MODULE 5: CONTROLLED EXPERIMENT DESIGN

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Pepper: A Human-Robot-Interaction Focused Robot

CITEC
Cognitive Interaction Technology
Cluster of Excellence
Bielefeld University

CITEC conducted research on human-robot interaction using Pepper (which is developed by SoftBank Robotics); to **study social interaction and how patterns of motion are learned**

- One 3-D and two HD cameras
- Two ultrasonic microphones and speakers
- Six laser sensors
- Four directional microphones
- Tablet computer as an input interface
- Three omni-directional wheels

Pepper: A Human-Robot-Interaction Focused Robot

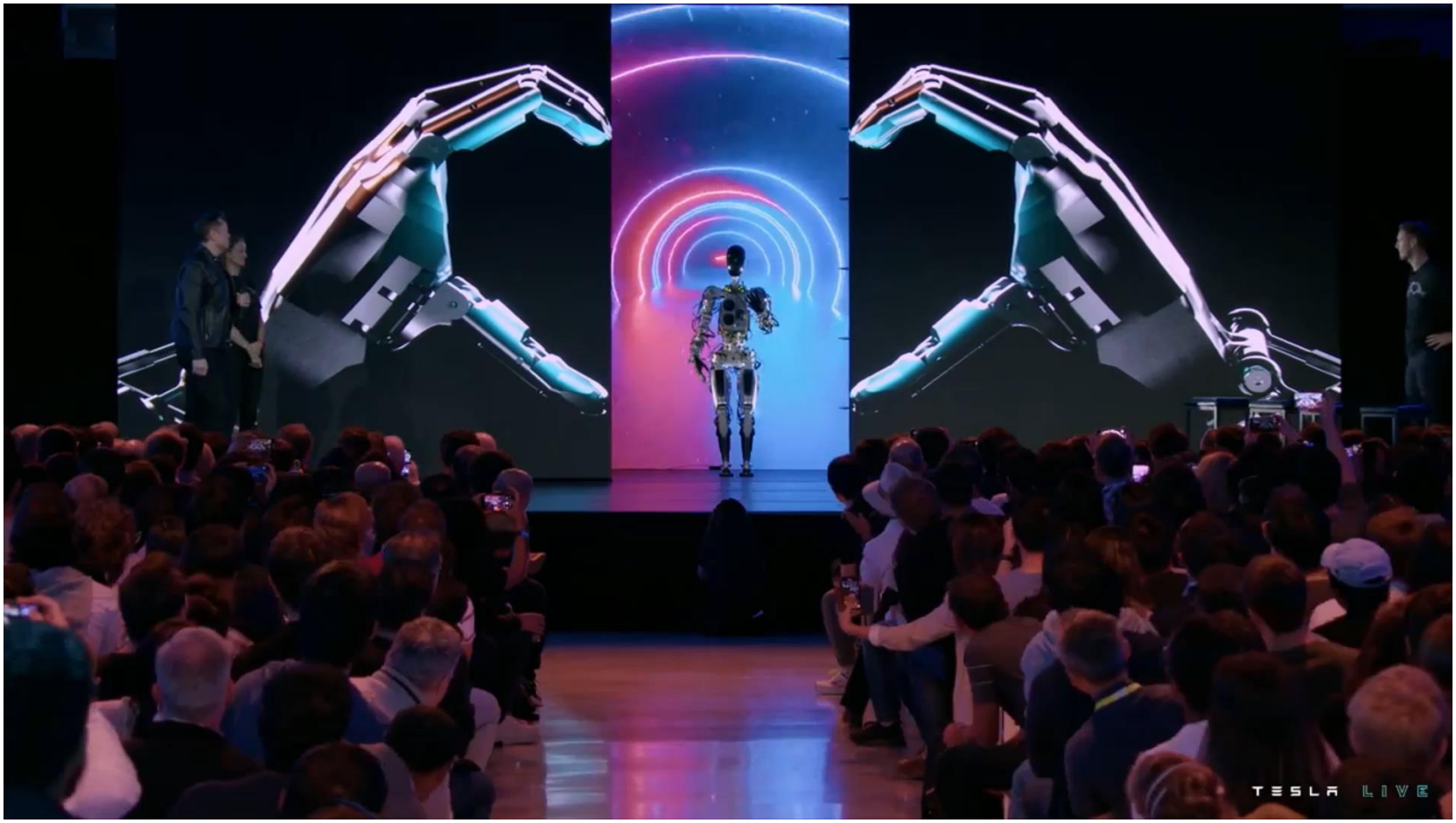
Researchers at CITEC

- Transformed Pepper into a robot that is able to **reliably recognize its environment and attentively understand reactions from humans**
- Are especially **interested in the interface between human and robot**; include integrating AR system to allow people to view Pepper's status from an AR device (e.g. planning route, battery level)
- Taught Pepper to **throw a ball in a cup** and also **to be a museum guide that has to deal with customers' behavior**

Pepper: A Human-Robot-Interaction Focused Robot

Source: https://www.youtube.com/watch?v=0cR26duOhDA

Extra: Tesla Bot



Source: https://www.youtube.com/watch?v=ODSJsviD_SU

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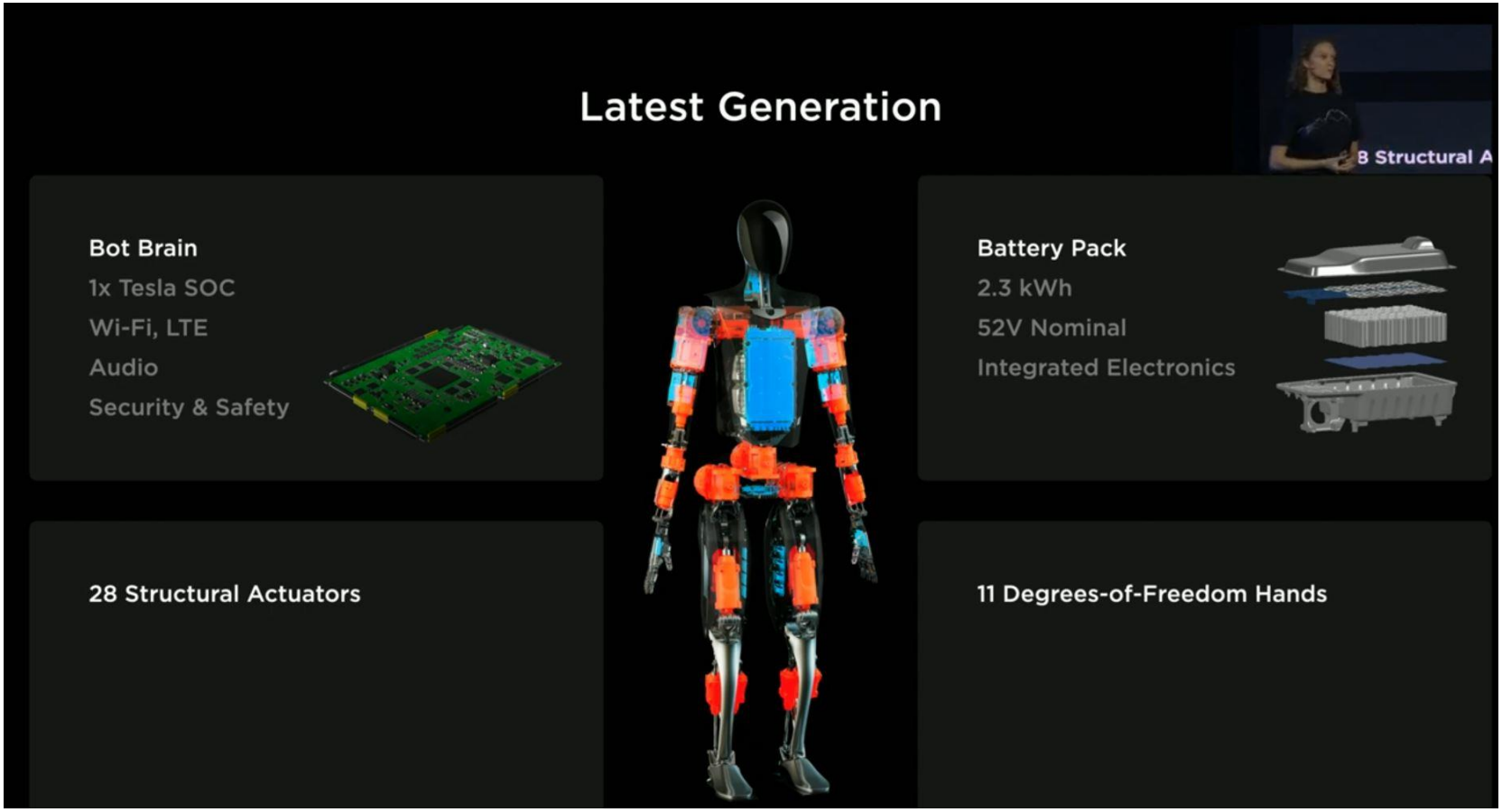


Source: https://www.youtube.com/watch?v=ODSJsviD_SU

EMPIRICAL RESEARCH FOR HUMAN-ROBOT INTERACTION

Topics

Acknowledgement: these slides were adapted from Scott MacKenzie's course in CHI and Shengdong Zhao's workshop in NUS.

What is Empirical Research???

Empirical Research is ...

- Experimentation to discover and interpret **facts**, revise **theories** or **laws**
- Capable of being verified or disproved by observation or experiment
- Very useful in applied research!

Why do Empirical Research???

We conduct empirical research to

- Answer (and raise!) questions about new or existing user interface designs or interaction techniques

- Find cause-and-effect relationships
- Transform baseless opinions into informed opinions supported by evidence
- Develop or test models that describe or predict behavior (of humans interacting with robots/computers)

How do we do Empirical Research???

We conduct empirical research through …

- A program of inquiry conforming to the scientific method,
- Ensuring data collection and analysis are systematic and objective.
- This approach allows for replicable and verifiable results.

The scientific method involves …

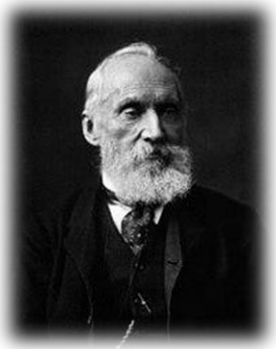
- The recognition and formulation of a problem
- The formulation and testing of hypotheses
- The collection of data through observation and experiment

Observe and Measure

Observations are gathered …

- Manually (human observers)
- Automatically (computers, software, cameras, sensors, etc)

A measurement is a recorded observation



"When you cannot measure, your knowledge is of a meager and unsatisfactory kind."

--- William Thomson, 1st Baron Kelvin (1824 - 1907)

Research Questions

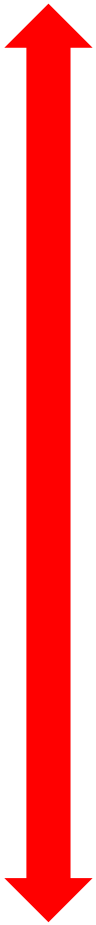
- **Consider the following questions**
  - Is it viable?
  - Is it better than current practice?
  - Which of the several design alternatives is the best?
  - What are the performance limits and capabilities?
  - What are the strengths and weaknesses?
  - Does it work well for novices, for experts?
  - How much practice is required to become proficient?
- **Are these good questions?**

Testable Research Questions

- Preceding questions, while unquestionably relevant, are **not testable**
- Try to re-cast as testable questions (even though the new question may appear less important)
- Scenario …
  - You have invented a new user interface for photo taking using flying cameras, and you think it is better than the existing joystick/joypad interface widely used today
  - You decide to undertake a program of empirical enquiry to evaluation your system
  - What are your research questions?

Testable Research Questions (cont'd)

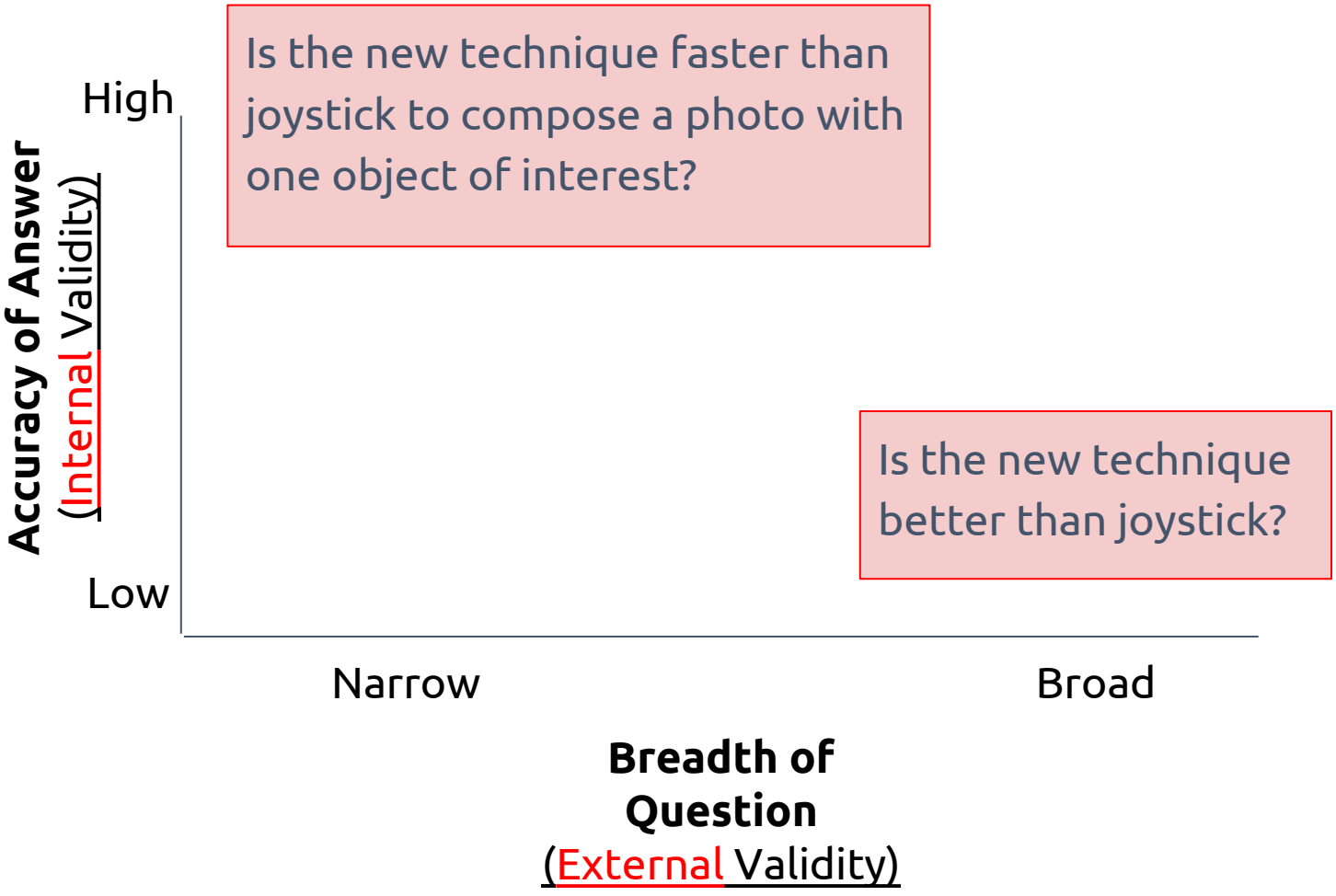
- Is the new technique any good?
- Is the new technique better than joystick?
- Is the new technique faster than joystick?
- Is the new technique faster than joystick to compose a photo with one object of interest?



Weak & untestable

Stronger & more testable

Tradeoff



Internal Validity

- **Definition:**
  - The extent to which the effects observed are due to the test conditions
  - E.g. joystick vs new

- **Statistically …**
  - Differences (in the means) are due to inherent properties of the test conditions
  - Variances are due to participant differences
  - Other potential source of variance are controlled or exist equally and randomly across the test conditions

External Validity

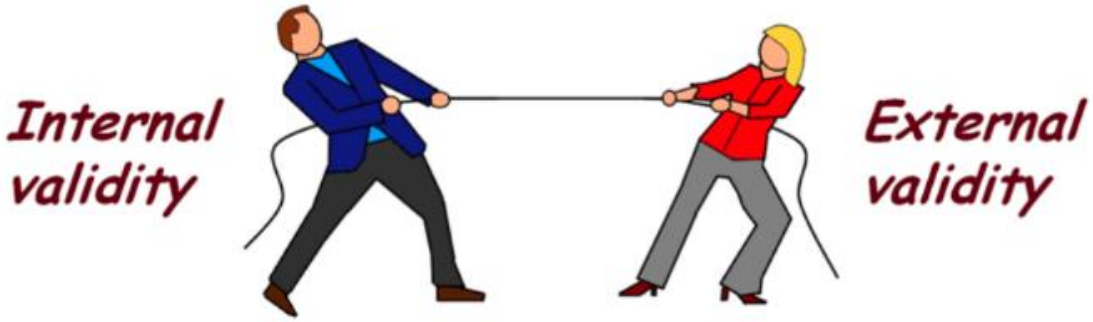
- **Definition:**
  - The extent to which the results are generalizable to other people and other situations

- **Statistically …**
  - The participants are representative of the broader intended population of users
  - The test environment and experiment tasks are representative of real world situations with the interface or technique will be used

Test Environment Example

- **Scenario …**
  - You wish to compare two interfaces for flying camera photography
- **External validity is improved if the test environment mimics expected usage**
- **Test environment should probably involves ..**
  - Taking selfie in a scenery place, e.g., the Marina Bay
  - Let participants use their own mobile devices
  - Let them take photos freely as they like
- **But … is internal validity compromised?**

Tradeoff



- There is tension between internal and external validity
- The more the test environment and experimental tasks are “relaxed” (to mimic real-world situations), the more the experiment is susceptible to **uncontrolled sources of variation**, such as environmental variations, distractions, or secondary tasks.
- How can we deal with the tradeoff??

Best of both worlds

- **Internal and external validity are increased by …**
  - Posing multiple narrow (testable) questions that cover the range of outcomes influencing the **broader** (untestable) questions
  - E.g. A technique that is faster, is more accurate, take fewer steps, is easier to learn, and is easier to remember, is generally **better**

- **The good news**
  - There is usually a positive correlation between the testable and untestable questions
    - ➢ Participants generally find a system **better** if it is faster, more accurate, takes fewer step, easier to learn and remember, etc

EXAMPLES OF APPLICATION USE CASES OF EMPIRICAL RESEARCH FOR HRI

Body Language Communications

by The University of British Columbia

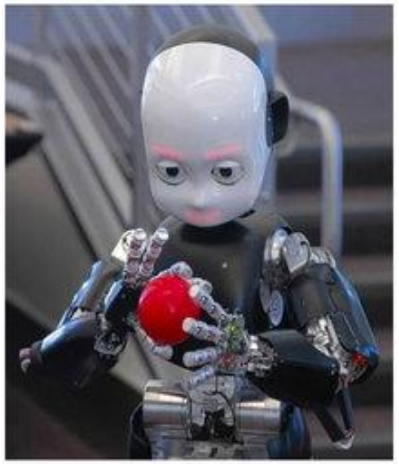
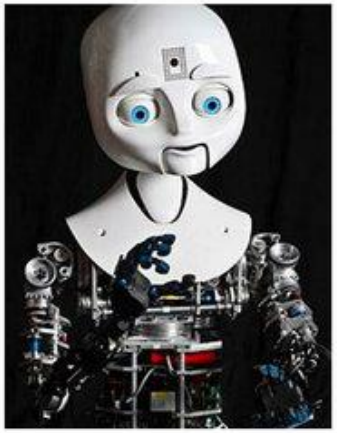
Source: https://www.youtube.com/watch?v=5AQ-E3njViw

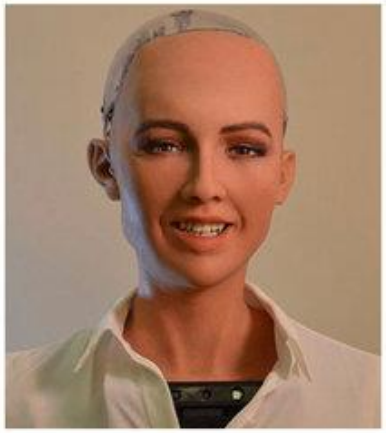
Experiment Ideas for Body Language; E.g.

1. **Trying out variety of gestures** – to evaluate the effectiveness of different robot gestural communication styles in conveying information and facilitating interaction
2. **Cultural Variations in Interpretation** – investigate how people from different cultural backgrounds interpret and respond to the body language of robots, considering variations in cultural norms and expectations
3. **Influence on human comfort/task performance** – Explore how the robot's posture or body language influences human comfort and/or task performance in shared workspaces
4. **Proxemics and Personal Space** – Investigate how people respond to a robot invading or respecting their personal space, and how adjusting proxemic behavior affects user comfort and engagement

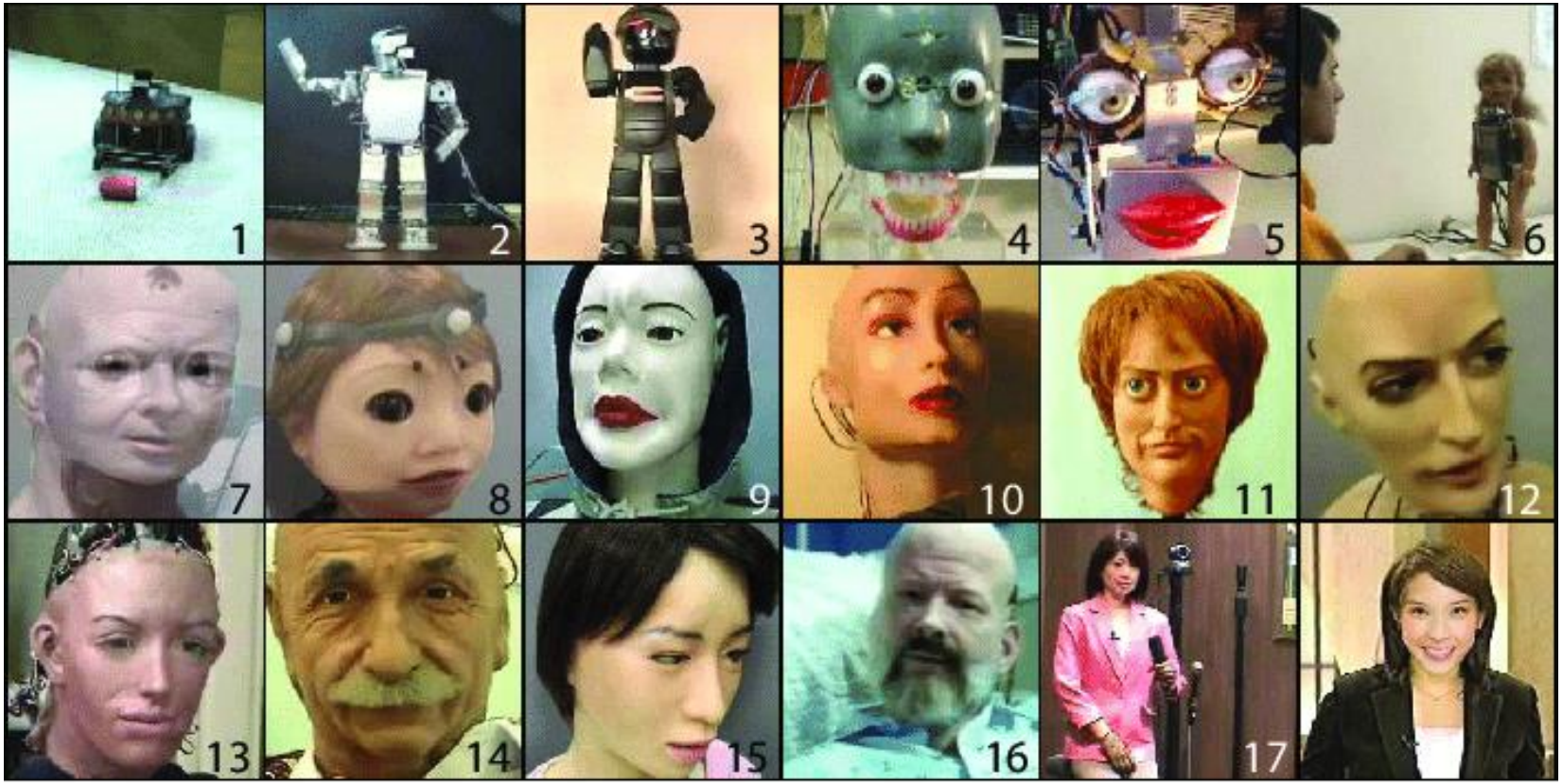
Physical Appearance of Robots



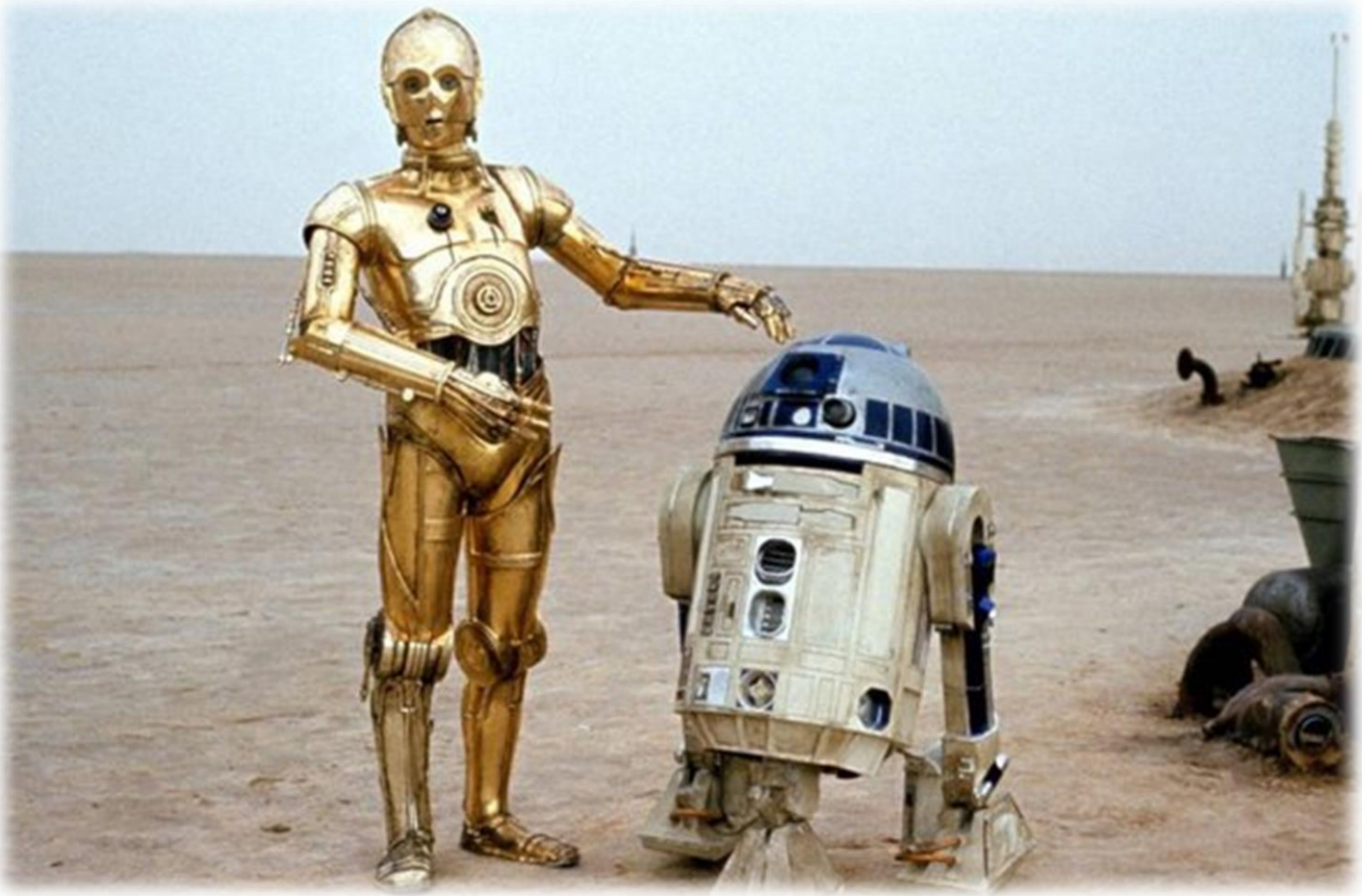






Physical Appearance of Robots



Physical Appearance of Robots



Experiment Ideas for Physical Appearances of Robots; E.g.

1. **Anthropomorphism and Trust** – to investigate how different levels of anthropomorphism in a robot's design influence user trust and acceptance, human-like vs machine-like features
2. **Cultural Perceptions of Robot Appearance** – investigate how people from different cultural backgrounds perceive and respond to robots with varying physical appearances, considering cultural norms and aesthetics
3. **Gender Influence** – Explore how gendered characteristics of a robot (e.g., masculine, feminine, or gender-neutral) affect user preferences, engagement, and comfort in various interaction scenarios
4. **Humanoid vs. Non-Humanoid Robots** – Compare user perceptions and preferences for humanoid robots against non-humanoid robots in specific contexts, such as healthcare, assistance, or entertainment

Other Empirical Research Topics for HRI

1. User experience in HRI-based systems
2. User adaptation to various robot behaviors
3. Robot verbal communication
4. Emotional Intelligence in Robots
5. Trust between humans and robots in various contexts, e.g. healthcare, manufacturing, personal assistance
6. Privacy Concerns in HRI-based systems

THE FUTURE OF HUMAN ROBOT INTERACTIONS

The Future of Human Robot Interactions by MIT CSAIL
(Computer Science & Artificial Intelligence Laboratory)

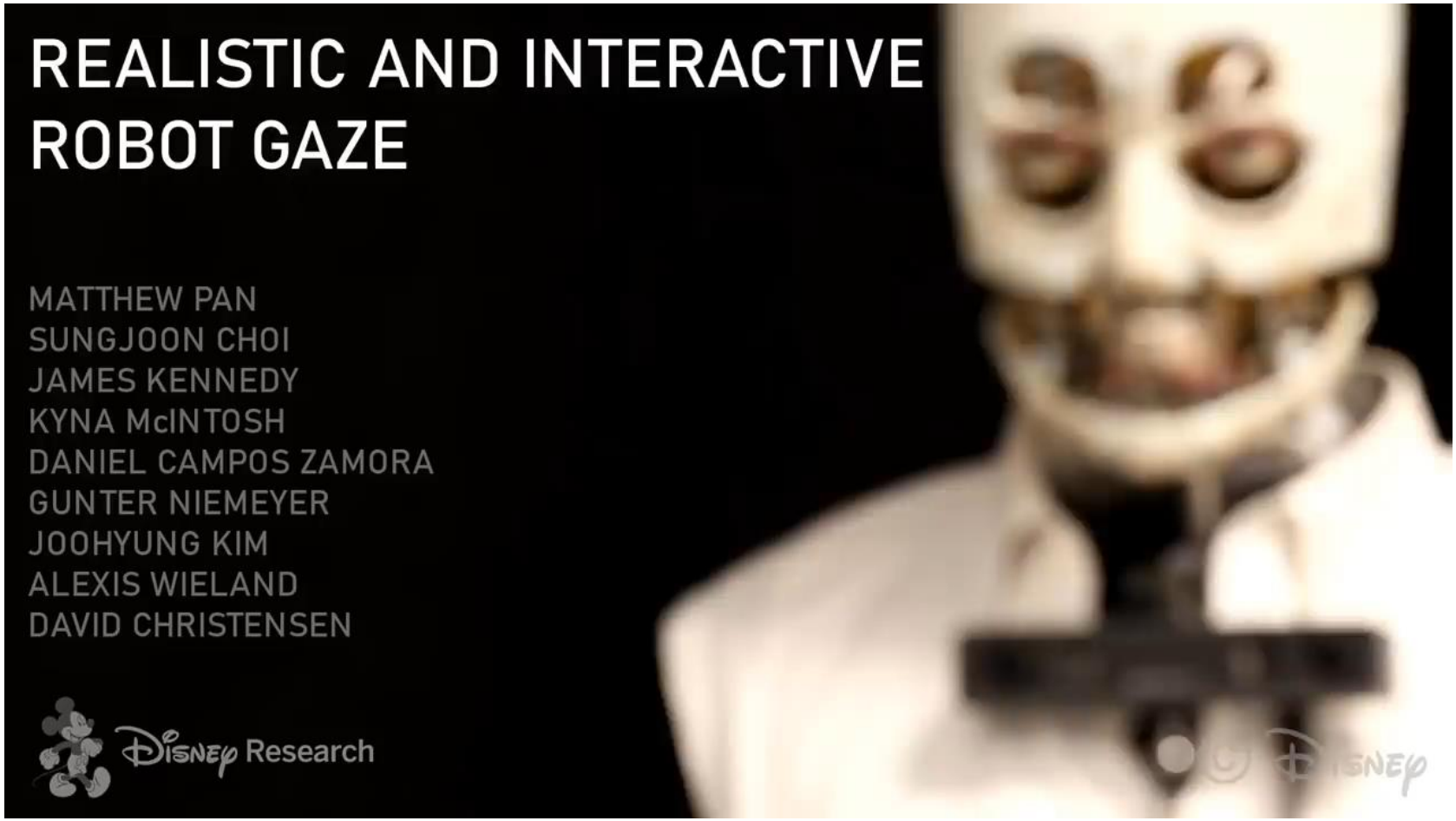
Source: https://www.youtube.com/watch?v=Zd9WhJPa2Ok

The Future of Human Robot Interactions by Embodied Inc.

(Moxie, an Emotionally Intelligent Robot)

Source: https://www.youtube.com/watch?v=LQlNtxurleo

The Future of Human Robot Interactions by Disney Research



Source: https://www.youtube.com/watch?v=D8_VmWWRJgE&feature=youtu.be

THANK YOU

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