Models of Anticipatory Thinking

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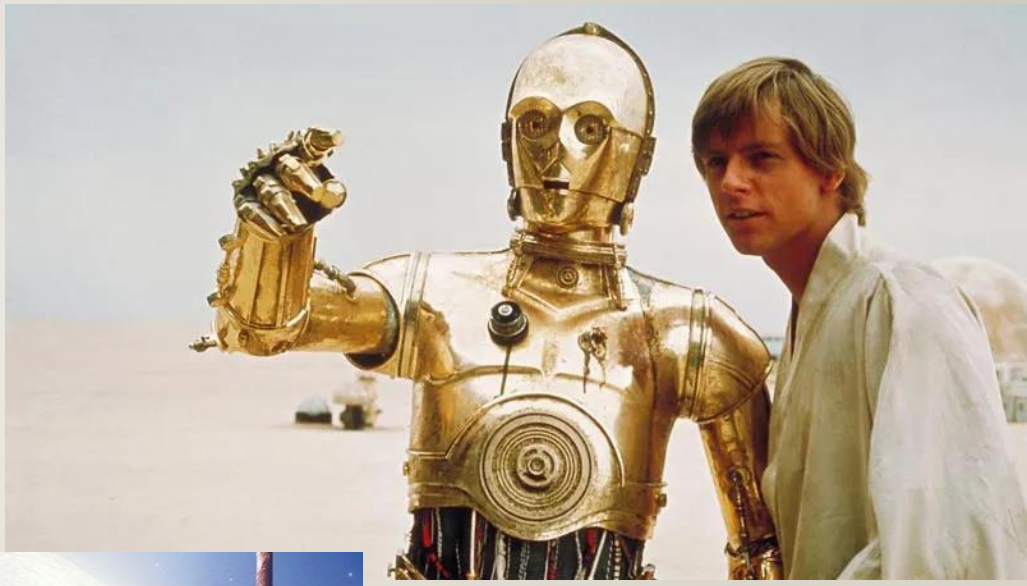
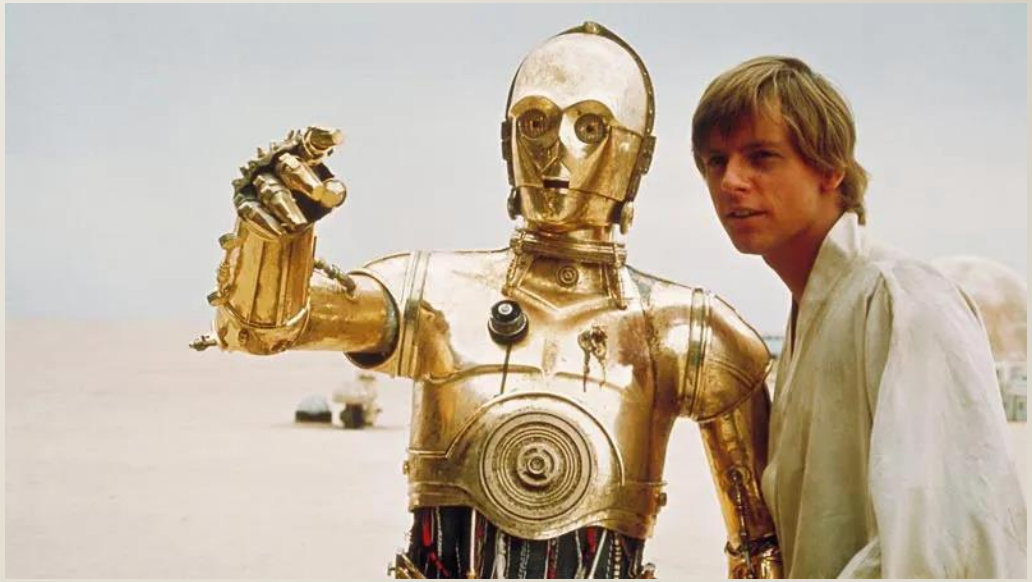
WHERE ARE THE INTELLIGENT INTERACTING PARTNERS?



CHALLENGES OF HUMAN AWARE AI (KAMBHAMPATI, 2012)

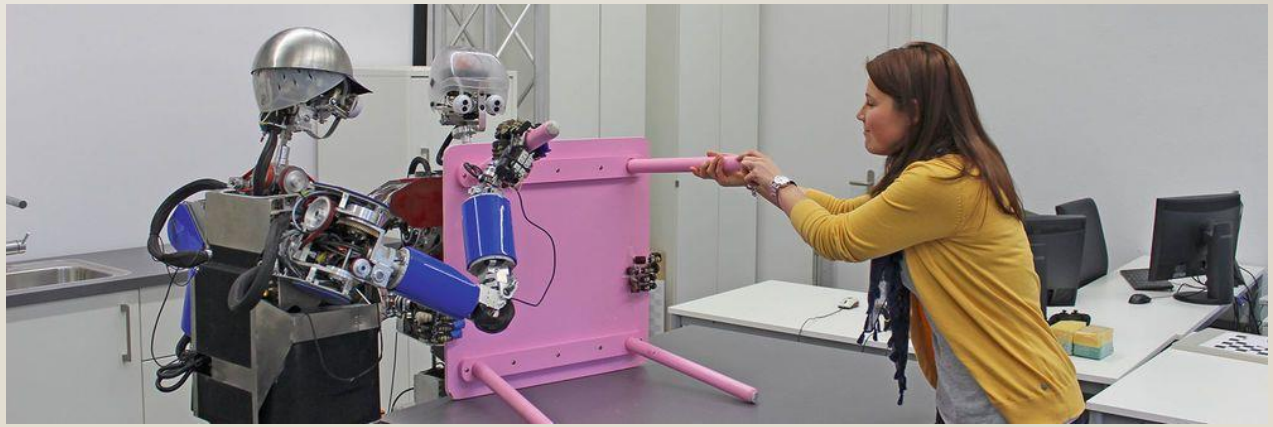
- Human-Aware AI Systems— goal-directed autonomous systems that are capable of effectively interacting, collaborating, and teaming with humans.
- *Challenges in designing such human-aware AI systems, include*
  - *modeling the mental states of humans-in-the-loop and*
  - *Recognizing their desires and intentions,*
  - *providing proactive support,*
  - *Exhibiting explicable behavior,*
  - *giving cogent explanations on demand, and*
  - *Engendering trust.*



WHAT CAN COGNITIVE MODELLING DO FOR INTELLIGENT SYSTEMS?

"**What can cognitive architectures do for robotics?** "(Kurup & Lebiere, 2012)

1. Represent, Integrate and Use Large Amounts of Knowledge
2. Learning and Recognizing Instances of Known or Familiar Patterns
3. Problem Solving & Reasoning – Not all situations are familiar or similar enough to previous situations to directly benefit from previous episodes.
4. Flexible, Adaptive, Dynamic, and Real-time Behavior – Robust real-world behavior cannot be pre-programmed. It requires flexibility.
5. Interact with Humans in a Natural Way



ANTICIPATORY THINKING (GARRY KLEIN ET AL., 2007)

- Anticipatory thinking is a critical macrocognitive function of individuals and teams.
- It is the ability to prepare in time for problems and opportunities.
- Distinguishes from prediction because anticipatory thinking is functional—people are preparing themselves for future events, not simply predicting what might happen.
- It is aimed at potential events including low-probability high threat events, not simply the most predictable events.
- Anticipatory thinking includes active attention management—focusing attention on likely sources of critical information.

MODELS OF ANTICIPATORY THINKING

- It‘s not a model how a person works on a task. It is the ability to anticipate another person working on a task.
- Reduce to the max: What are the most relevant information sources to identify e.g. a dangerous situation?
- Tracing the human partner in the task (only relevant parts)
- What details are less relevant?
- Flexibility to adapt to situation development

EXAMPLES

- In interactive situations, additional information is provided through actions of the partner, feedback, expressions of mental state (facial expressions, EEG, Heartrate, careful or less carful decisions, a.s.o), these can be used to confirm or reject assumption about the hypothesized cognitive state of the partner.

1. Neuro Cognitive Assistance (Klaproth et al., 2019)
2. "Integrated models of cognitive and physical human-robot interaction"

    - What is anticipated?
    - What is the focus of the model?
    - What is the simplest way to approach this?
    - What details are not part of the model?

Cognitive Models for Intelligent Interfaces in the Cockpit

KModyS
TU Berlin

Further cooperation partners:

Prof. Thorsten Zander
(Brandenburg University of Technology)
Laurenz Kroll (TU Berlin)

Christoph Vernaleken
& Inge Wenzel (Airbus)

zander laboratories

AIRBUS CR&T

AIRBUS
Classic Cockpit Operations

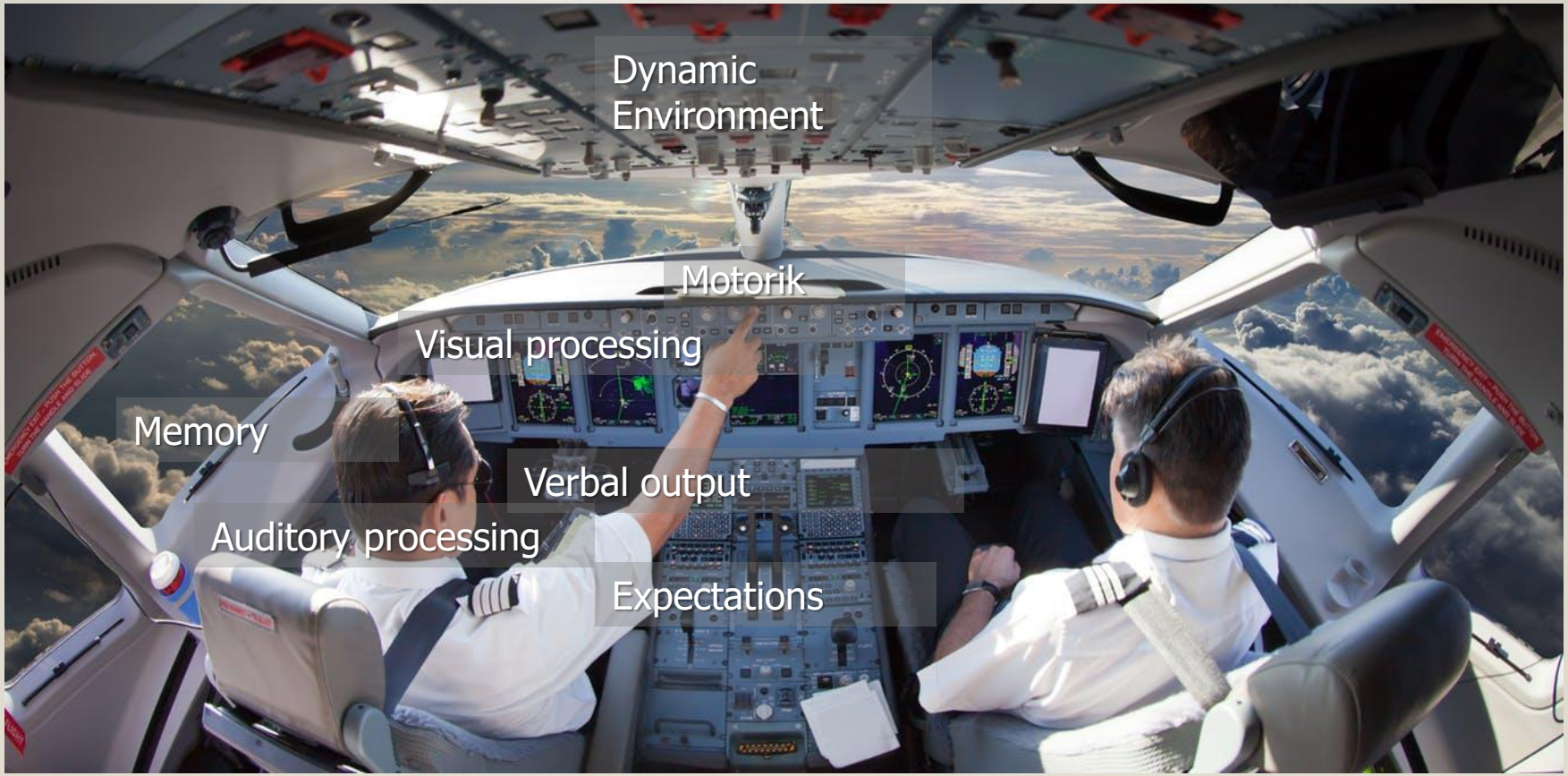
Oliver Klaproth

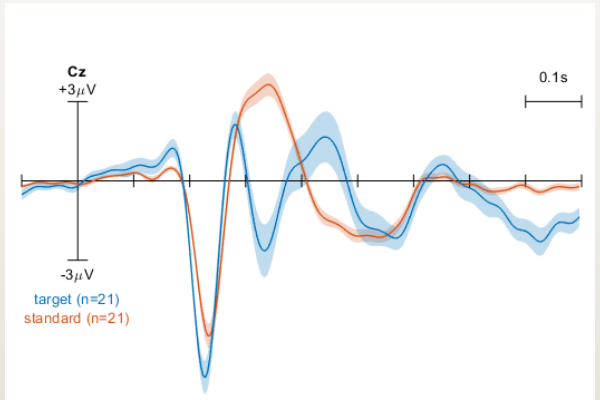
Klaproth, O.W., Halbrügge, M., Krol, L.R., Vernaleken, C., Zander, T.O., & Russwinkel, N. (2020), A Neuroadaptive Cognitive Model for Dealing With Uncertainty in Tracing Pilots' Cognitive State. Topics in Cognitive Science, 12(3), 1012-1029. doi:10.1111/tops.12515

Klaproth, O.W., Vernaleken, C., Krol, L.R., Halbrügge, M., Zander, T.O., & Russwinkel, N. (2020). Tracing Pilots' Situation Assessment by Neuroadaptive Cognitive Modeling, Frontiers in Neuroscience, 10.3389/fnins.2020.00795, 14, (2020).

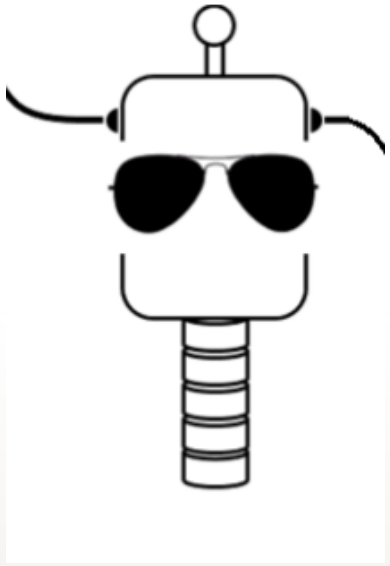
COMPLEX HUMAN MACHINE INTERACTION

The largest proportion of pilot errors is due to incorrect perception (70.3%) and understanding of the situation (20.3%) (Jones & Endsley, 1996).





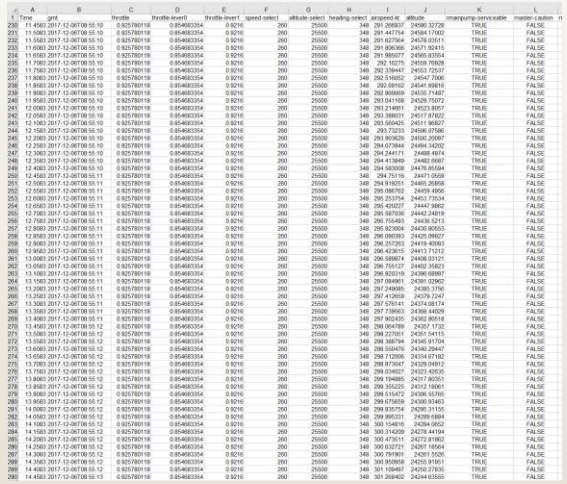
Aleatory uncertainty



Hierarchical Task Analysis

Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7
Fly scenario						
	0. Manage speed during climb and cruise					
		0.1. Monitor selected speed				
		0.2. Monitor ground speed				
		0.3. Monitor altitude				
		0.4. Adjust thrust lever accordingly				
	1. Handle fuel pump alert					
		1.1. Hear alert				
		1.2. Read warning				
		1.3. Press master caution/master warning				
		1.4. Go through pump failure checklist				
			1.4.1. Right main fuel pump OFF			
			1.4.2. X-Feed-Valve ON			
			1.4.3. Gravity X-Flow ASS REQ.			
		1.5. Validate by checking fuel display				
	2. Handle TCAS					
		2.1. Hear Callout "Traffic Traffic"				
		2.2. Prepare for manual maneuver				
			2.2.1. Grab throttle			
			2.2.2. Grab Sidestick			
		2.3. Spot orange dot on Nav/MiniNav				
		2.4. See dot turn white				
		2.5. Take hands off of sidestick and throttle				
	3. Handle engine failure					
		3.1. Hear warning				
		3.2. Press master caution/master warning				
		3.3. Go through engine fire checklist				
			3.3.1. Right thrust lever to IDLE			
			3.3.2. Right engine master switch to OFF			
			3.3.3. Engine fire push button to off			
				3.3.3.1. Open switch guard		
				3.3.3.2. PRESS button		
			3.3.4. Wait for 10 seconds			
			3.3.5. DISCHARGE fire extinguishing agent #1			
			3.3.6. Wait for 30 seconds			
			3.3.7. DISCHARGE fire extinguishing agent #2			
		3.4. Go through follow-up checklist opens				
			3.4.1. Rudder trim			
			3.4.2. Engine mode to ignition			
			3.4.3. Open crossfeed valve (overhead)			
			3.4.4. Shut down right generator			
			3.4.5. TCAS Mode change			
	4. Handle fuel imbalance					
		4.1. Notice fuel imbalance early on				

Cognitive model



Epistemic uncertainty

DATA SOURCES

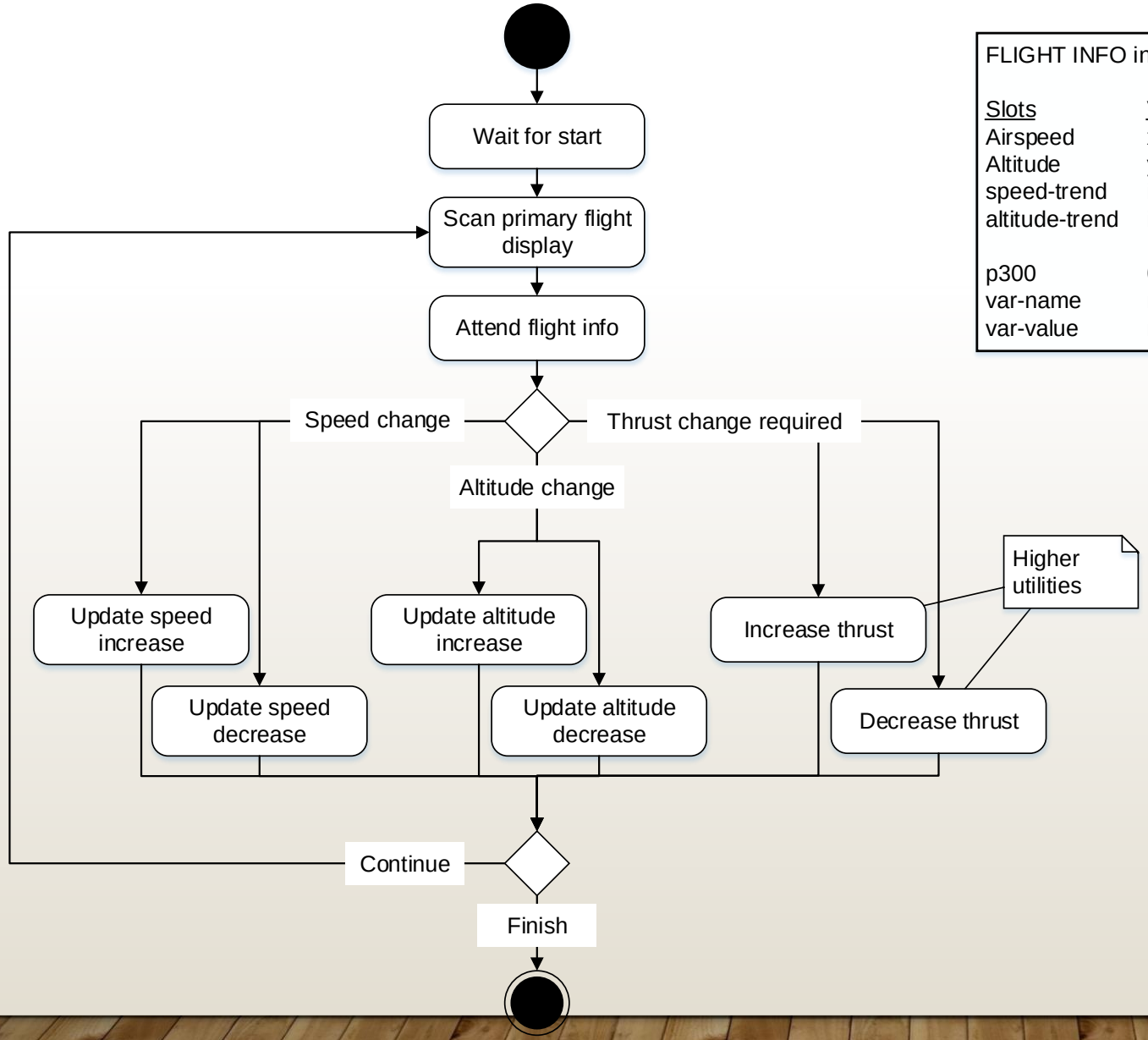
The model is based on task analysis an integrated information out of cockpit protocols…. and EEG Data of the pilot

21 Vps ~18 min Scenario incl. ~10-14 acustic warnings

Experimental cockpit simulator (A320-like)

Cockpit instrument logs recorded with 20hz

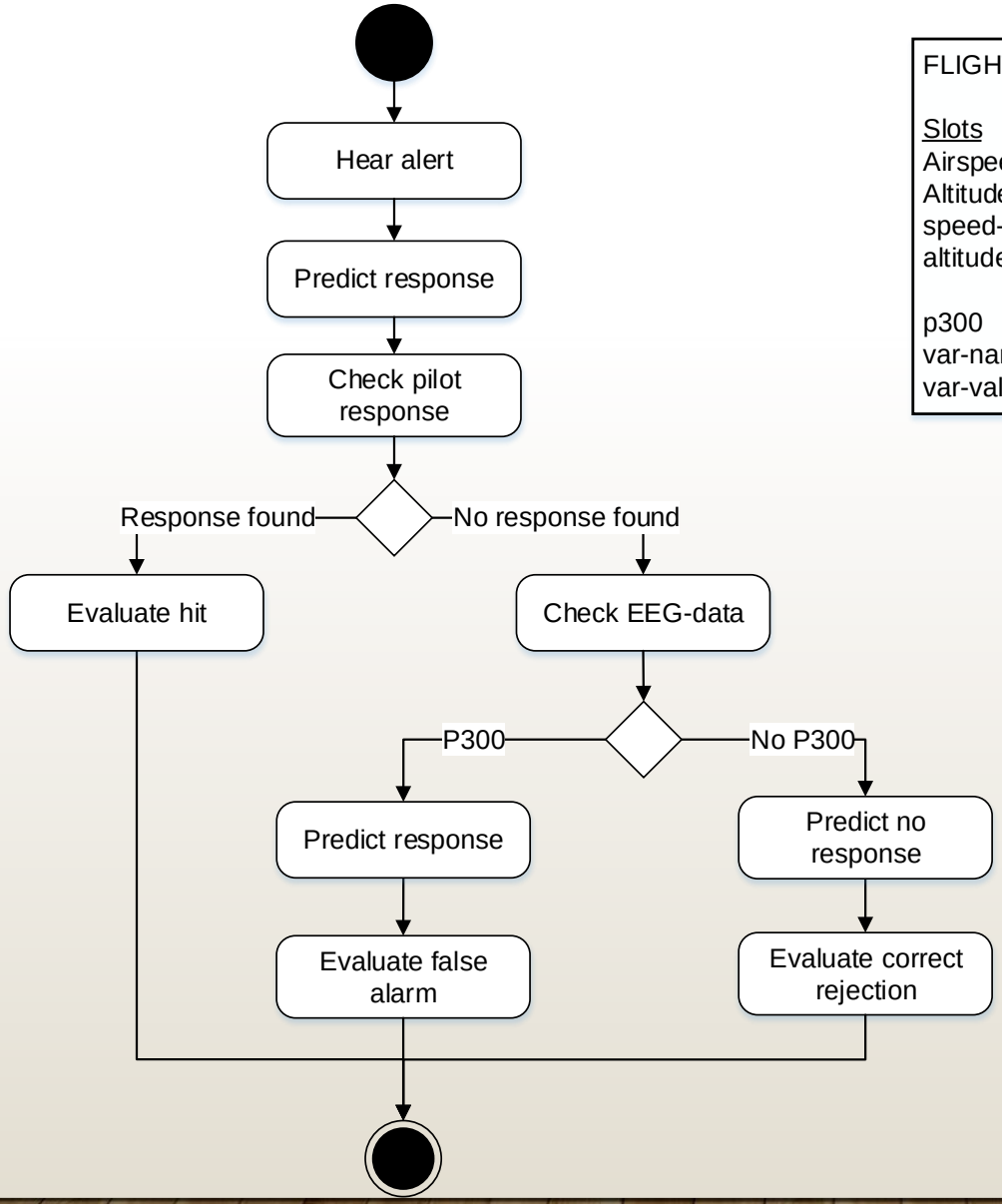
COGNITIVE PILOT MODEL



FLIGHT INFO in imaginal buffer

Slots	Values
Airspeed	x knots
Altitude	y feet
speed-trend	incr./decr.
altitude-trend	incr./decr.
p300	0/1
var-name	response (where)
var-value	response (what)

COGNITIVE PILOT MODEL



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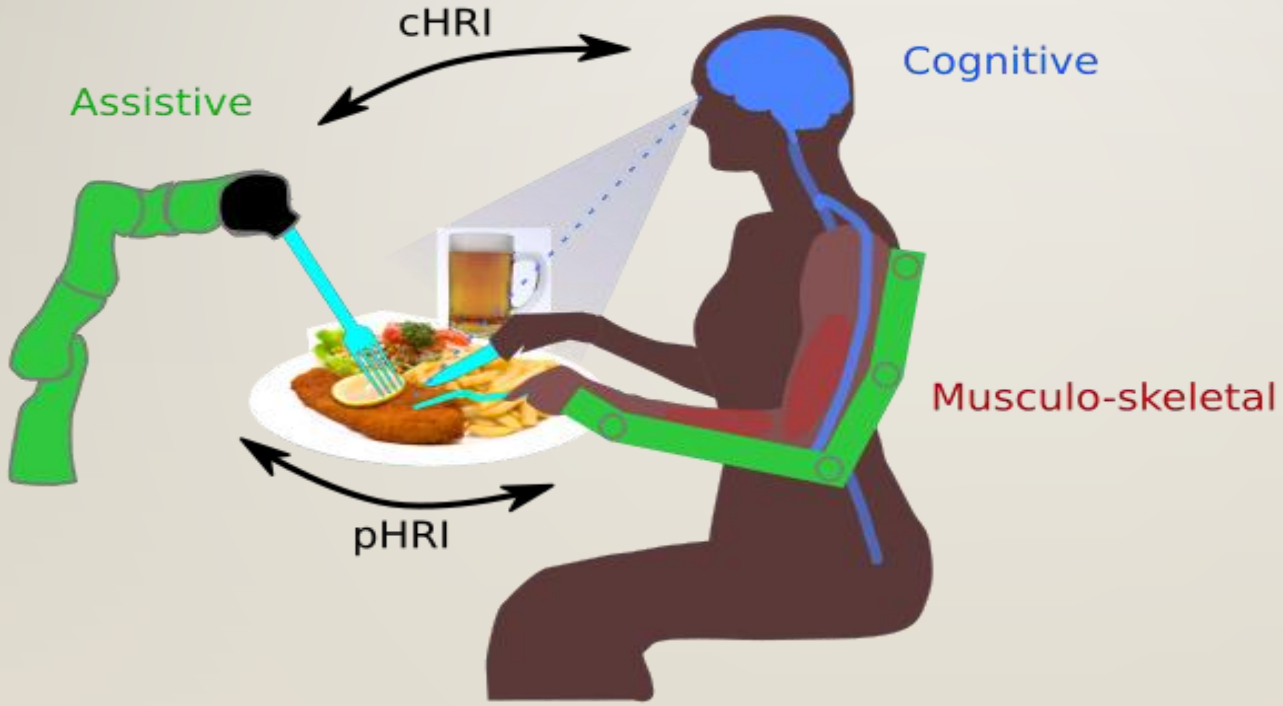
INTEGRATED MODELS OF COGNITIVE AND PHYSICAL HUMAN-ROBOT INTERACTION

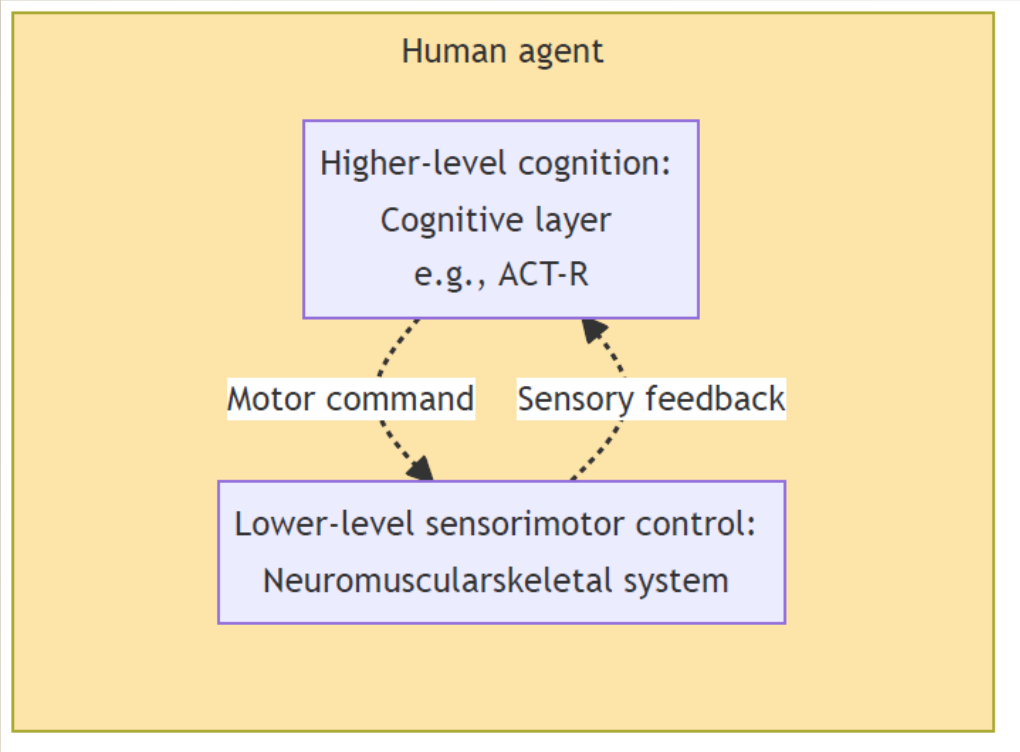
Philipp Beckerle & Stella Hao Chenxu (Uni Erlangen-Nürnberg),
Nele Rußwinkel (TU Berlin), Daniel Häufle (Uni Tübingen)



Requirements of the cognitive Model:

- Understands the task, and next steps in the task (also flexible parts of the task)
- Traces situation awareness (what information gathered so far, interpretation, where in the task, what will happen next?)
- Understand context information (beer in the glass → heavy, steak needs to be fixed for cutting, fries are light and move a lot →short picking movements necessary)
- What is that state of the Human – strong tremor, well coping, …

INTEGRATED MODELS OF COGNITIVE AND PHYSICAL HUMAN-ROBOT INTERACTION



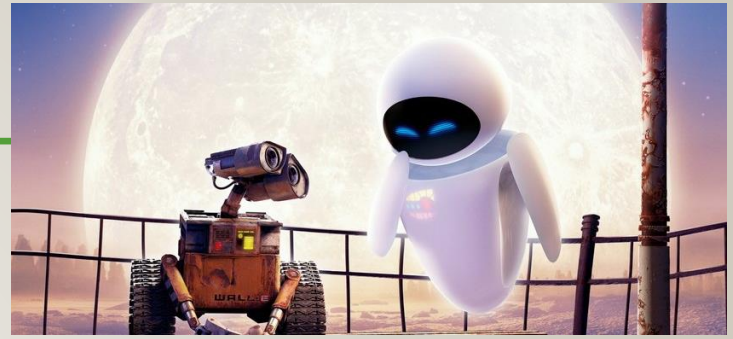
- Needed: Approach that integrates higher cognitive level with sensorimotor control. (Kahl et al., 2021)
- Different levels of support place different requirements on the anticipatory model.
- Joint action?
- Vision: Both sides are adaptive to one another

Kahl, S., Wiese, S., Russwinkel, N., & Kopp, S. (2021). Towards autonomous artificial agents with an active self: modeling sense of control in situated action. *Cognitive Systems Research*, 72, 50-62. https://doi.org/10.1016/j.cogsys.2021.11.005

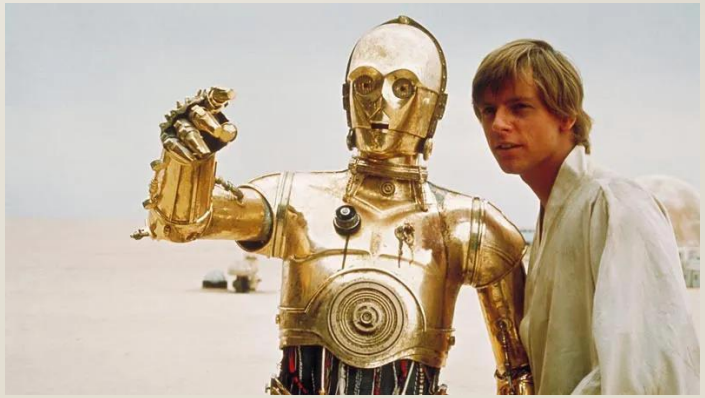
CHALLENGES

- Connecting further models/simulator/sources of information to the cognitive Model.
- Integrating information – considering reliability of information and uncertainty
- How can such models be evaluated if every individual anticipatory thinking model will develop individually?
- What cognitive principles are most relevant for „Anticipatory Thinking“ approaches?

SUMMARY



- Models of Anticipatory Thinking are NOT models of the cognitive processes of someone engaged in a task!
- RATHER: Captures how another agent anticipates a partner.
- Anticipation can be about anticipating the partner (just observing and understanding), and offering support (e.g. force applied by robot), or anticipating own actions and trying to cope with environmental changes or other processes.



THANK YOU FOR YOUR ATTENTION!