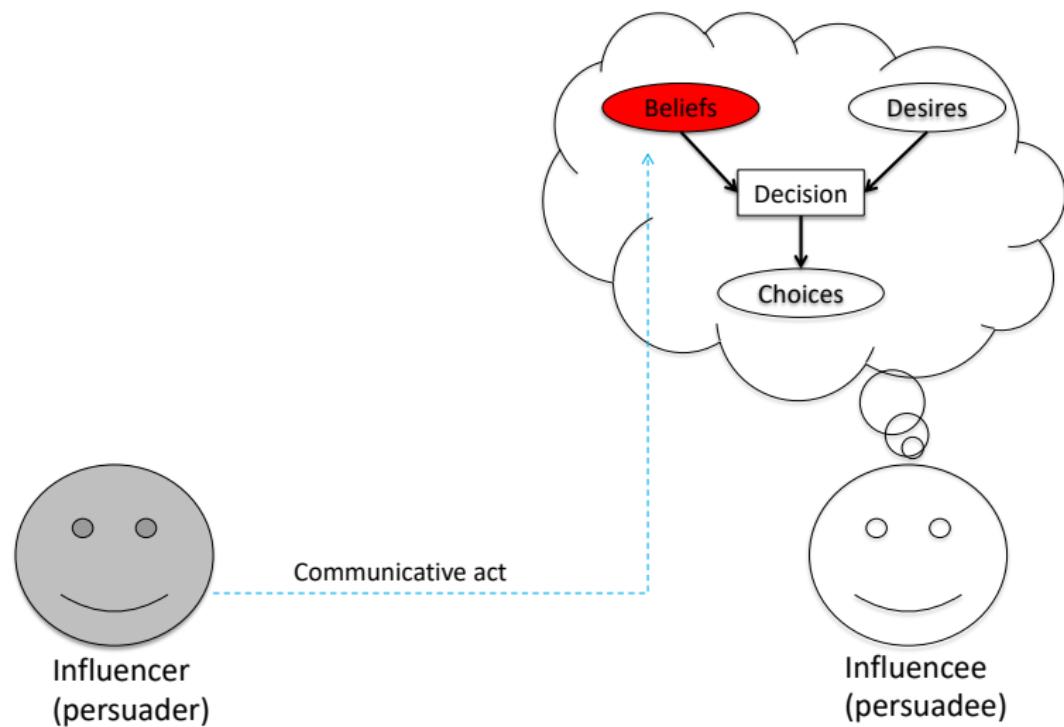


Influencer
(persuader)

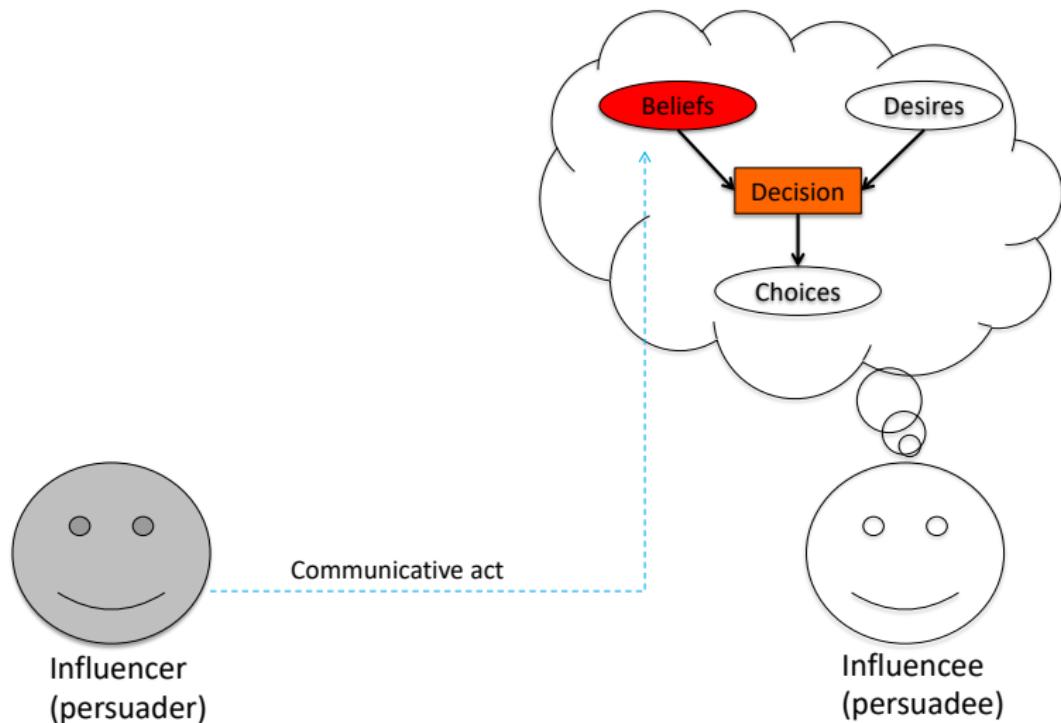


Influencee
(persuadee)

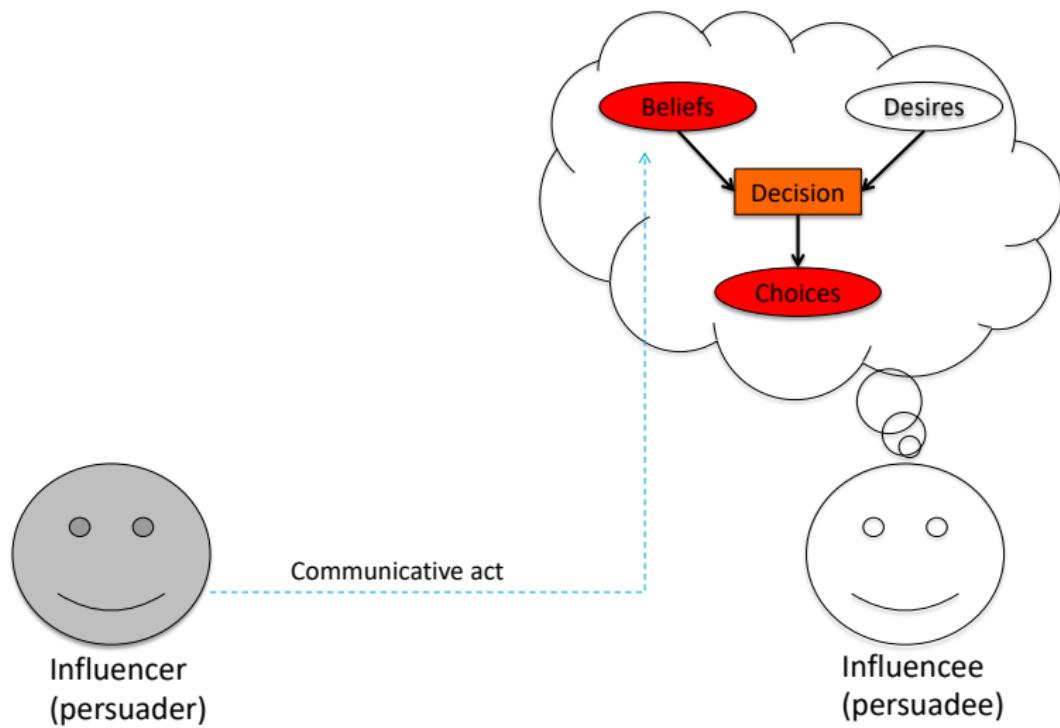
Cognitive planning for persuasion and influence



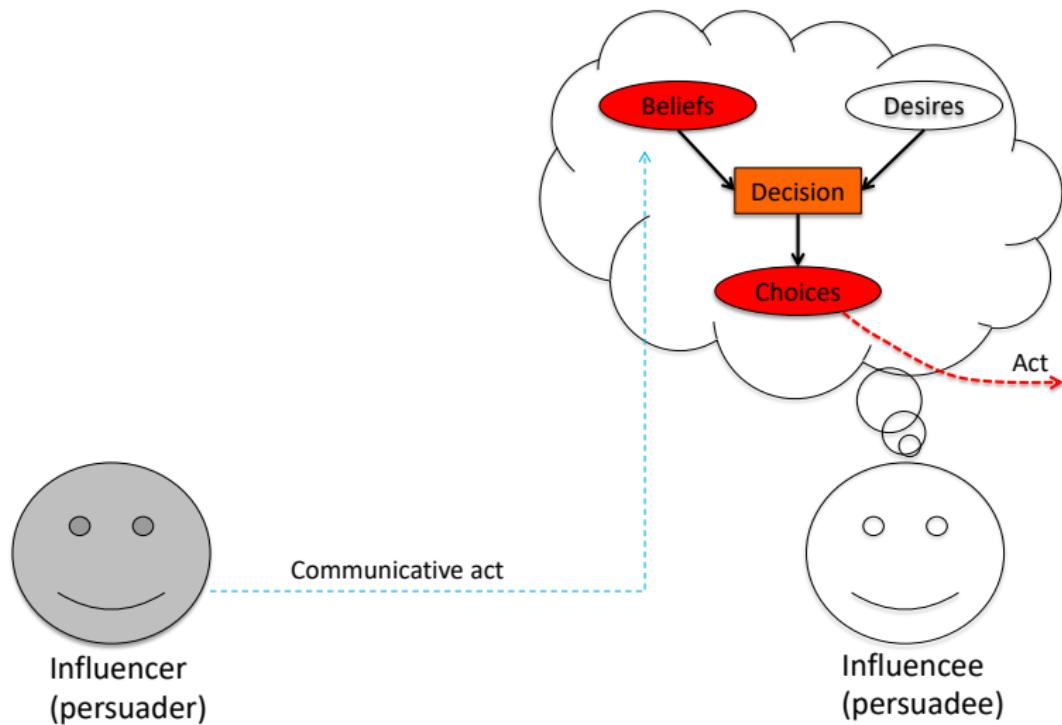
Cognitive planning for persuasion and influence



Cognitive planning for persuasion and influence



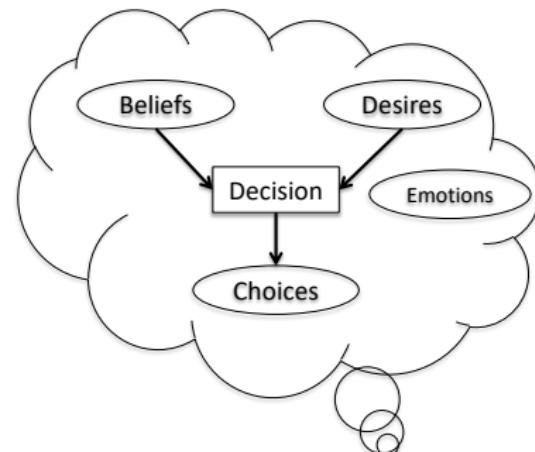
Cognitive planning for persuasion and influence



Adding emotions to the picture

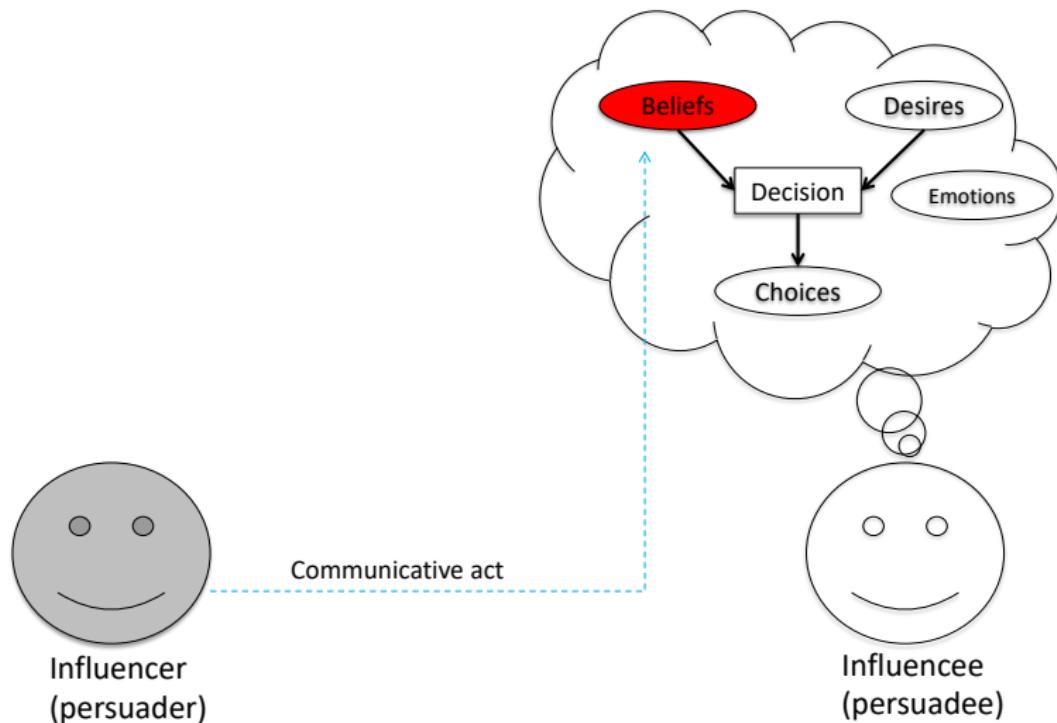


Influencer
(persuader)

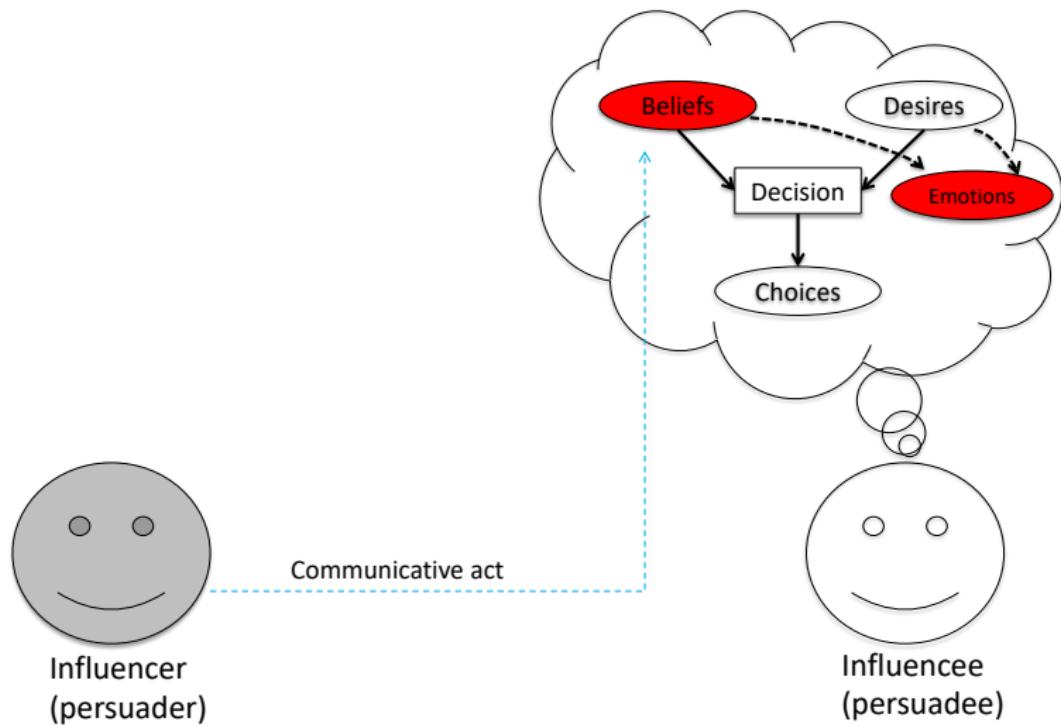


Influencee
(persuadee)

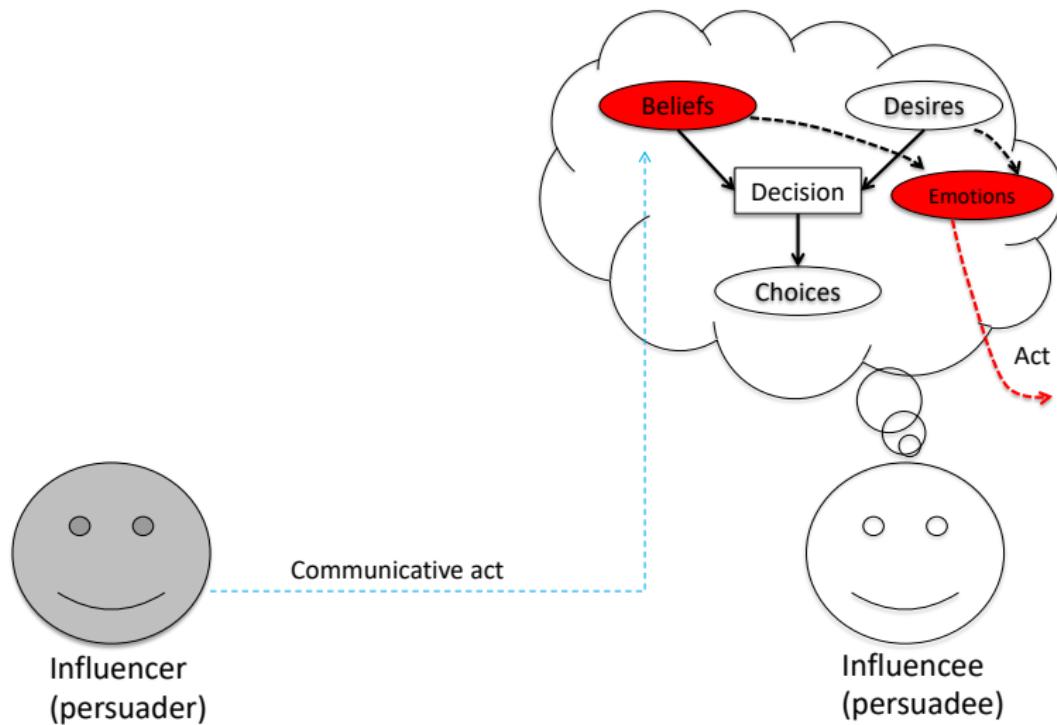
Adding emotions to the picture



Adding emotions to the picture



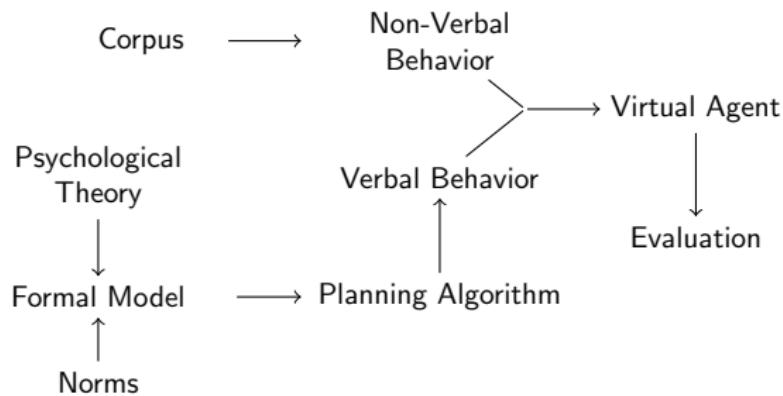
Adding emotions to the picture



Example of the emotion circuit

- ▶ Rob induces Ann to escape by triggering the fire alarm
- ▶ Causal chain:
 1. Rob triggers the fire alarm
 $\xrightarrow{\text{cause}}$ Ann believes that her life is in danger
 2. Ann believes that her life is in danger and desires to be alive
 $\xrightarrow{\text{cause}}$ Ann feels fearful
 3. Ann's fear
 $\xrightarrow{\text{cause}}$ Ann's escape reaction

Cognitive planning in H-M multimodal interaction: a methodology



Case study: ANR project CoPains 2019-2024
(<https://www.irit.fr/CoPains/>)

Formal specification

- ▶ **Logical language** for representing
 - ▶ the agent's **theory of** the human interlocutor's **mind**
 - ▶ the **cognitive planning** problem
 - ▶ beyond classical and epistemic planning
 - ▶ aimed at changing/affecting the human's overall cognitive state
- ▶ **Logic-based algorithms:** cognitive planning, belief revision

Fernandez Davila, J., Longin, D., Lorini, E., Maris, F. (forthcoming). Logic-based Cognitive Planning for Conversational Agents. *JAAMAS*.

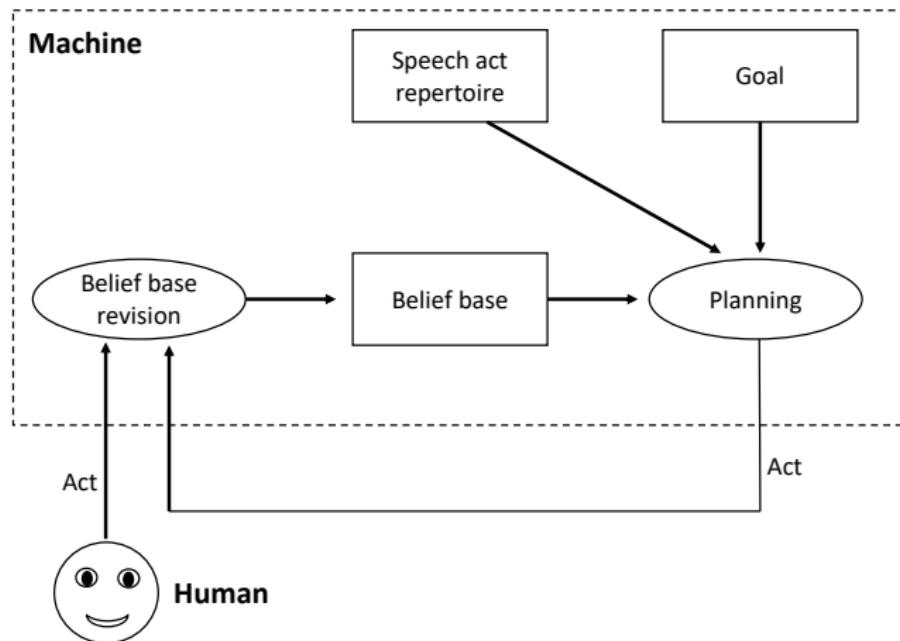
Fernandez Davila, J. L., Longin, D., Lorini, E., Maris, F. (2021). A Simple Framework for Cognitive Planning. In *Proceedings of AAAI-21*, pp. 6331-6339.

NP-complete language

- ▶ One modality for the human (\mathfrak{h})
 - ▶ $\Delta_{\mathfrak{h}}$: explicit belief
- ▶ Two modalities for the machine (\mathfrak{m})
 - ▶ $\Delta_{\mathfrak{m}}$: explicit belief
 - ▶ $\square_{\mathfrak{m}}$: implicit belief
- ▶ Interpreted using a **belief base semantics** [Lorini, AAAI-18, AIJ 2020]
- ▶ Polysize reduction of satisfiability into SAT

$$\mathcal{L} \xrightarrow{\text{tr}_1} \mathcal{L}_{\text{Mod}} \dashrightarrow^{\text{tr}_2} \mathcal{L}_{\text{Prop}}$$

Agent architecture



Cognitive planning algorithms

- ▶ Brute force SAT-based
- ▶ Reduction into TQBF

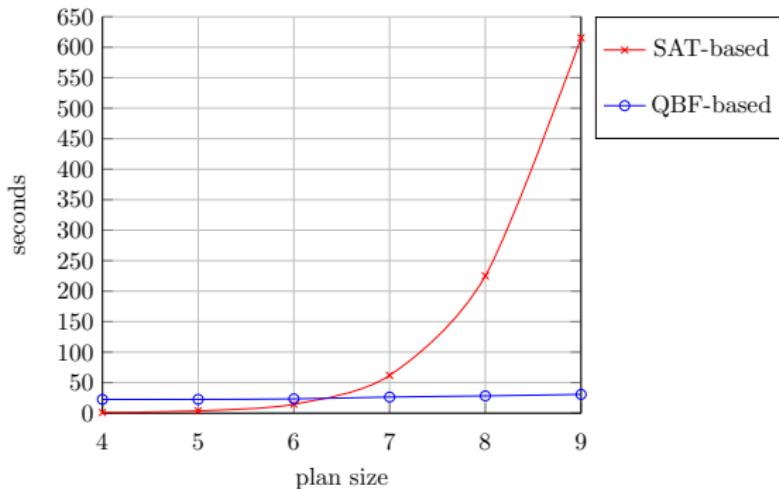


Figure: Computation times for SAT-based and QBF-based approach

Psychological theory

- ▶ **Motivational interviewing (MI)**: counseling method used in clinical psychology for eliciting behavior change [Miller & Rollnick, 2012]
- ▶ Beliefs to be induced to elicit behavior change
 - ▶ **Belief about inconsistent behavior**: the target believes that its actual behavior is inconsistent with its desires
 - ▶ **Self-efficacy belief**: the target believes that it has the capabilities and potential to change its behavior

Psychological theory

Speaker	Utterance	Speech act
m	Do you practice a sport regularly?	? _{m,h} does(h,ps)
h	I don't	+ _m $\neg\Delta_h$ does(h,ps)
m	Do you wish to be in good health?	? _{m,h} des(h,gh)
h	Yes	+ _m Δ_h des(h,gh)
m	Do you spend quite some time in the traffic everyday as a commuter?	? _{m,h} co
h	Yes	+ _m Δ_h co
m	Do you have an office work?	? _{m,h} ow
h	Yes	+ _m Δ_h ow
m	You spend quite some time in the traffic everyday as a commuter and you have an office work. Therefore, your life style is sedentary!	! _{m,h} ($\emptyset, \{co,ow\}, sl$)
m	Your life style is sedentary. Therefore, you will not satisfy your desire to be in good health unless you practice a sport regularly!	! _{m,h} ($\{gh\}, \{sl\}$, does(h,ps))

Figure: Example of human-machine dialogue

Lorini, E., Sabouret, N., Ravenet, B., Fernandez Davila, J., Clavel, C. (2022). Cognitive Planning in Motivational Interviewing. In *Proceedings of ICAART 2022*, pp. 508-517.

Application

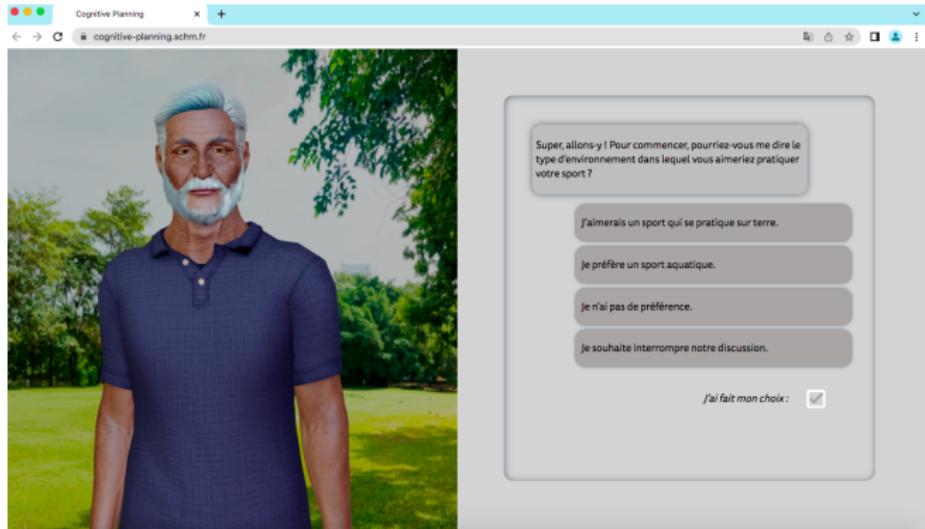


Figure: Conversational agent motivating the user to practice a regular physical activity (<https://cognitive-planning.schm.fr/>)

Non-verbal behavior

- ▶ No well-established theory of non-verbal persuasive communication which clearly identifies the persuasiveness of behavioral signals
- ▶ Necessity of **corpus-based** analysis and **machine learning** methods

Non-verbal behavior

1. Persuasive Opinion Multimedia (POM) corpus [Park et al., 2014]
2. Train a classifier to predict persuasiveness of a facial expression
3. Use trained classifier to evaluate the importance of each group of features in determining persuasiveness
4. Use a convolution-based method to automatically transform a neutral facial expression into a persuasive one

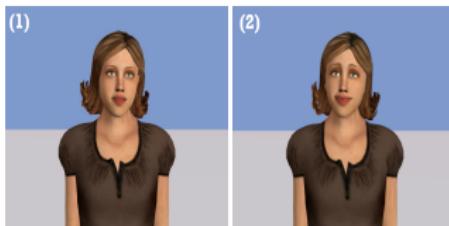


Figure: Neutral expression (1) transformed into a persuasive one (2)

Cherni, A., Bertrand, R., Ochs, M. (2024). Be persuasive! Automatic transformation of virtual agent's head and facial behavior. In *Proceedings of ICAART 2024*.