COMEING TOGETHER DER OÖ. INGENIEURBÜROS

UNIV.-PROF. DI DR. PHILIPP WINTERSBERGER
PROFESSOR OF INTELLIGENT USER INTERFACES

Mittwoch, 27. November 2024, 16:30 Uhr
WKO Oberösterreich, Europasaal

IT:U
interdisciplinary
transformation
university austria

Philipp Wintersberger

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Software Engineer

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CARISSMA Automotive Safety Research

Ph.D. @ CARISSMA Ingolstadt

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TU WIEN TECHNISCHE UNIVERSITÄT WIEN

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2024

IT:U interdisciplinary transformation university austria

Prof. of Intelligent User Interfaces @IT:U

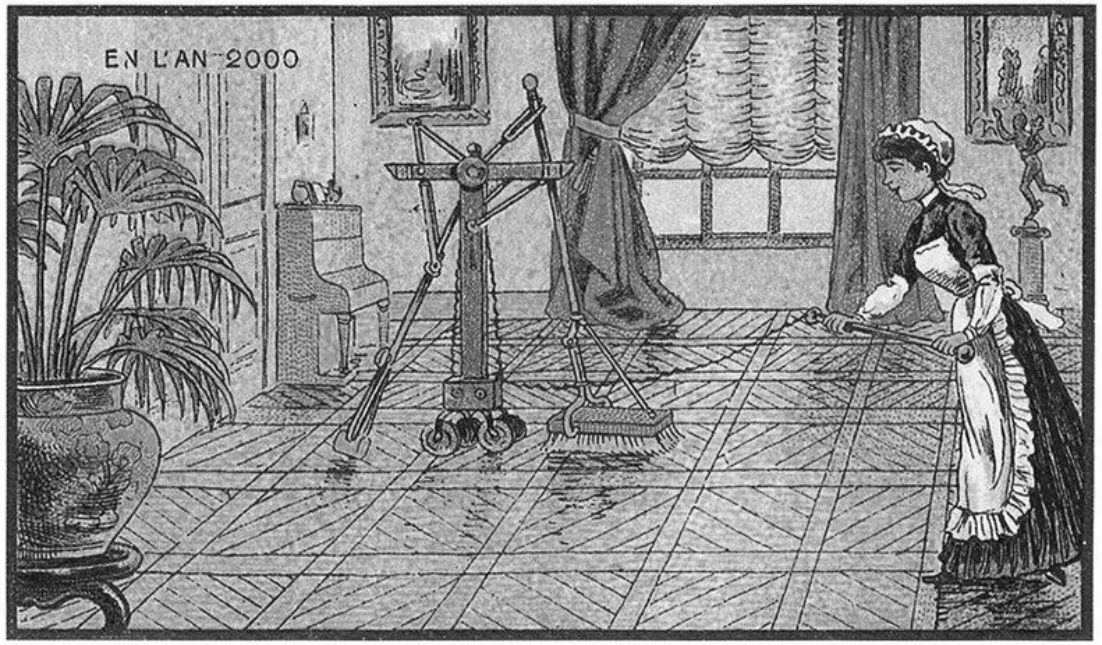
Global Context: A world in transformation

The world is facing increasingly complex and interrelated challenges.

- All of them require interdisciplinary efforts instead of advances in a single discipline
- Digital technologies have an unprecedented potential to drive innovative and scalable solutions.

The complex, interdisciplinary nature of these problems means, that science and higher education must adapt.

Why do we need Digital Transformers?



Very literal translations of human-shaped tasks into technology.

NOT more of the same!!!

IT:U – NEW Model University

Interdisciplinary BASIC Research in Computational X

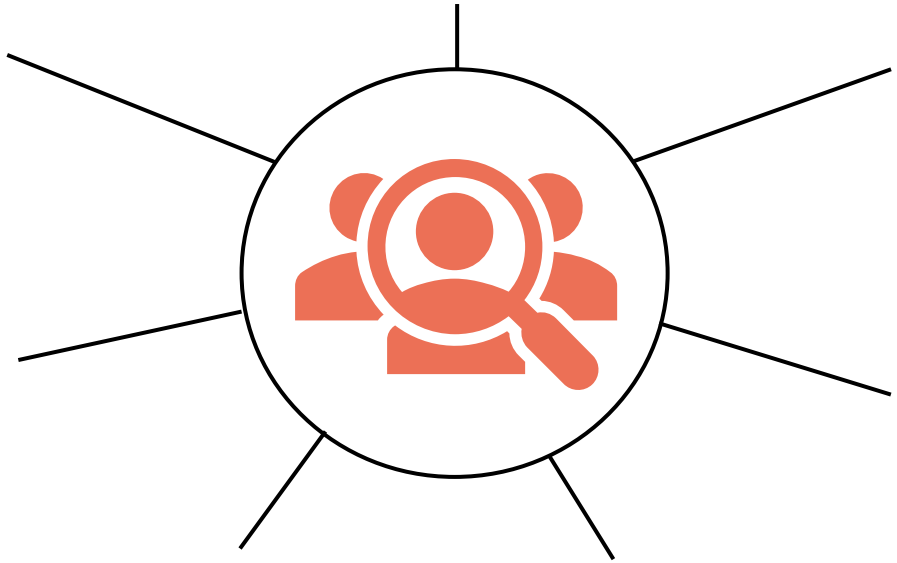
Project-based Learning scalable through LearnTech

New governance model

What is a
Digital Transformer?

Computational expert with hands-on experience on spectrum of key digital skills

Passionate problem solver, who frames and solves complex, interdisciplinary challenges



Domain expert, who understand the underlying systemic properties

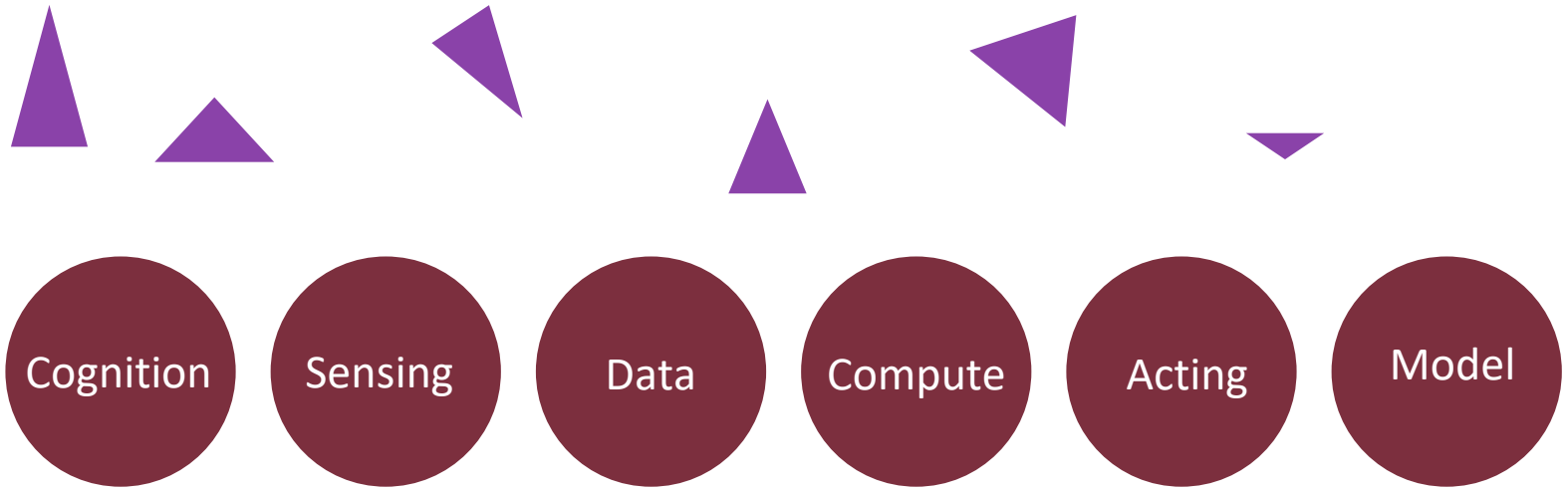
Builder and leader of effective, interdisciplinary teams

Crucial qualities: curiosity, sense of drive and mission, social intelligence, agility

Self-directed, continuous learner who learns effectively on-demand

Manager of change, who leads transformation projects with social intelligence

Toolbox of a Digital Transformer



Fluid Mechanics	Thermo Dynamics	CAD	Eng Math	Materials	…	…

IT:U Vision

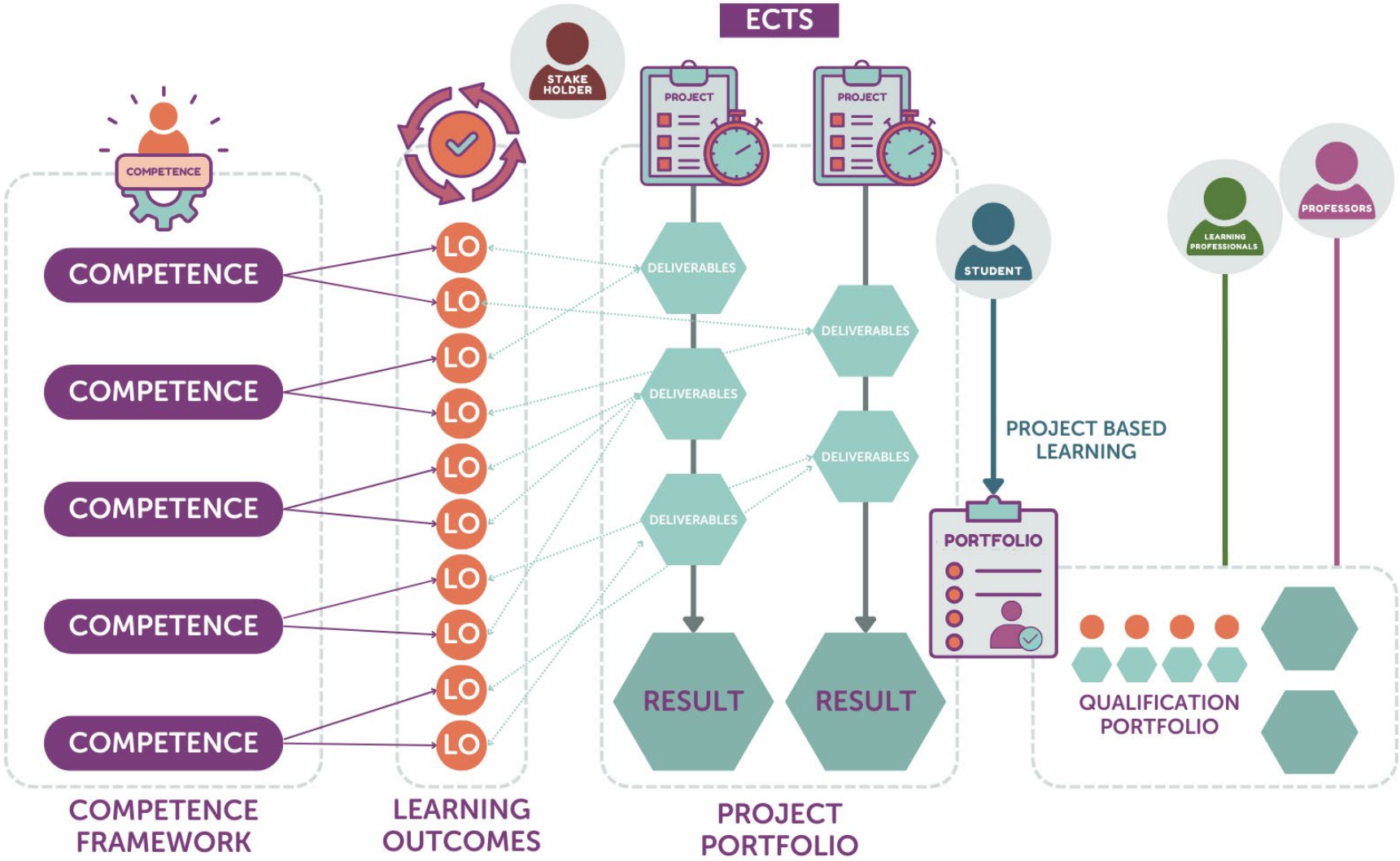
Transform Futures:

Addressing global challenges
enabled by digital methods and
implemented by a new generation of transformers

IT:U Mission

We offer experimental spaces
where humanity and technology interface.
A place where science, design, engineering, and art integrate.

IT:U Educational Model



Interdisciplinary learning labs

#Rita

Reality Lab // Augmented, Virtual and Mixed Reality

#Momo

Motion Lab // Capturing of human and drone motion

#Hans

Maker Lab // Prototyping of digital systems

#Rob

Robot Lab // Robot motion and interaction modes

#Ines

Interaction Lab // Human interaction with digitality

#Doro

Data Lab // Understanding data and infrastructure

IT:U Study Programs

2 PhD Programs in WS 2024/25

- PhD in Computational X
- PhD in Digital Transformation in Learning

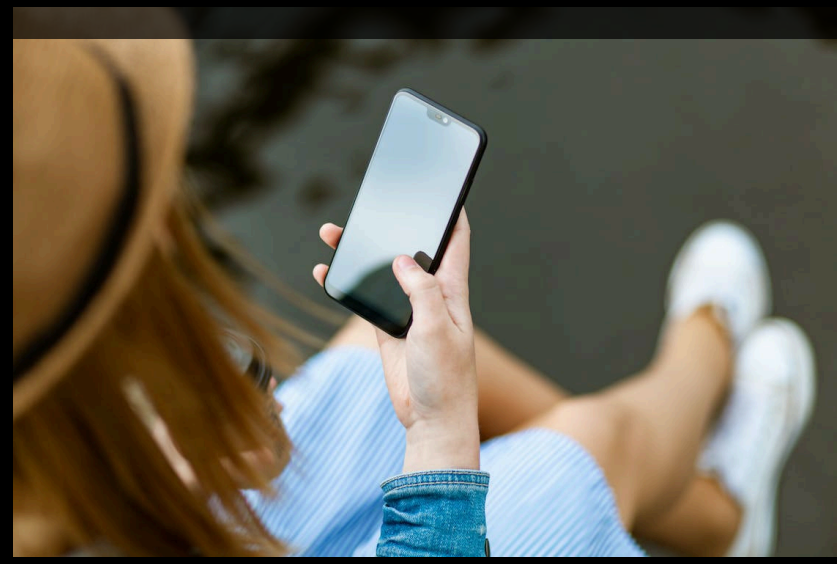
1 Master‘s Program in WS 2025/26

Additional Building starting Summer 2025 with 6000 qm

TOWARDS REAL-TIME ATTENTION MANAGEMENT

Motivation

Technology aiming to improve the life of their users?



Motivation

Technology aiming to improve the life of their users?

Motivation

The Age of Disruption and Multitasking

Image generated by Midjourney

Motivation
The Age of Disruption and Multitasking

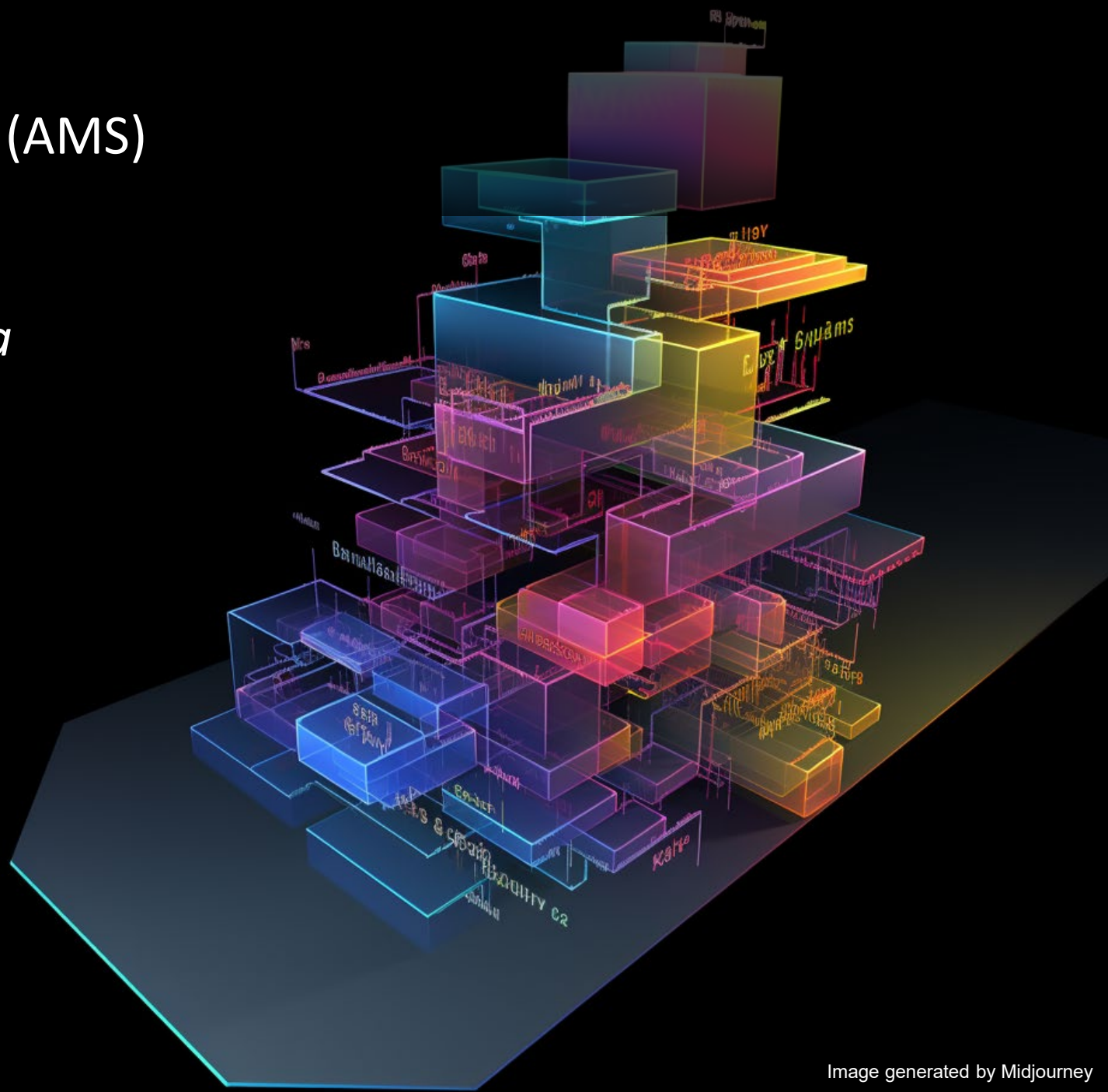
- Multitasking and task-switching comes with high socio-economic costs
- Each smartphone receives more than 60 push notifications per day [1]
- ***Permanent Task Switches decrease performance, lead to higher stress and error rates***

[1] Pielot, M., Church, K., & De Oliveira, R. (2014, September). An in-situ study of mobile phone notifications. In Proceedings of the 16th international conference on Human-computer interaction with mobile devices & services (pp. 233-242). ACM.
[2] Brian P Bailey and Joseph A Konstan. 2006. On the need for attention-aware systems: Measuring effects of interruption on task performance, error rate, and affective state. Computers in human behavior 22, 4 (2006) 685–708.
https://www.google.at/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwi3gbPG5MzdAhXH61MKHdu-BPcQjRx6BAgBEAU&url=https%3A%2F%2Fwww.amazon.com%2Fdp%2FB01GGE8CP8&psig=AOvVaw2-SabI8HdNLiig8YfWyQDB&ust=1537642943825356c

Image generated by Midjourney

Potential Solution
Attention Management Systems (AMS)

„Computationally seek to balance a user‘s need for minimal disruption and the applications‘ needs to deliver information“



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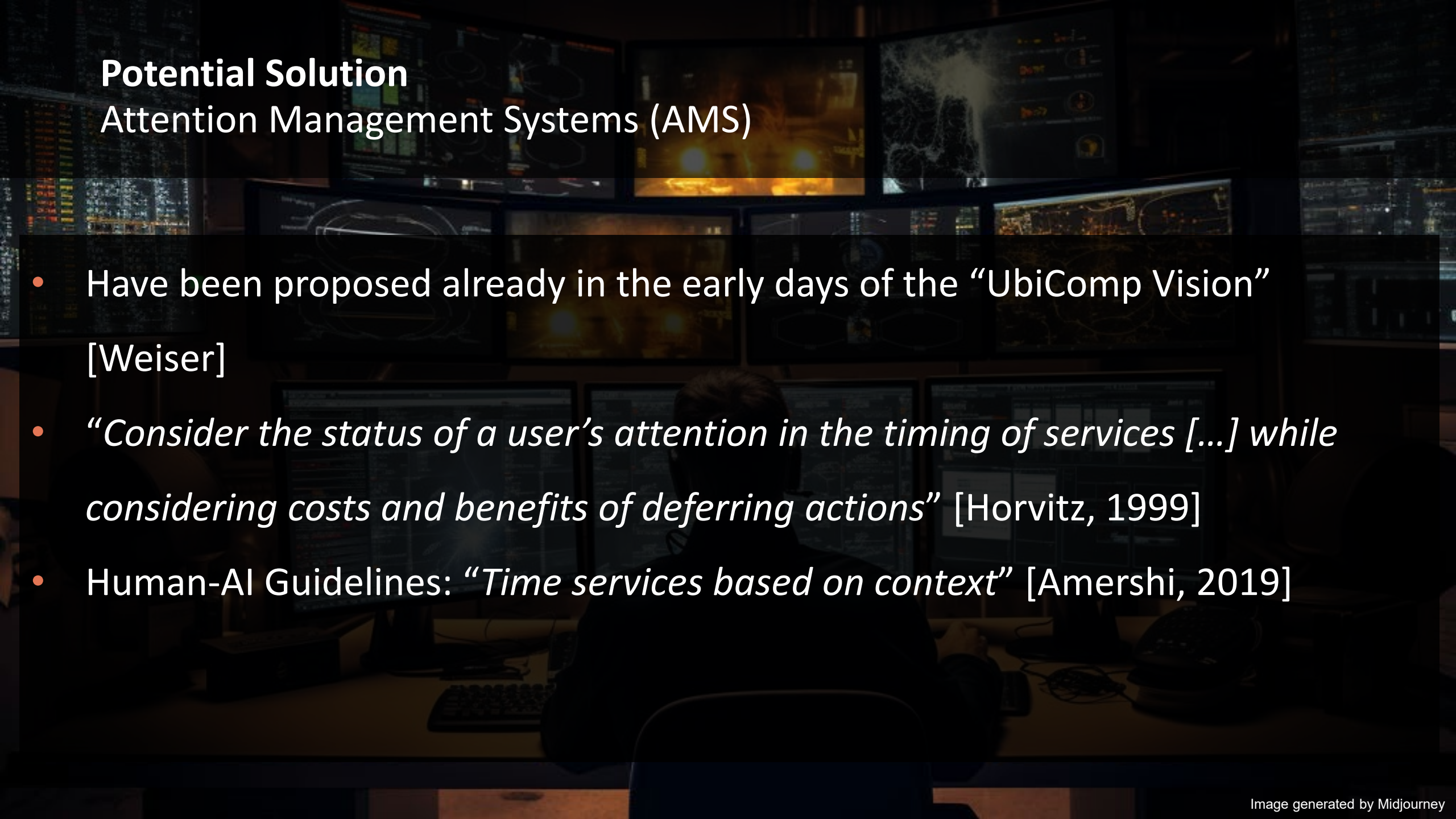
Potential Solution
Attention Management Systems (AMS)

- Have been proposed already in the early days of the “UbiComp Vision” [Weiser]
- “*Consider the status of a user’s attention in the timing of services […] while considering costs and benefits of deferring actions*” [Horvitz, 1999]
- Human-AI Guidelines: “*Time services based on context*” [Amershi, 2019]



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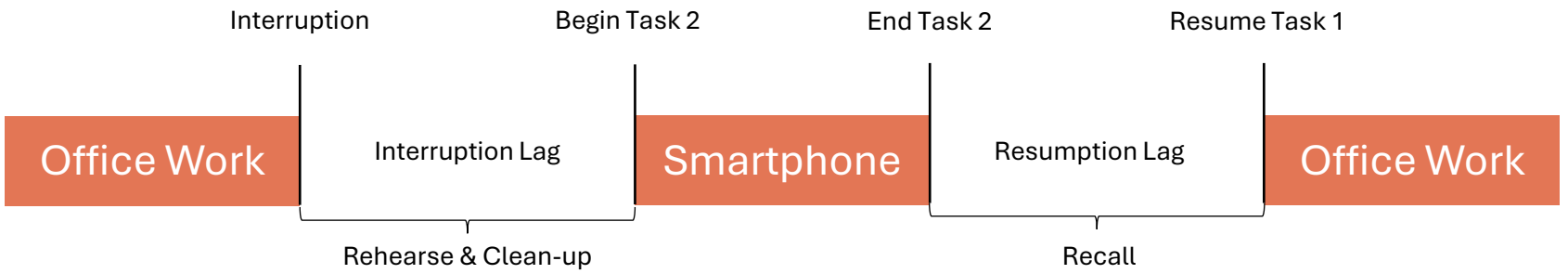
Sequential Multitasking - Theory



- Interruption lag: Time and effort to rehearse („store“) a mental representation of the task in (human) memory and to clean up („free“ the mind for another activity)
- Resumption lag: Time and effort to restore the mental representation of the before-interrupted task
- Task switching/Interruptions work best at task boundaries or times of low workload

Sequential Multitasking – Effects of Interruption Timing

Multitasking in safety-critical situations

- Independent variable – Notification timing: Interrupting users engaged in WhatsApp conversations, either while typing, or shortly after completing a message

Measurements

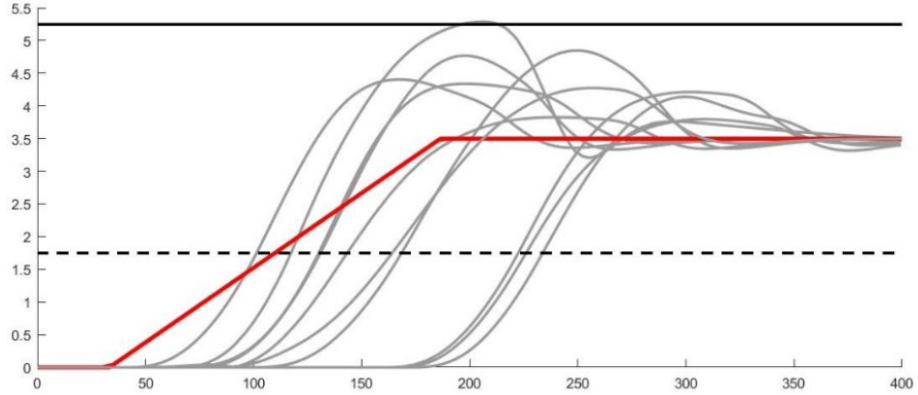
- Task performance (reaction times)
- Stress levels (galvanic skin response)
- WhatsApp typing performance (characters per second, error rates, etc.)

[6] Eriksson, A., & Stanton, N. A. (2017). Takeover time in highly automated vehicles: noncritical transitions to and from manual control. Human factors, 59(4), 689-705.
[5] Wintersberger, P., & Riener, A. (2016). Trust in technology as a safety

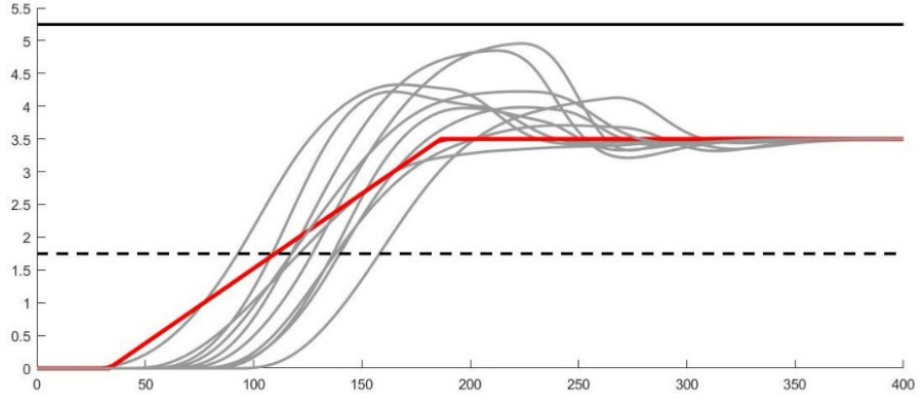

7:40
AUTOPILOT

Sequential Multitasking – Effects of Interruption Timing

- Precisely timed interruptions lead to significantly…
- Reaction Times: Faster and more stable reactions
- Stress Measurements (galvanic skin response): Lower stress, as indicated by various GSR parameters such as nSCR, ISCR, etc.
- Typing Performance (keys per second): Higher typing performance and fewer errors, even after „cleaning“ the data for resumption lag times



Driving trajectories: Interrupted while typing

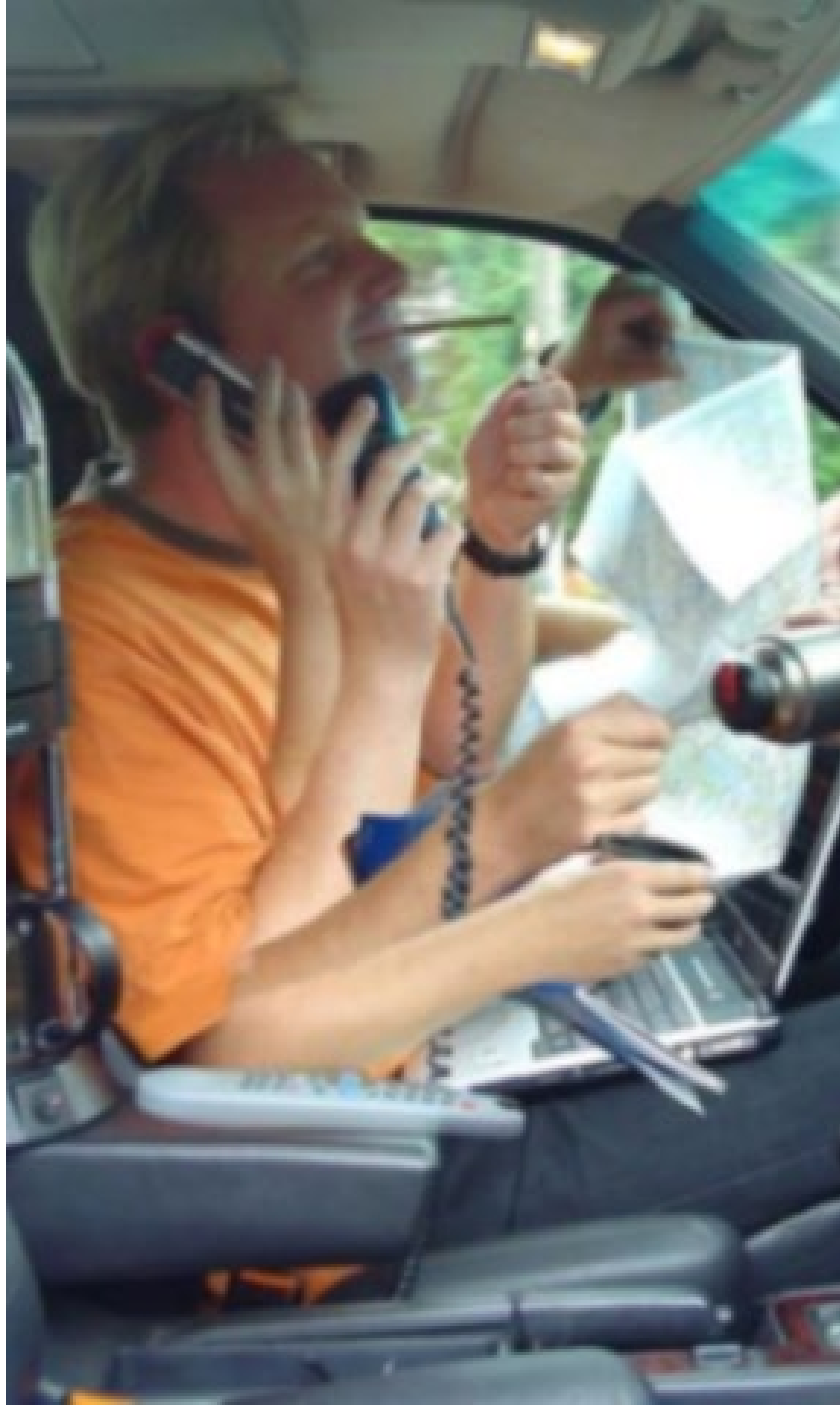


Driving trajectories: Interrupted shortly after typing

[6] Eriksson, A., & Stanton, N. A. (2017). Takeover time in highly automated vehicles: noncritical transitions to and from manual control. Human factors, 59(4), 689-705.
[5] Wintersberger, P., & Riener, A. (2016). Trust in technology as a safety

Attention Management & Multitasking

- Multitasking with nomadic devices is prevalent in many real-world situations, despite legal issues and users being aware of the issues (Wintersberger et al., 2018, 2022)
- The timing of interruptions has a significant impact on primary & secondary task performance, as well as users' stress levels (Wintersberger et al., 2018, 2019)
- The downsides can (at least partly) be mitigated by applying AMS principles!



Wintersberger, P., Shahu, A., Reisinger, J., Alizadeh, F., & Michahelles, F. (2022, November). Self-Balancing Bicycles: Qualitative Assessment and Gaze Behavior Evaluation. In Proceedings of the 21st International Conference on Mobile and Ubiquitous Multimedia (pp. 189-199).

Wintersberger, P., Riener, A., Schartmüller, C., Frison, A. K., & Weigl, K. (2018, September). Let me finish before I take over: Towards attention aware device integration in highly automated vehicles. In *Proceedings of the 10th international conference on automotive user interfaces and interactive vehicular applications* (pp. 53-65).

Wintersberger, P., Schartmüller, C., & Riener, A. (2019). Attentive user interfaces to improve multitasking and take-over performance in automated driving: the auto-net of things. *International Journal of Mobile Human Computer Interaction (IJMHCI)*, *11*(3), 40-58.

Attention-Awareness & Multitasking

Can an AI supervise us better then we can?

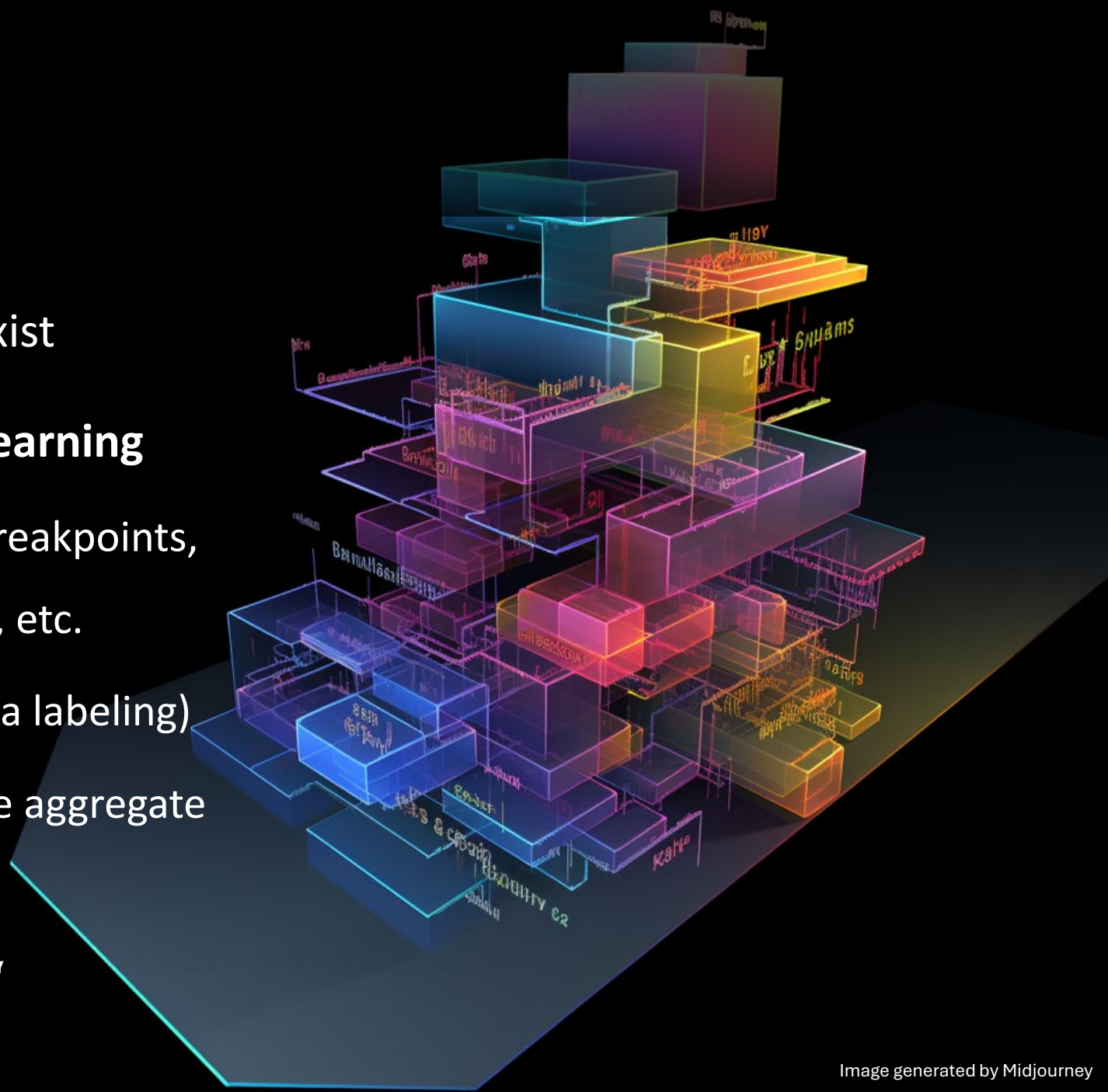
› The timing of interruptions in an (automated) car has significant impact on driving task performance (Wintersberger et al., 2018)

These were “scripted experiments”

How can we develop a “real” Attention Management System that operates in real-time and in a great variety of multitasking situations?

Potential Solution
Attention Management Systems

- Why AMS in „the real world“ hardly exist
- Existing concepts rely on **supervised learning**
  - Complex ML-pipelines for detecting breakpoints, conducting decisions based on theory, etc.
  - Strongly task-dependent (requires data labeling)
  - Difficult to adapt to individuals (simple aggregate models of human behavior)
  - **Impossible to become „superhuman“**



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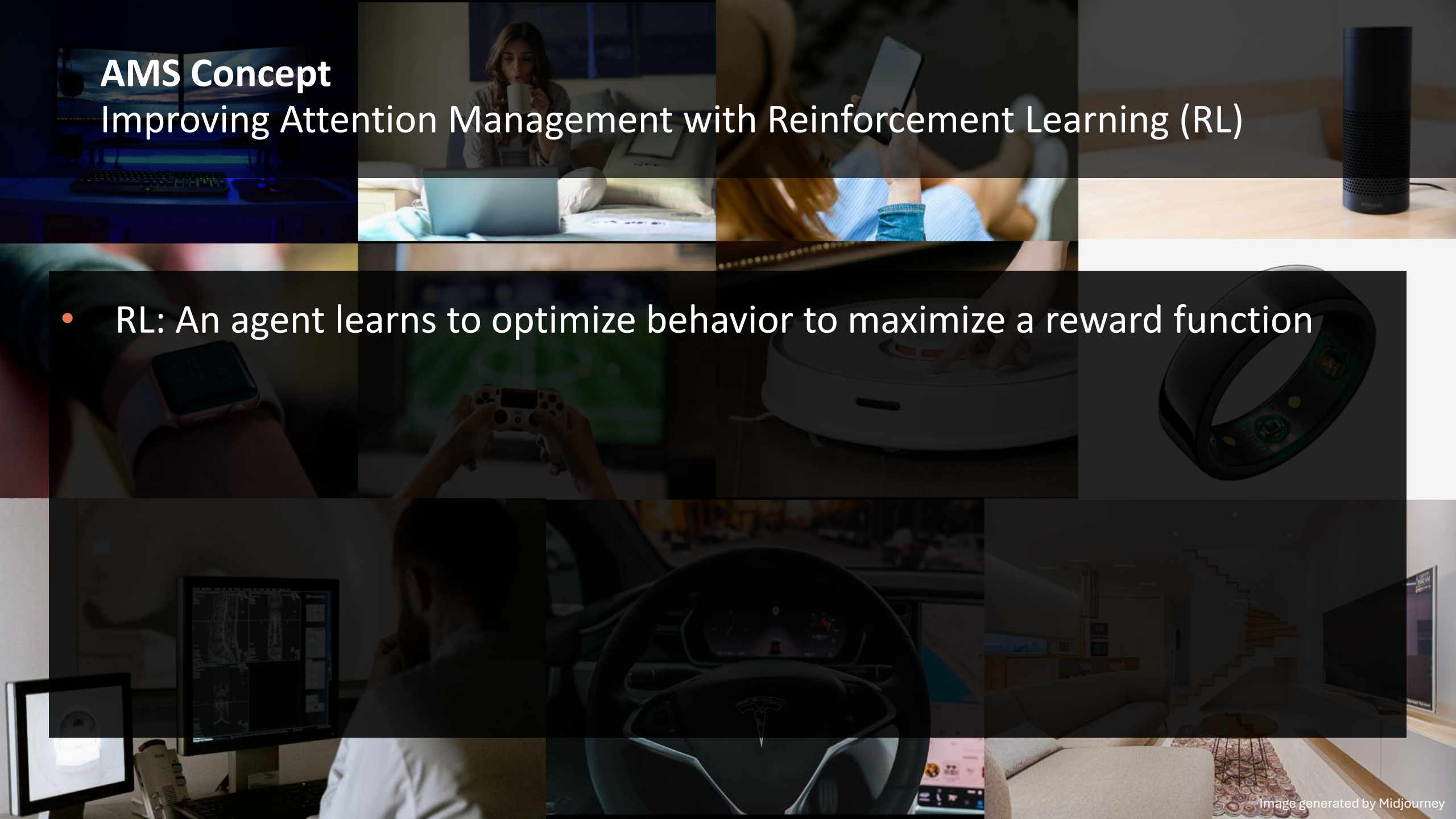
AMS Concept

Improving Attention Management with Reinforcement Learning (RL)

- RL: An agent learns to optimize behavior to maximize a reward function



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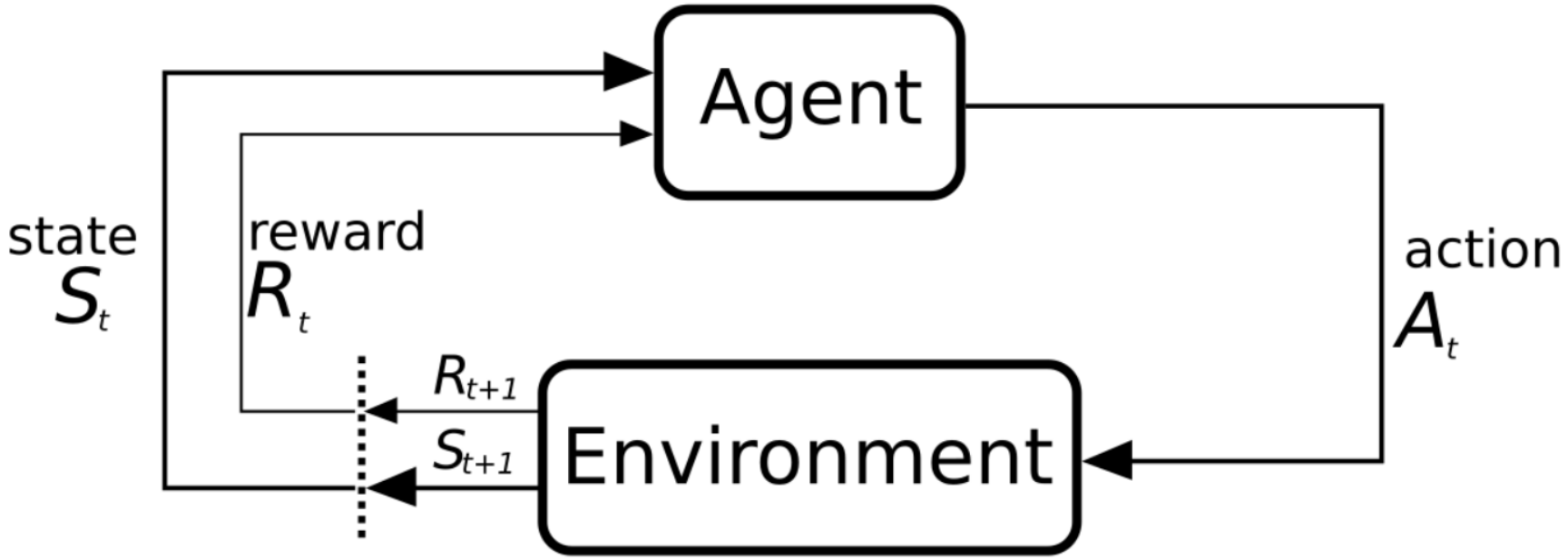
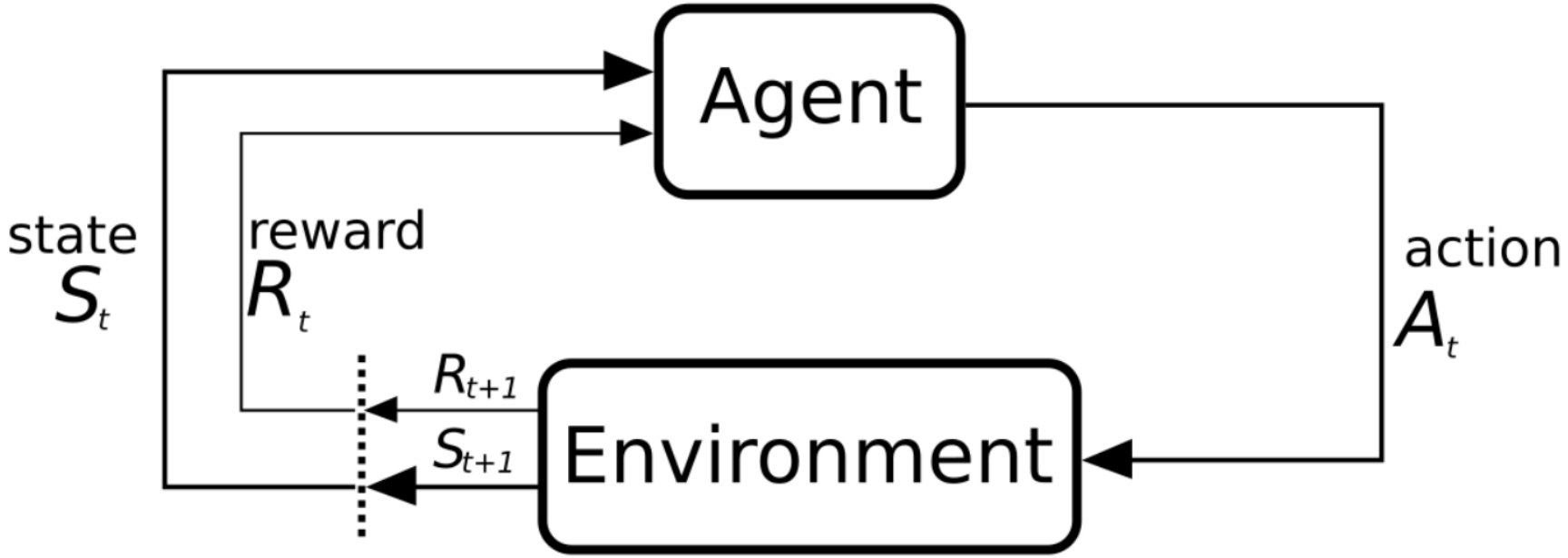
Quick Intro: Reinforcement Learning



Quick Intro: Reinforcement Learning

Deliver interruptions at the best moment in time



Quick Intro: Reinforcement Learning

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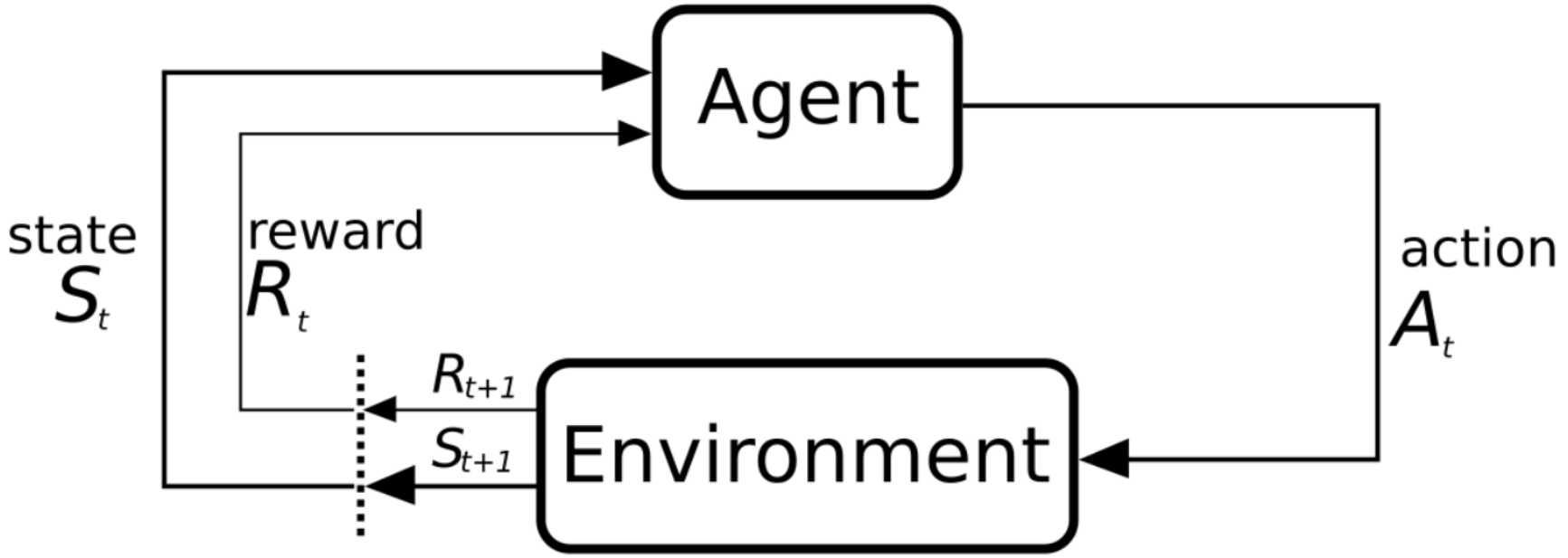
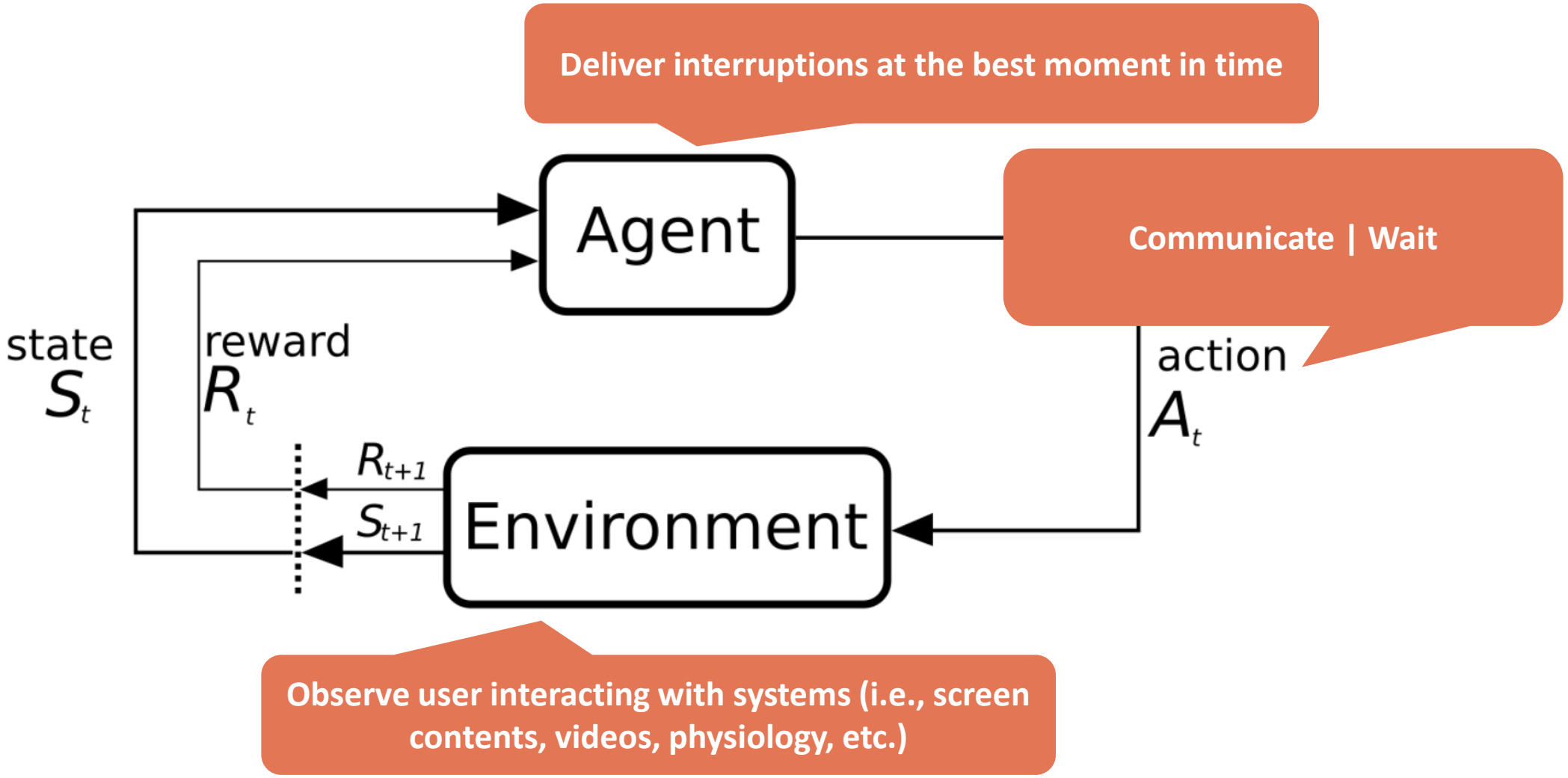


Observe user interacting with systems (i.e., screen contents, videos, physiology, etc.)

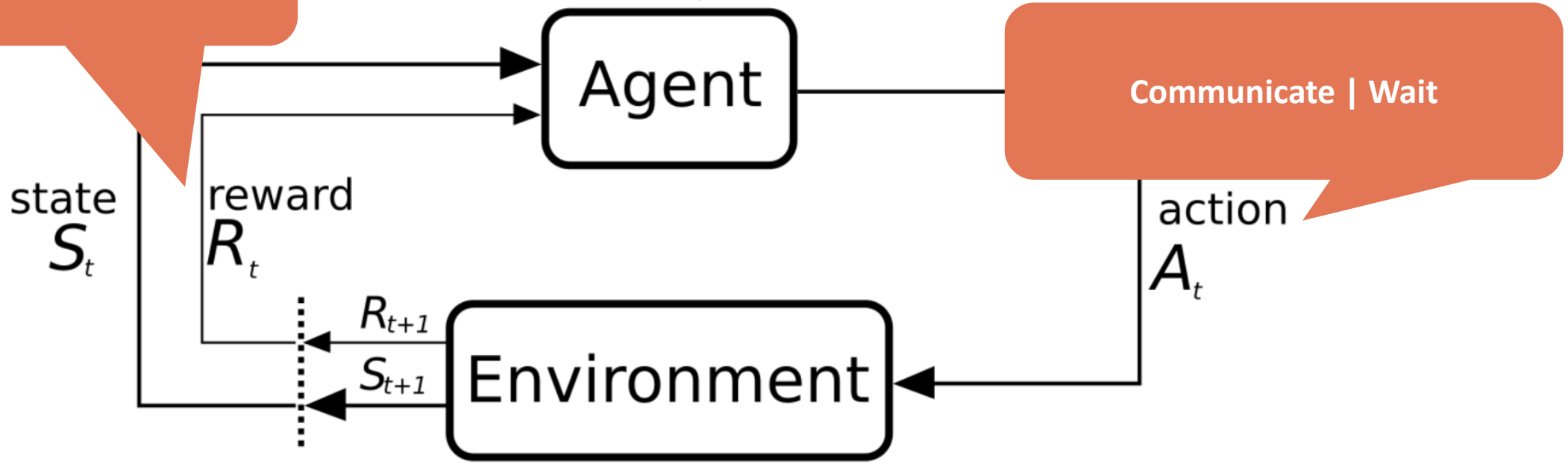
Quick Intro: Reinforcement Learning



Quick Intro: Reinforcement Learning

Maximize performance in tasks
Minimize users‘ stress levels

Deliver interruptions at the best moment in time



Observe user interacting with systems (i.e., screen contents, videos, physiology, etc.)

AMS Concept

Improving Attention Management with Reinforcement Learning (RL)

- RL: An agent learns to optimize behavior to maximize a reward function
- RL-based Attention Management
  - Potentially less task-dependent, no need for labeled training data
  - Can adapt to individuals, may achieve “superhuman” performance

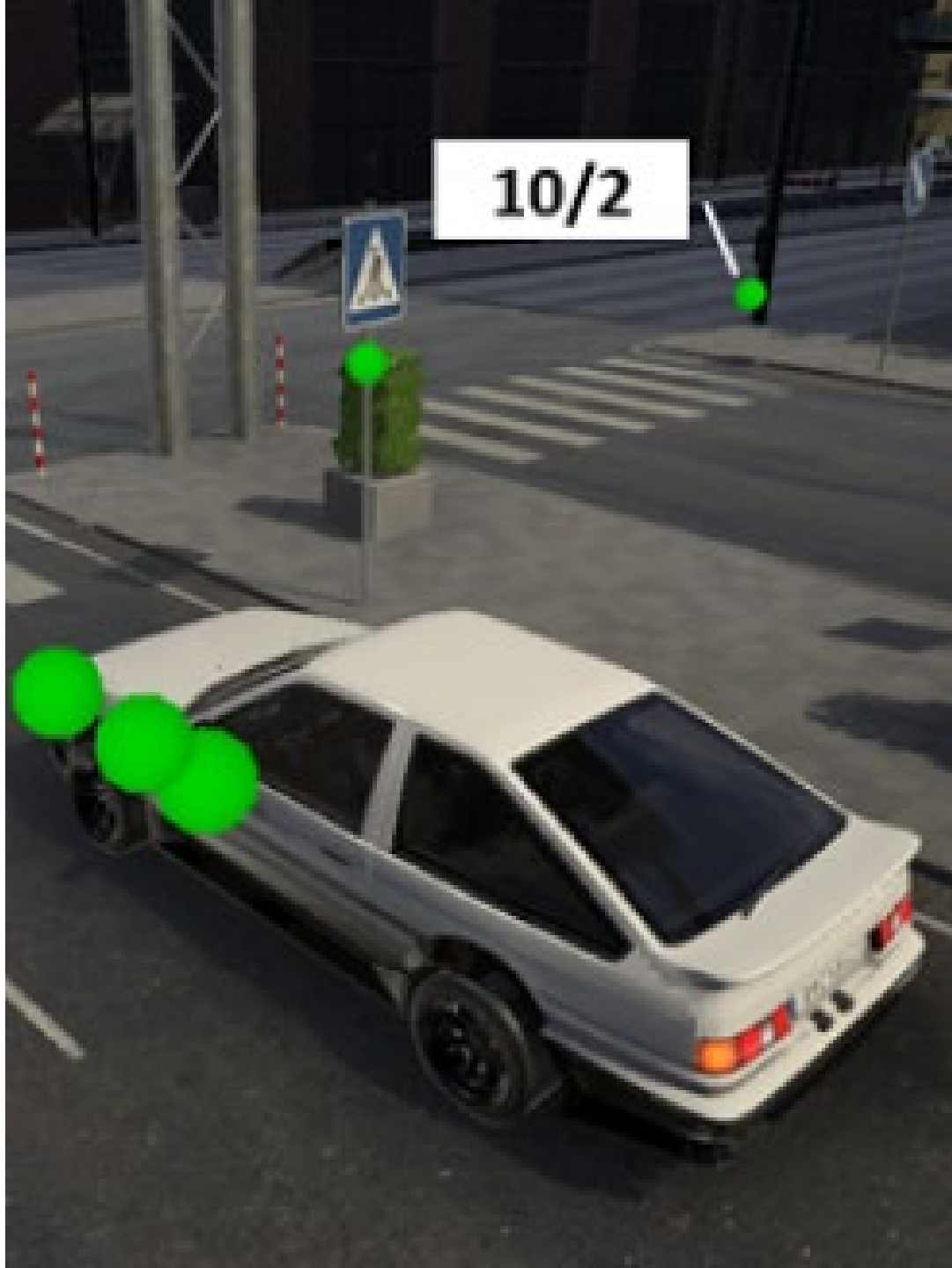
Hypothesis: We can design an RL-based AMS that improves human performance

Image generated by Midjourney

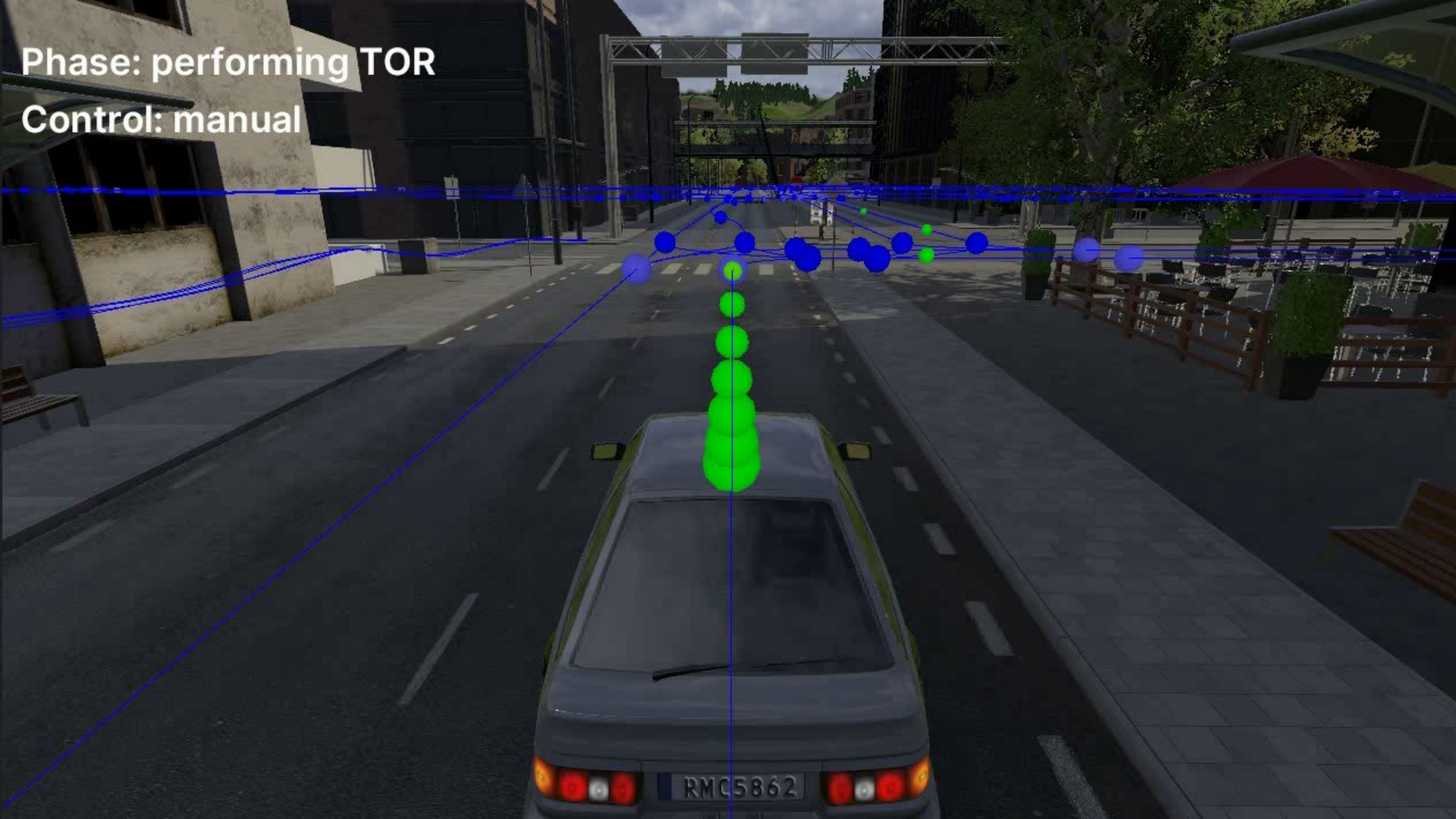
Attention Management

Transitions in Automated Vehicles

- RL-Agent managing transition timing
- Actions: issue or delay transition
- Environment observations: function of the upcoming road layout
- Reward: driving performance after the transition
- Evaluation with simulated drivers



Kuen, J., Schartmüller, C., & Wintersberger, P. (2021, September). The TOR Agent: Optimizing Driver Take-Over with Reinforcement Learning. In *13th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (pp. 47-52).


Phase: performing TOR
Control: manual
RMC5862

AMS Concept

Improving Attention Management with Reinforcement Learning (RL)

We can design an RL-based AMS system that improves human performance

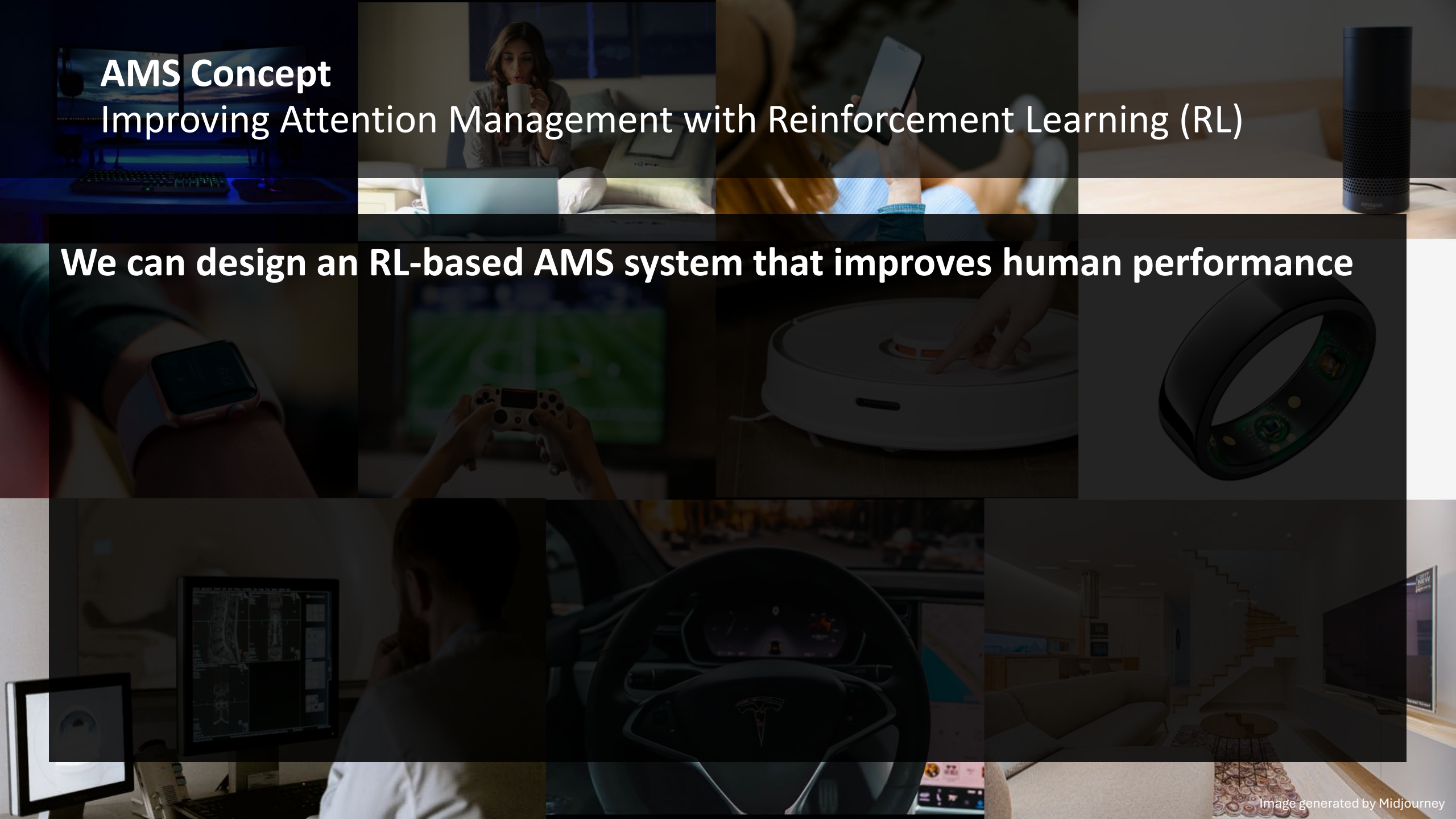


Image generated by Midjourney

AMS Concept

Improving Attention Management with Reinforcement Learning (RL)

We can design an RL-based AMS system that improves ~~human~~ performance

- In theory, yes – but we need a simpler and more controllable scenario

  (as the driving environment is extremely complex)
- How can we train such a system without burdening human users?

  (as humans are not RL agents)

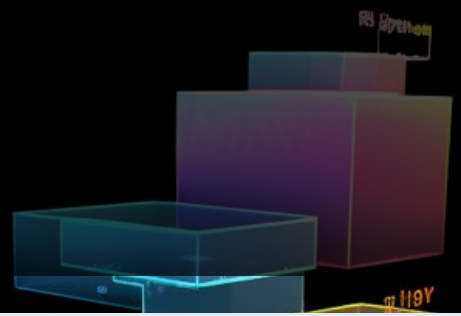
Image generated by Midjourney

RL-based Attention Management
Approach: Balancing Task

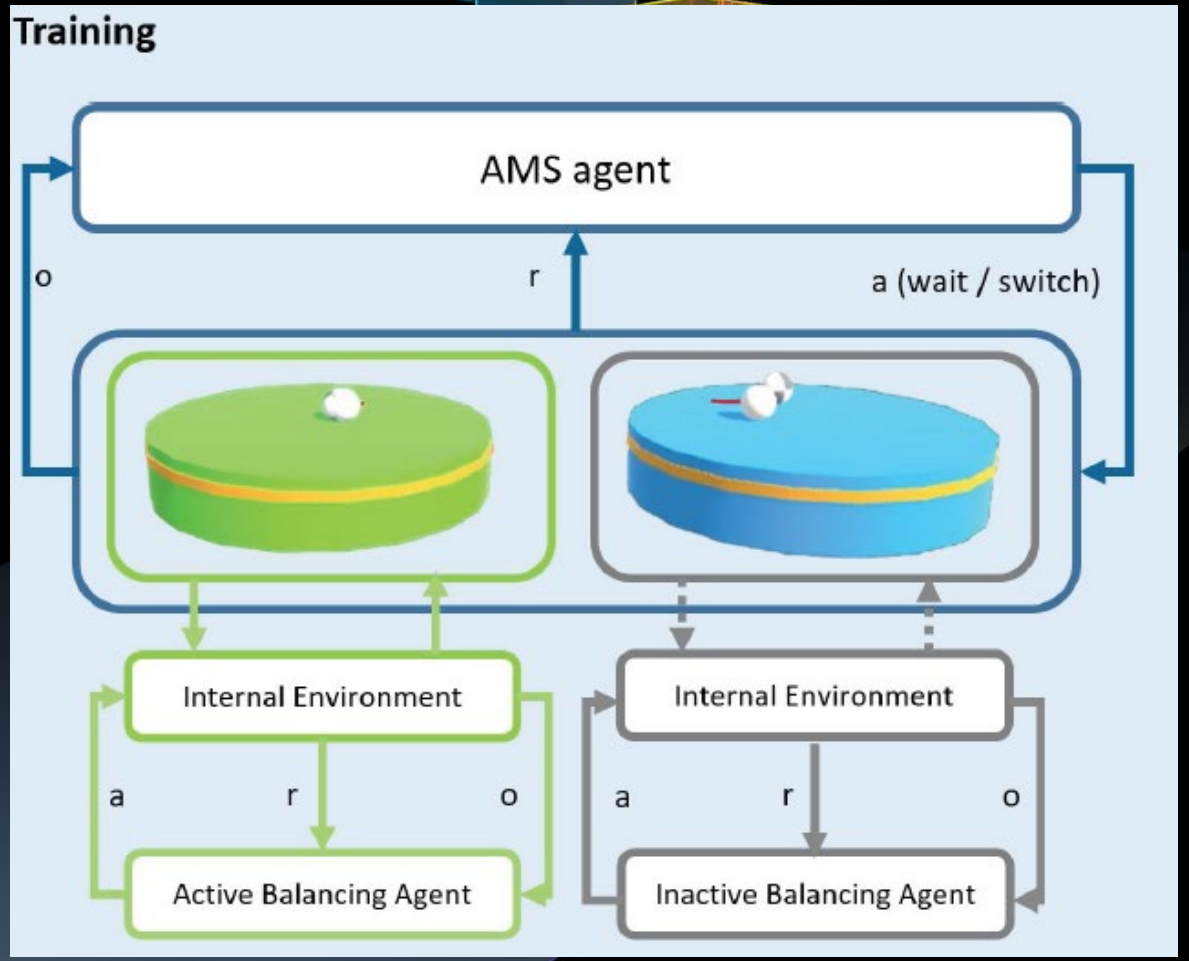
- Fast-paced visual-motoric dual task
- Users have to balance balls on 2 platforms
  - Only 1 platform can be active any time
  - Users have to switch between platforms
  - Task gets more difficult over time
  - **Can we train an AMS that switches better than humans?**

Image generated by Midjourney

RL-based Attention Management
Modeling Humans with Computational Rationality



- Humans are no RL-agents
- **Computational Rationality**
  - Assumption: Humans perform optimal under given bounds
  - RL/CR can simulate humans when bounds (i.e., reaction time, visual constraints) are modeled appropriately
  - The agents do not operate on the „true“ but an internal environment representing the constraint perception-action space



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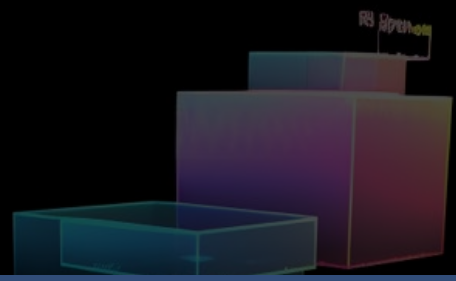
RL-based Attention Management
Modeling Humans with Computational Rationality



- **Computational Rationality**
  - RL user models do not perceive the true environment state but a probability distribution („Belief State“)
  - The agents are implemented via a partially observable Markov decision process (POMDP)

$$POMDP(S, A, P, R, \gamma; H, \Omega, O)$$

  - The strength of the update can vary and model the diverse capabilities (forgetting=>attending) and reaction times of users
  - The AMS agent is rewarded with the time (i.e., performance) the user can balance the balls:

$$r_t = \frac{1}{1 + e^{-e^2(\Delta t_s - 0.5)}}$$

1) Probability distribution when distracted

2) Probability distribution when attending the task

Image generated by Midjourney

RL-based Attention Management

Approach: Modeling Humans with Computational Rationality

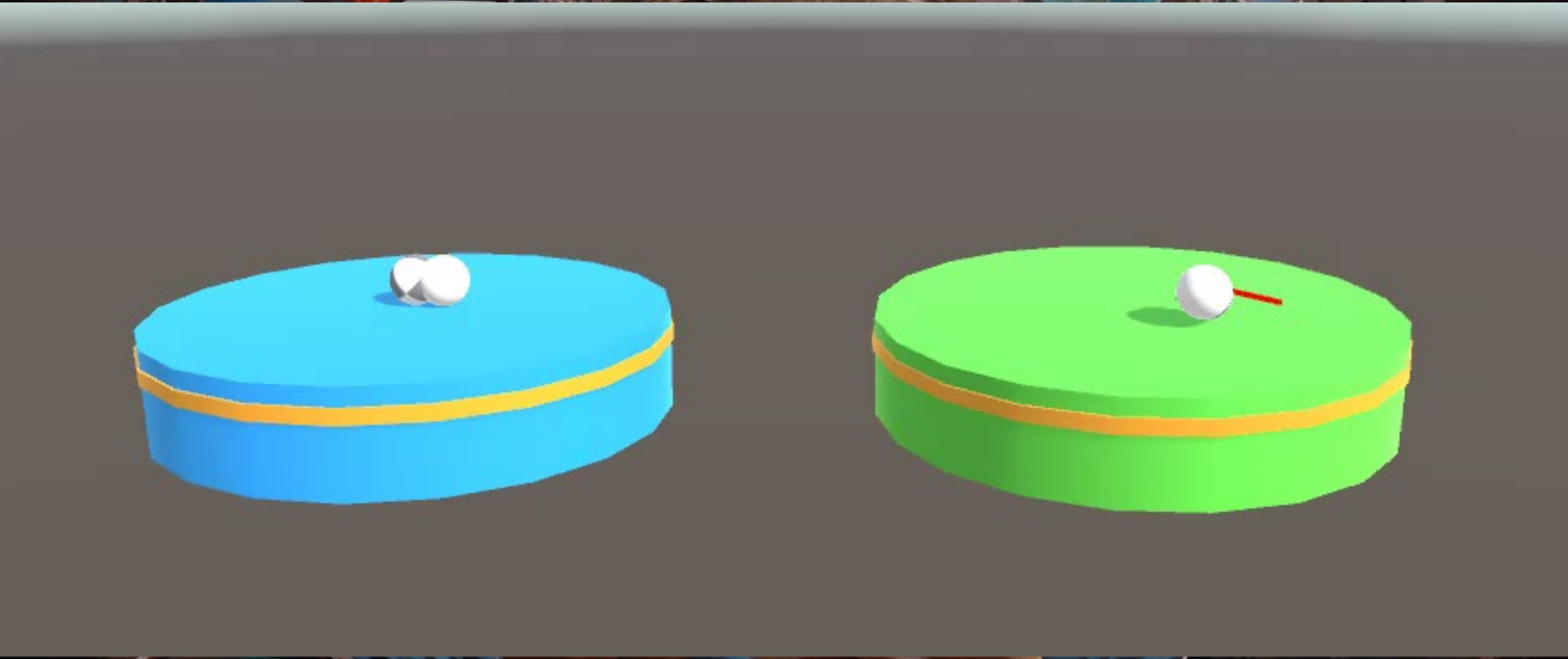
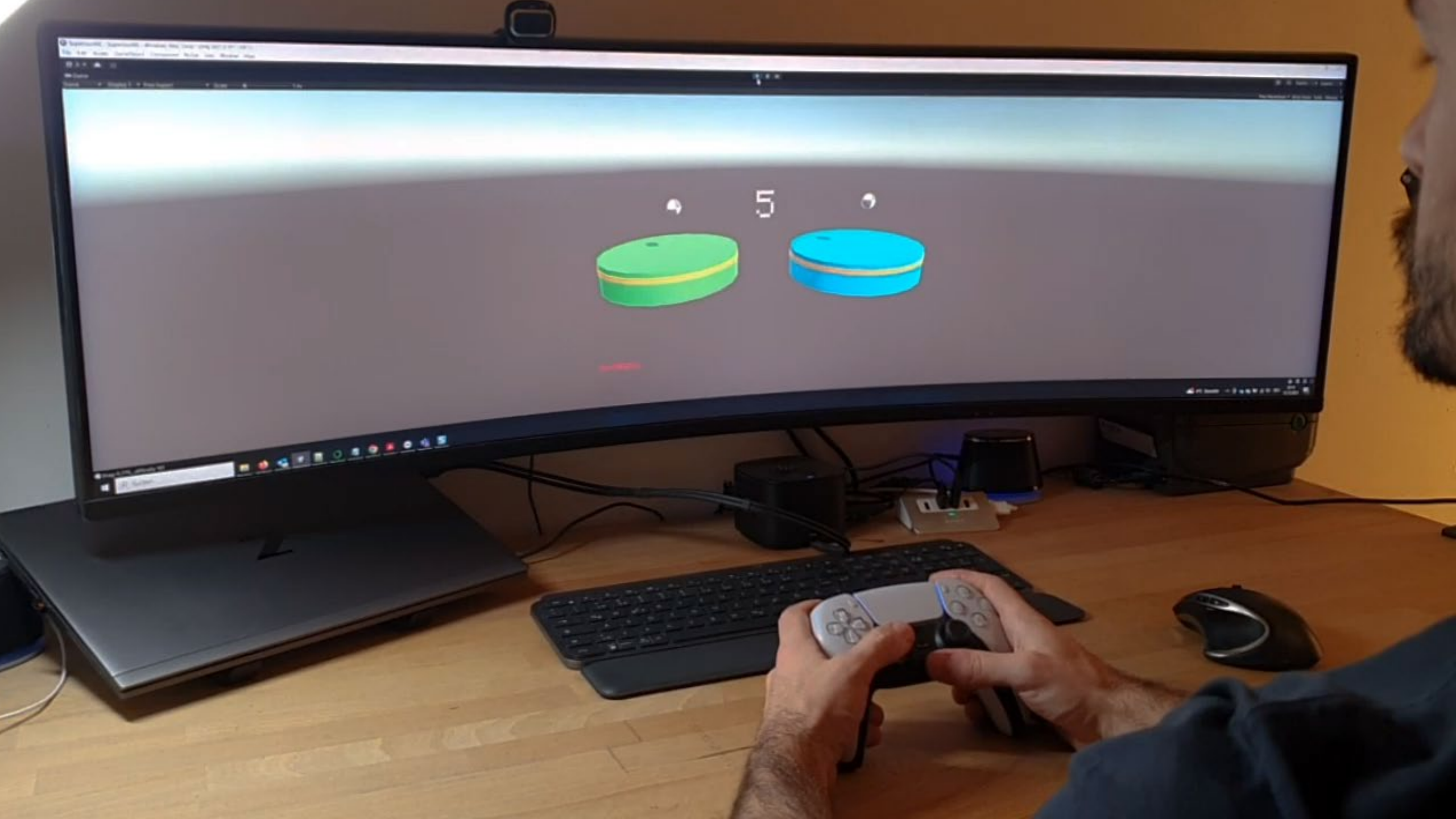


Image generated by Midjourney

RL-based Attention Management
Evaluation

- User study with N=43 participants
  - 30 male/12 female/1 preferred not to say
  - M=27.73, SD=4.21 years
- **Conditions**
  - Cognitive CR Model (based on a single user)
  - Unconstrained Model (optimal RL)
  - Notification (no automated switching)
  - No Supervisor (human switching, baseline)

Image generated by Midjourney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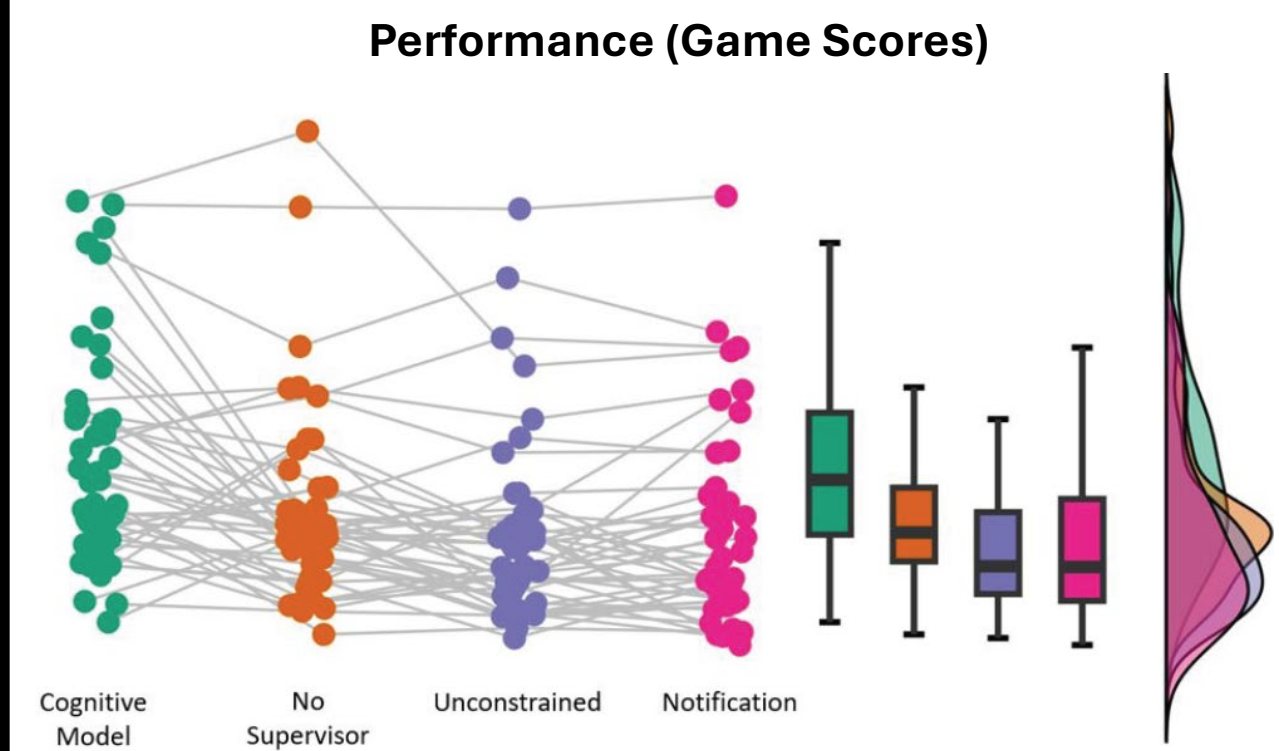
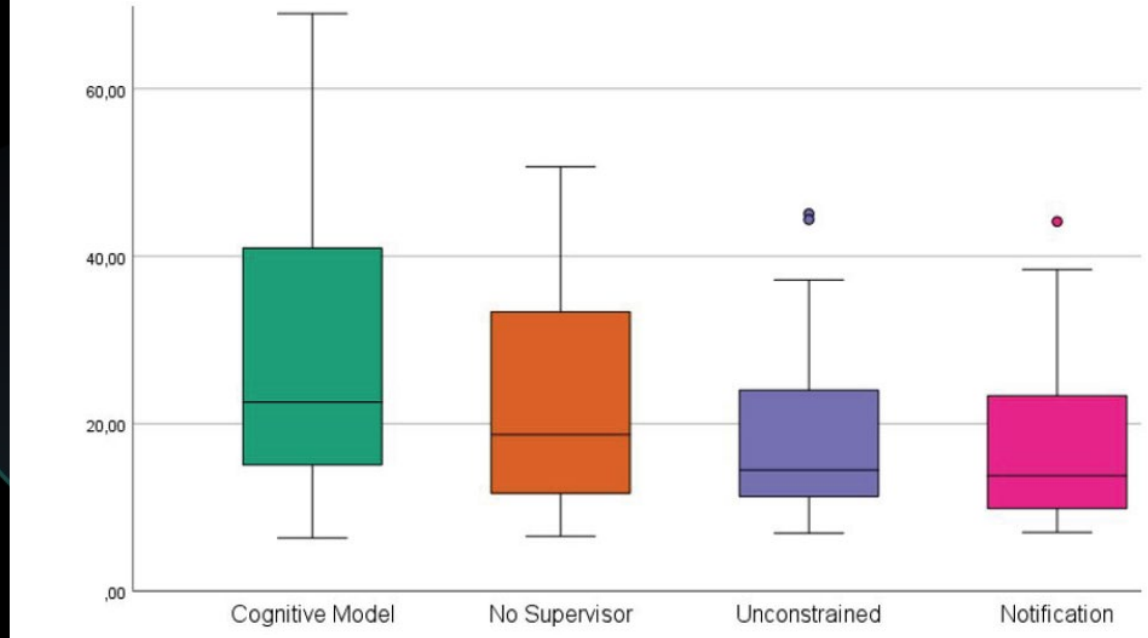
RL-based Attention Management
Results

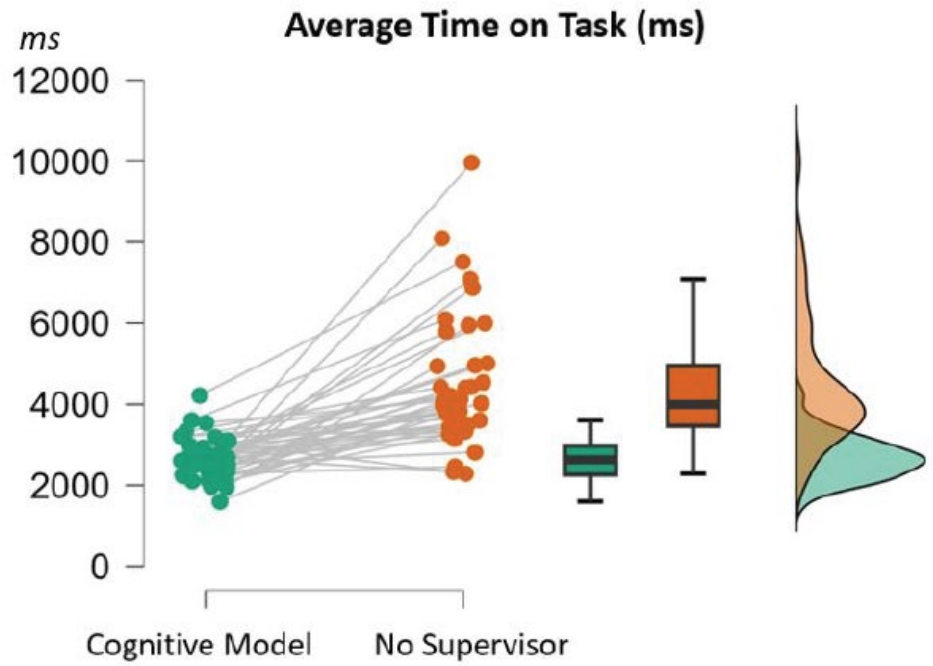
- **Performance**
  - The RL/CR-based AMS could significantly improve human performance in the game
  - Participants performed up to 1.5x better than in other modes
  - CR is necessary to achieve this result
  - Auto-switching worked better than the notification condition

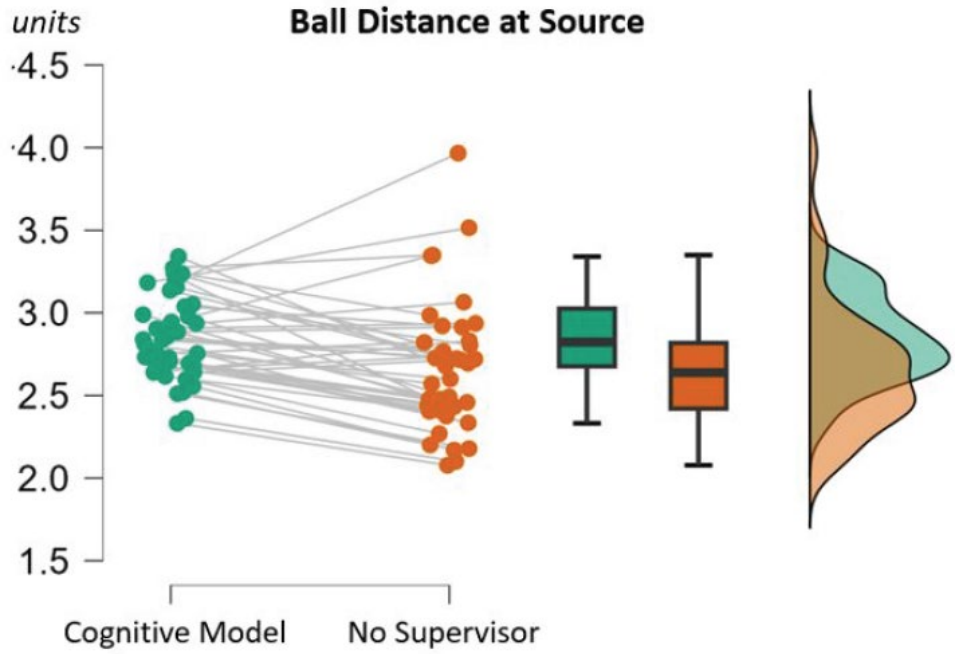




RL-based Attention Management
Evaluation

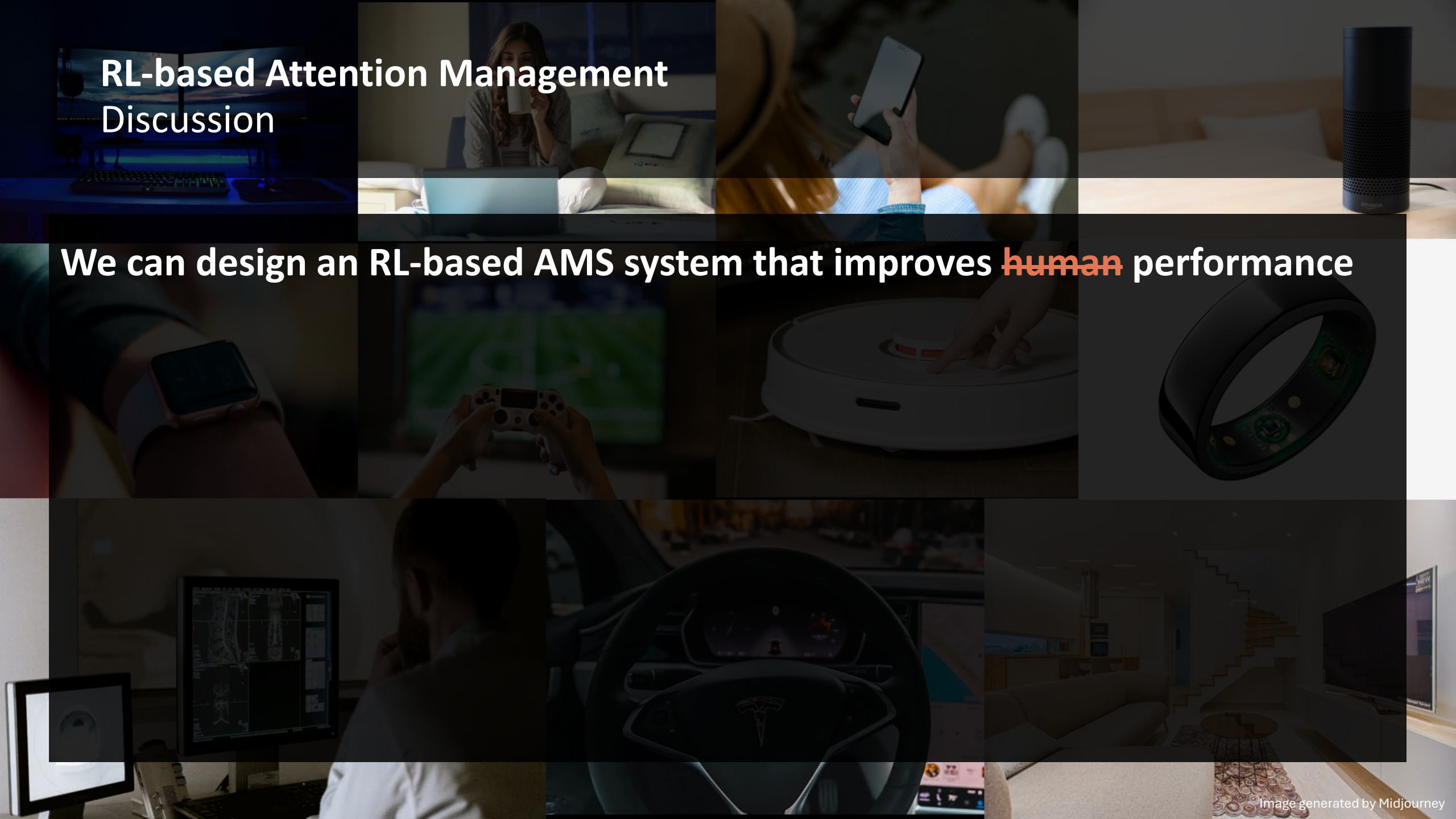
- **Behavior and subjective Perception**
  - Participants switched significantly more „cautious“ in self-supervision
  - The CR-AMS made users switch more often and in more difficult situations (i.e., ball distance to center, ball speeds), countering theory
  - The CR-AMS was perceived a significantly less cognitively and physically demanding (NASA-TLX)





RL-based Attention Management
Discussion

We can design an RL-based AMS system that improves ~~human~~ performance



RL-based Attention Management
Discussion

We can design an RL-based AMS system that improves human performance

- Concept demands computational cognitive models of user behavior
- AMS can provoke fast-paced performance without influencing workload
- Automated switching is superior over user freedom (in fast-paced scenarios)

RL/CR may inspire a new class of interactive systems that integrally consider human resources and limitations

Lingler, A., Talypova, D., Jokinen, J., Oulasvirta, A. & Wintersberger, P. (2024 May). Supporting Task Switching with Reinforcement Learning. *In CHI Conference on Human Factors in Computing Systems (Best Paper Honorable Mention)*

Image generated by Midjourney

RL-based Attention Management
Implications and Future Work

- Confirm results with **different tasks and multitasking scenarios** (driving, airport control tower, office work, smartphone notifications, etc.)
- Optimize for user stress and wellbeing, look into the subjective perception of AMS

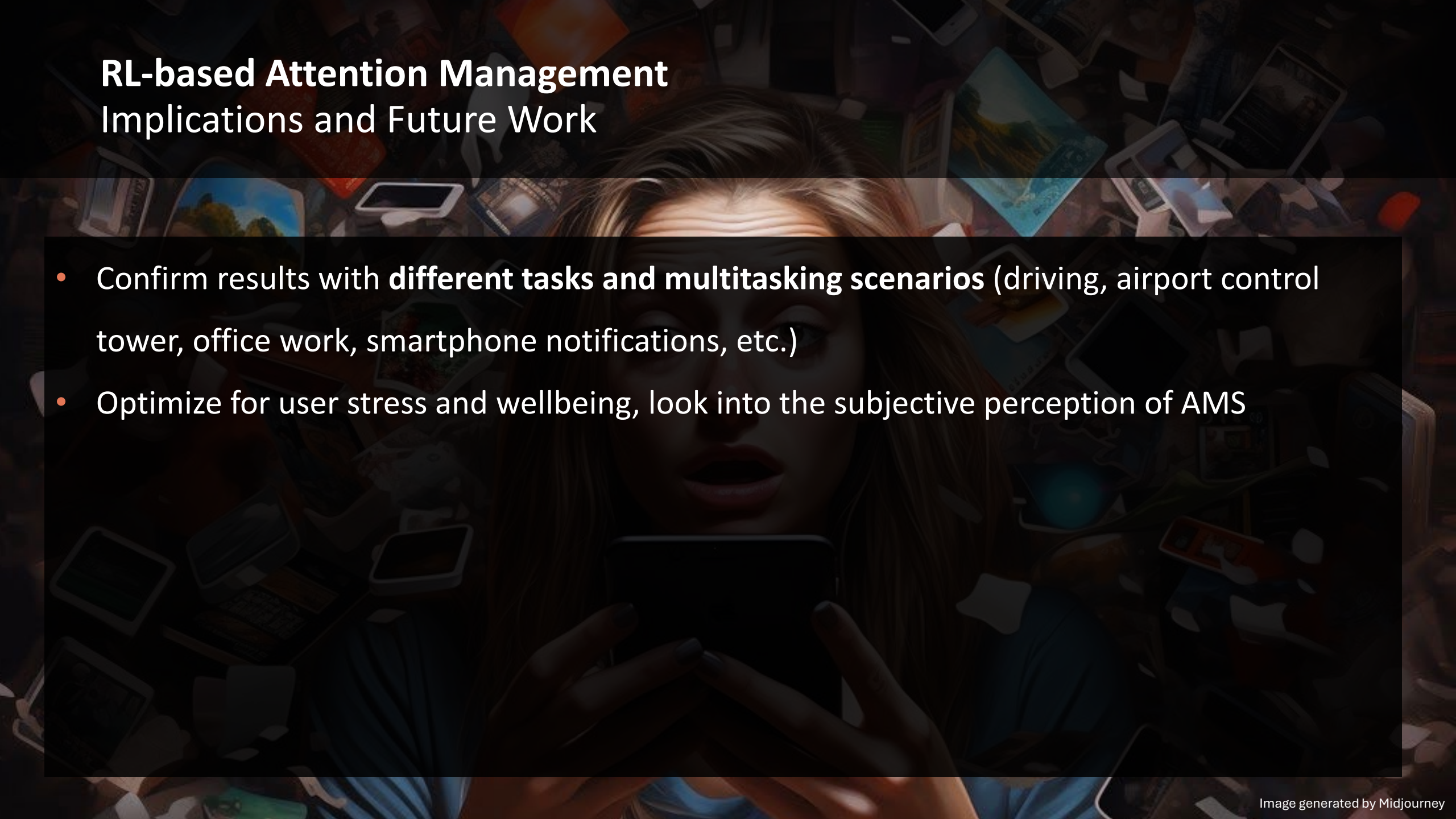


Image generated by Midjourney

Attention Management
Subjective Perception of AMS

- What are accepted notification delay times considering (1) the scenario context and (2) the notification context?
- Which data collection (tracking methods) do users feel comfortable with, considering the scenario context?

Talypova, D., Lingler, A., & Wintersberger, P. (2023, December). User-Centered Investigation of Features for Attention Management Systems in an Online Vignette Study. In Proceedings of the 22nd International Conference on Mobile and Ubiquitous Multimedia (pp. 108-121).




RL-based Attention Management

Implications and Future Work

- **Extend to real environments** that incorporate uncertainty
- **Develop a task- and domain-independent computationally rational model** for task interruption/resumption
- Gauge into other novel AI methods to be utilized, such as LLMs for modeling human memory processes
- Extend to other HCI problems (for example, shared control and distribution of tasks between humans and machines)

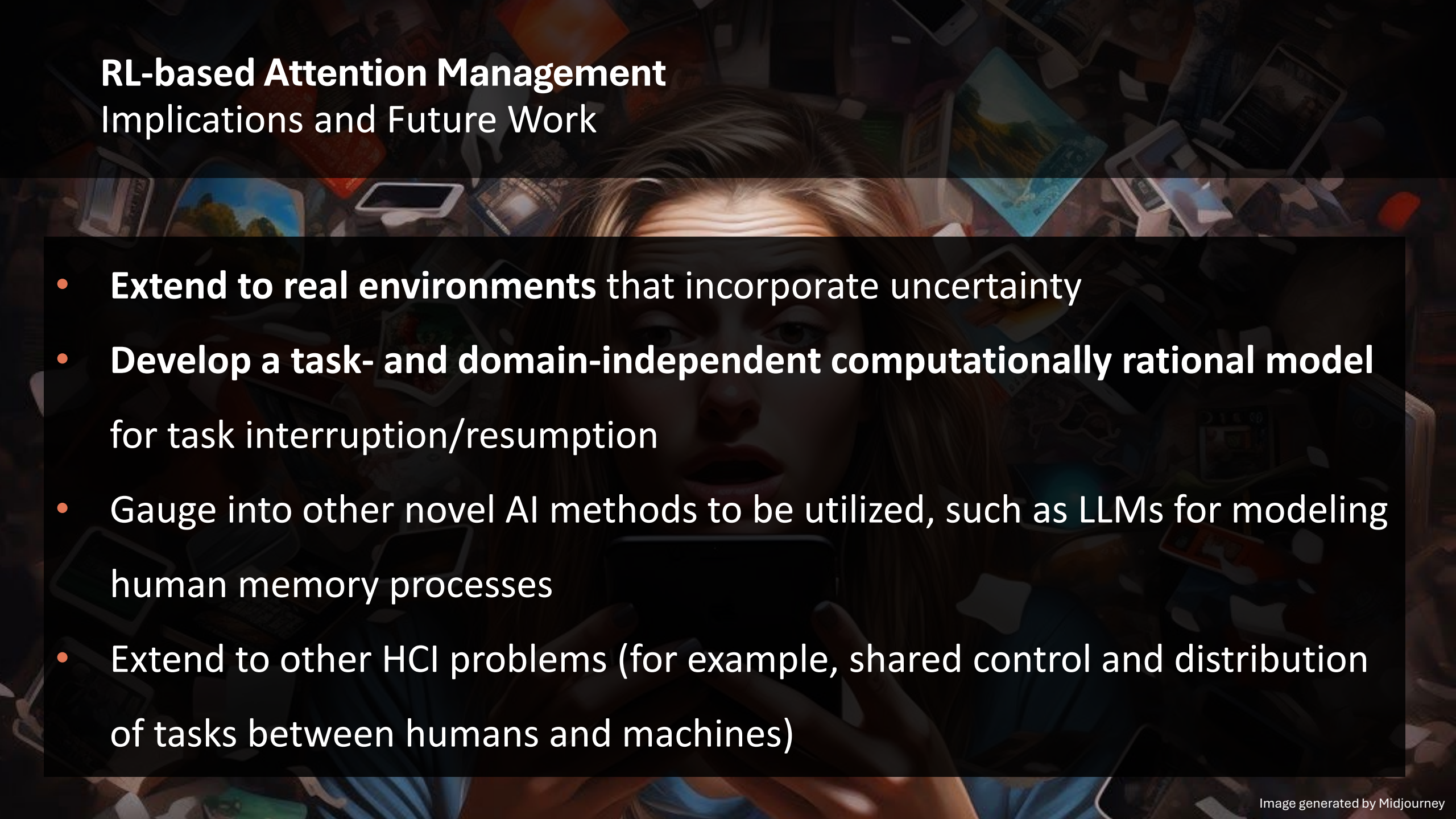


Image generated by Midjourney

GENERATIVE AI FOR FUTURE BUSINESS CASES

Generative Artificial Intelligence

- GenAI: the production of previously unseen synthetic content, in an form and to support any task, through generative modeling [1]
- GenAI Applications:
  - Text generation (Large Language Models, such as GPT.X, etc.)
  - Image Generation (Image Diffusion Models, such as MidJourney, etc.)
  - Video Generation (Video Diffusion Models, such as Dream Machine, etc.)

[1] García-Peñalvo, F., & Vázquez-Ingelmo, A. (2023). What do we mean by GenAI? A systematic mapping of the evolution, trends, and techniques involved in Generative AI.

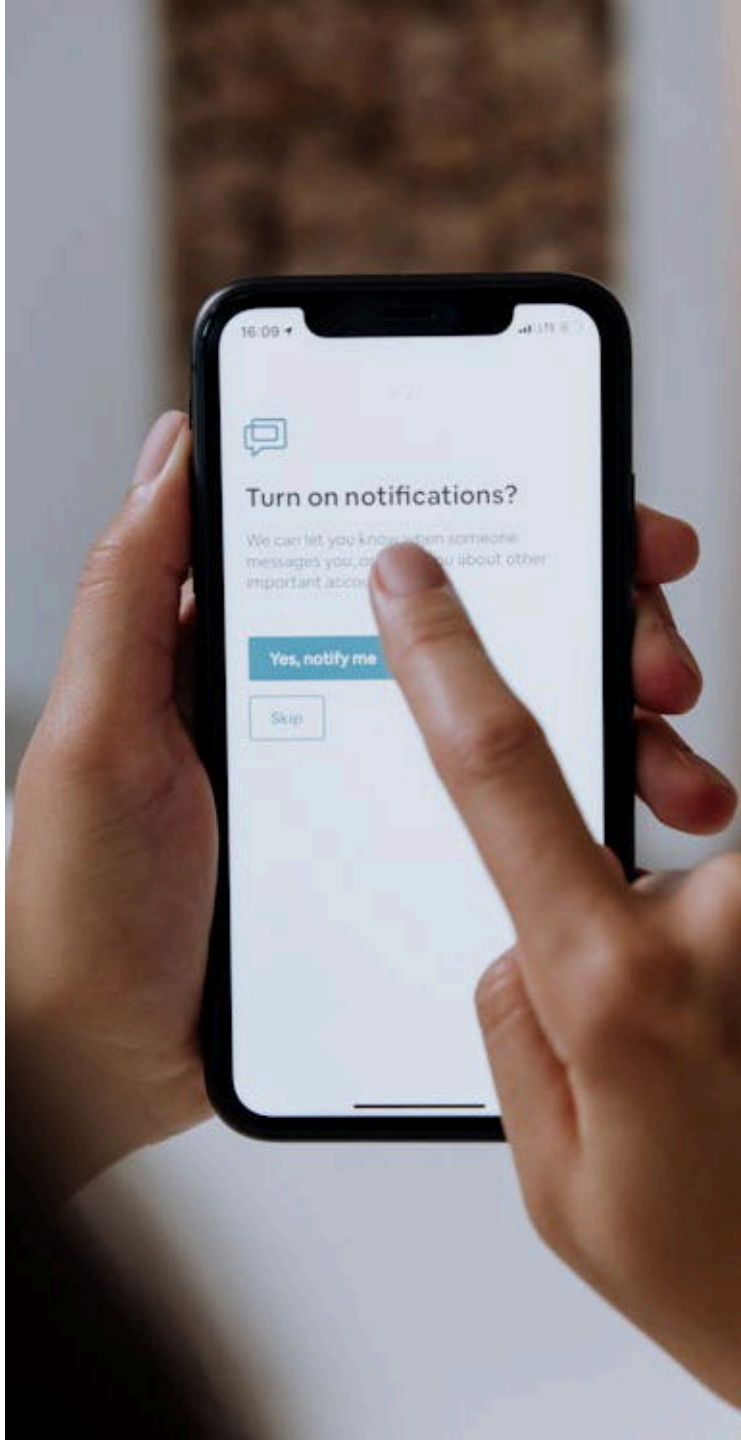
Generative Artificial Intelligence

- Applications and Use-Cases
  - The most boring application of a language model is to just “talk to it” (i.e., ChatBots for service, etc.)
  - Digital Transformation: What underlying problems do we have, and how can we utilize GenAI to help solve these problems?
  - (My) General Guideline: GenAI is especially promising in situations where the risk is low (by default, or due to human oversight) but the value is high

GenAI Example #1: Memory Stream for Attention Management

- Current Situation
  - Any short message (email, WhatsApp, etc.) instantly triggers a notification for the user

- Intelligent User Interfaces Support
  - Every message is put into a prompt-based memory stream
  - The memory stream creates a virtual representation of the users' contacts, their relationships, and frequently discussed topics
  - The memory stream can judge incoming messages to provide context and plan when the user should be notified about the contents



GenAI Example #1: Memory Stream

10:08 Barbara: What do you want to eat tonight?

[Barbara (friend): Asking Philipp about dinner plans.]

13:42 Barbara: Do you remember our wedding, i am currently looking at the pictures

[Barbara (spouse): Reminiscing about their wedding with Philipp.]
[Relevance: 5 Barbara: What do you want to eat tonight?]

17:12 Barbara: I think Pizza would be a good idea!

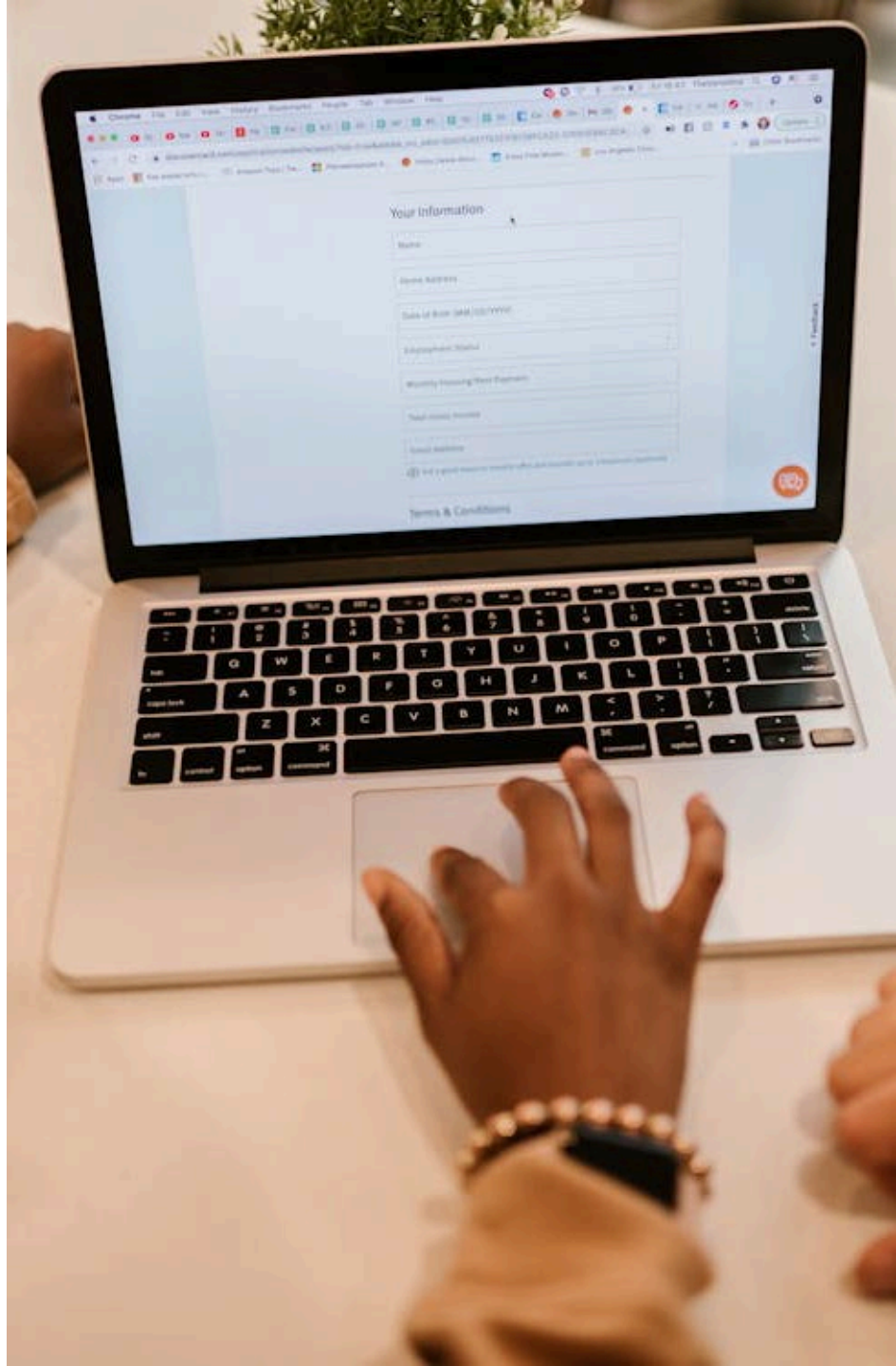
[Barbara (spouse): Suggesting pizza as a good dinner idea to Philipp.]
[Relevance: 2 Reminiscing about their wedding with Philipp.]
[Relevance: 8 Asking Philipp about dinner plans.]

Suggested Notification Delay: Notify immediately to plan tonight's dinner

GenAI Example #2: Semi-Automated Service

- Current Situation
  - A service employee receives images of hand-scanned bills and fills the necessary details into an online form (real example from a project with a company)

- Intelligent User Interfaces Support
  - Entire images of bills are translated into text fragments (extract text from image)
  - An LLM tries to extract the form fields from the text fragments and…
    - Prefills the form fields
    - Provides a rating on the fields (un)certainty
  - The service employee screens and confirms the pre-filled form
  - Result: Increased throughput of bills



GenAI Example #3: Semi-Automated Home Staging

- Current Situation
  - To increase the value of a property for sale, one needs to clear it, take pictures, and find a designer to photoshop a new image of the home to increase sales prices

- Intelligent User Interfaces Support
  - Take a photo of the property
  - Preprocessing: detect edges in the images
  - Utilize image generation AI (here: Stable Diffusion with Control Net to maintain edges) for staging
  - Create multiple pictures, and let users choose

GenAI Example #4: Automated Tourism Experiences

- Current Situation
  - When doing a city trip, one has to pay a tour guide or buy travel books

- Intelligent User Interfaces Support
  - An app uses location and user preferences to tailor a custom tourist experience
  - A guiding story is created in real-time
  - Locations are automatically chosen and garnished with small quizzes
  - Progressing in the story requires visiting the selected sites and answering the questions correctly
  - A new story can be created at any time and for any place


MADER REISEN
08.2.24 - 29.9.24
GLENN MILLER

GenAI Example #5: Automated Advertisement Videos

- Current Situation
  - Writing a script, video shooting, cutting, post-production, etc.
  - Play with multiple GenAI tools separately and iteratively to

- Intelligent User Interfaces Support: Entire Video from a single Prompt
  - LLM: Takes video generation tool documentation and story idea to create a script with multiple scenes and supported camera perspectives
  - Image Generation Tool: Creates starting image for each scene based on the created script
  - Video Generation Tool: Utilizes starting image together with the before-created scene script to create a convincing video
  - Create multiple videos and choose “winner”

„An advertisement for a company selling seeds“

Generative Artificial Intelligence

- Conclusion:
  - The combination of multiple GenAI tools allows for easily ideating and developing new services, tools, and business cases
  - The capabilities of LLMs allow the build of intelligent architectures that go beyond what traditional AI (such as supervised learning) can deliver: context-aware intelligence
  - In its current state, GenAI is best utilized in situations with potentially low-risk but high-value gain

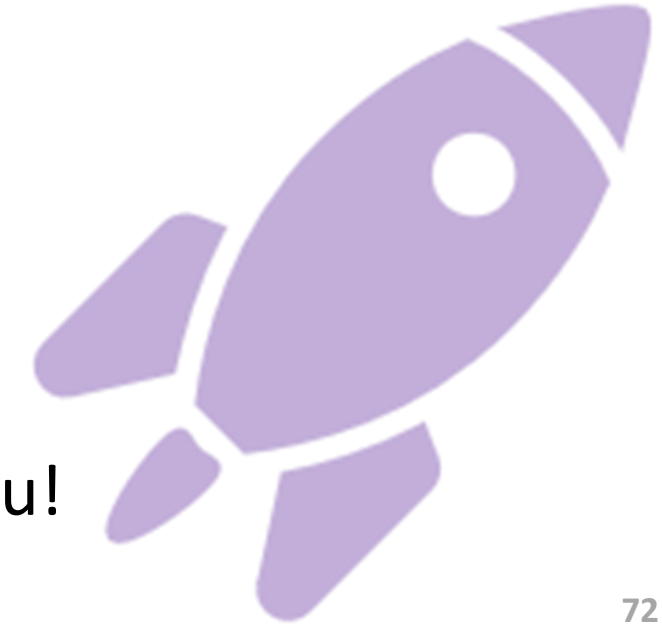
IT:U Offers for Collaboration in Research and Education

interdisciplinary
transformation
university austria

Research Cooperations

How can a company cooperate with IT:U in Research activities?

- Contact us with a problem/use case: office@it-u.at
- We will find the best group/lab for cooperation
- We will find an appropriate call for the project
  - Fundamental research: FWF Programs
  - Applied research: FFG Programs
  - Individual calls for particular projects (i.e., EU level, etc.)
- Our experts will support in proposal writing
- We will act as lead and conduct the project with you!



1. „Friends of IT:U“

A group of committed companies collaborating with IT:U in education

- Contributing challenges
- Supporting a project
- Regular interaction with students
- Invitation to project presentations
  - Major closing event at the end of the semester/year
  - Recognition of the best projects
    - Sponsoring prizes

2. Lab Sponsoring

Facility on IT:U Campus

Equipment

Branding

Joint selection of a lab expert

Facility within the company

3. Industry PhD Funding

- Sponsorship by the company
- Joint call for application
- Time allocation: 50% IT:U| 50% company

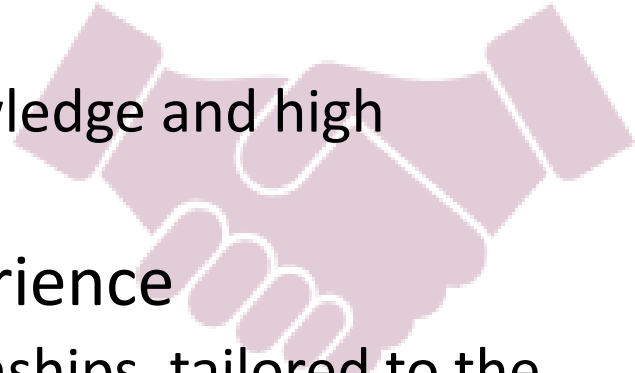
Direct access to current scientific findings and new technologies	The opportunity to outsource specific research tasks and utilize academic funding	Use of university resources and networks by the doctoral candidate	Early access to highly qualified young talents

4. Executive Education

- Enhancement of managers and high potentials with digital skills
- Targeted development of computational and data thinking
- Inspiration for new ideas and solutions to drive innovation and competitiveness
- Multi-day intensive courses
  - Maximum flexibility and compatibility with professional life
- Networking and exchange at a high level

5. Internships

- Targeted access to qualified young talents
  - Provision of motivated students with up-to-date knowledge and high willingness to learn
- Internship placement for relevant academic experience
  - Support in placing students in practice-oriented internships, tailored to the company's needs
- Minor employment opportunities
  - Connecting students for part-time jobs and internships to ease daily operations



Long-term talent acquisition with the opportunity to get to know potential future employees early and retain them in the long run.

COMEING TOGETHER DER OÖ. INGENIEURBÜROS

UNIV.-PROF. DI DR. PHILIPP WINTERSBERGER
PROFESSOR OF INTELLIGENT USER INTERFACES

Mittwoch, 27. November 2024, 16:30 Uhr
WKO Oberösterreich, Europasaal

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