Design and Evaluation of Service Robot's Proactivity in Decision-Making Support Process

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Service Robot – Support Human Decision-Making

Role examples

- Shop assistants *(Canda et al., 2009)*
- Receptionists *(Lohse et al., 2014)*

Previous work focuses on

- Question answering algorithm
  (Johannes et al., 2015)

Gap: manner of service

- Human proactivity
  (Grant et al., 2008)
- Affect worker's performance
  (Crant et al., 2000)

Source:
https://www.japantimes.co.jp/news/2014/12/01/business/tech/softbanks-pepper-robot-debuts-coffee-machine-salesman-bic-camera/#.XMAfzej7SUk

This Work

Possible effects of robot’s manner

- On users’ perceptions *(Sun et al., 2017)*
- On users’ behaviors *(Takayama et al., 2009)*

Anticipation-autonomy robot policy framework

- Principle: *high-*, *medium-*, *low*-proactivity
- Behavior policies in a decision-making support (DMS) process

Within-subject, Wizard-of-Oz experiment

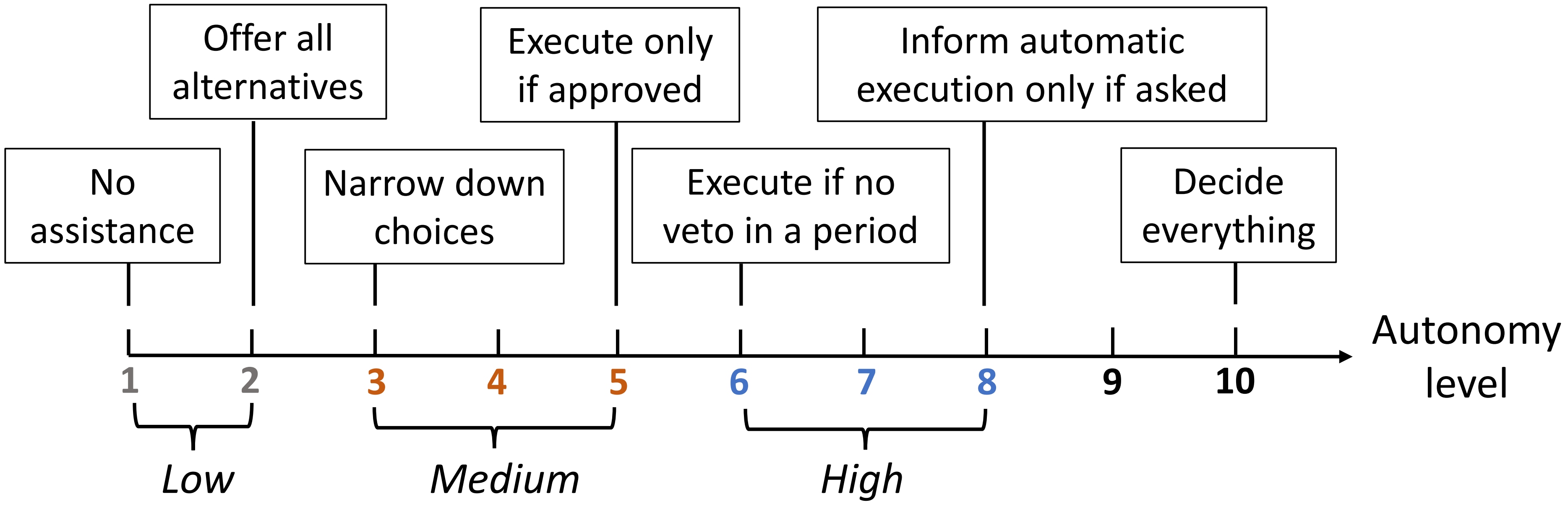
- How people perceive and interact with robots of different proactivity
- Insights into designing robot’s way of behaving

Robot's Proactivity

Definition: *(derived from Grant et al., 2008)*

Anticipatory action that robots initiate to impact themselves and/or others

- **Anticipation** – Assumption on human's next action
- Initiation of action – System **autonomy** *(Sheridan et al., 1978)*



- Target of impact – Human Partner

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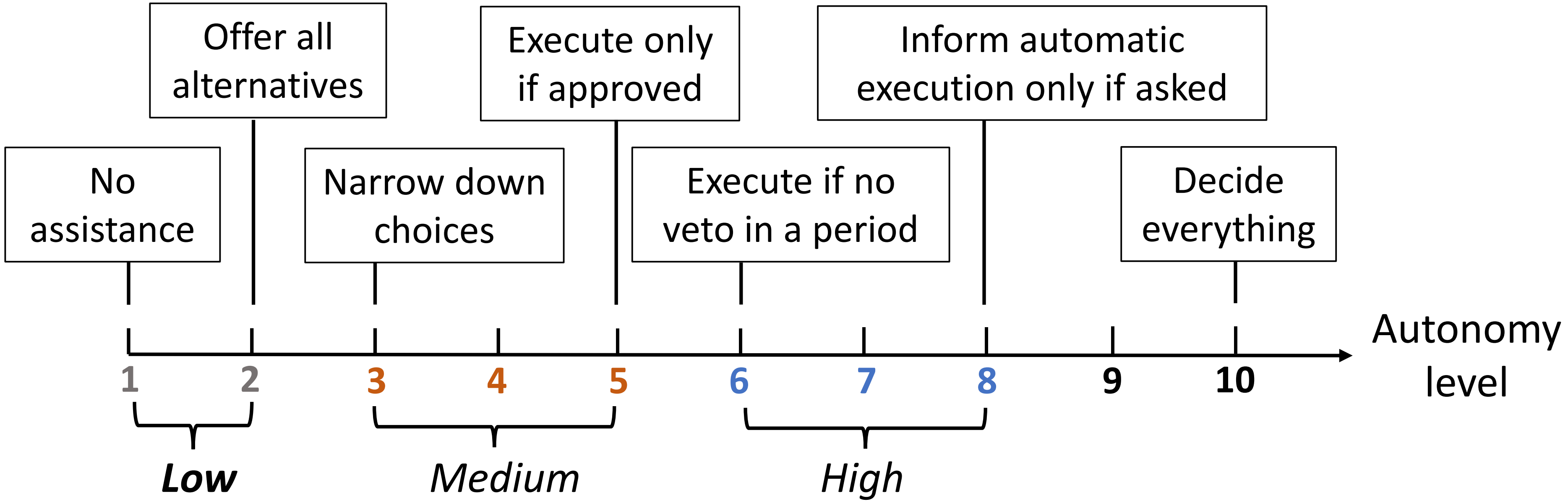

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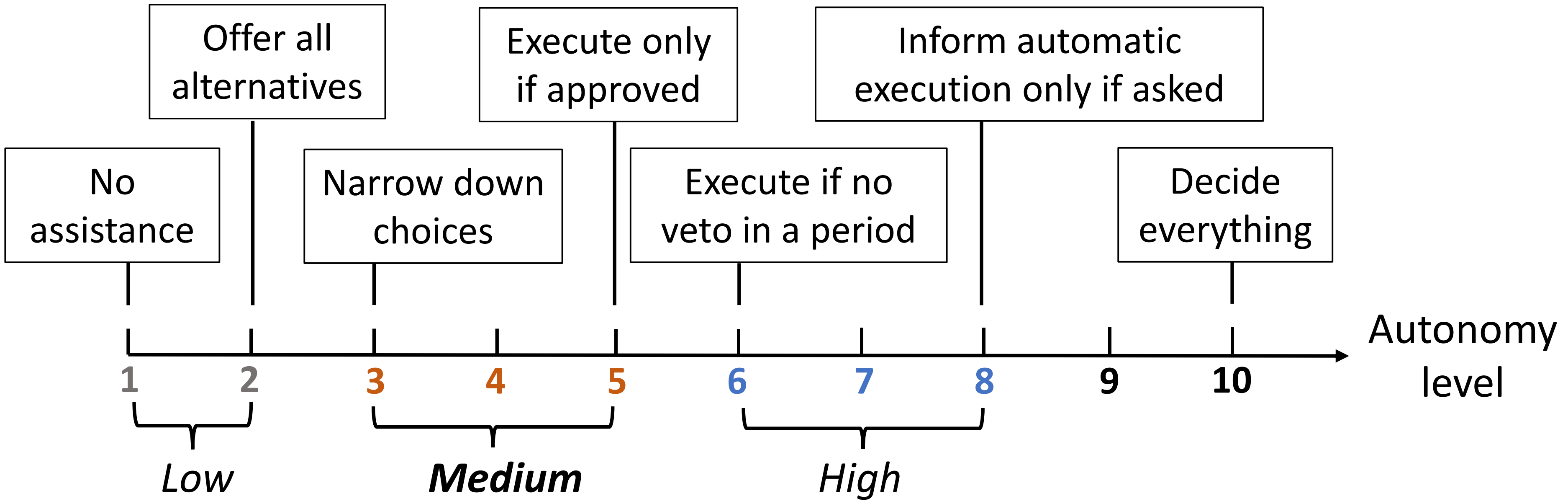

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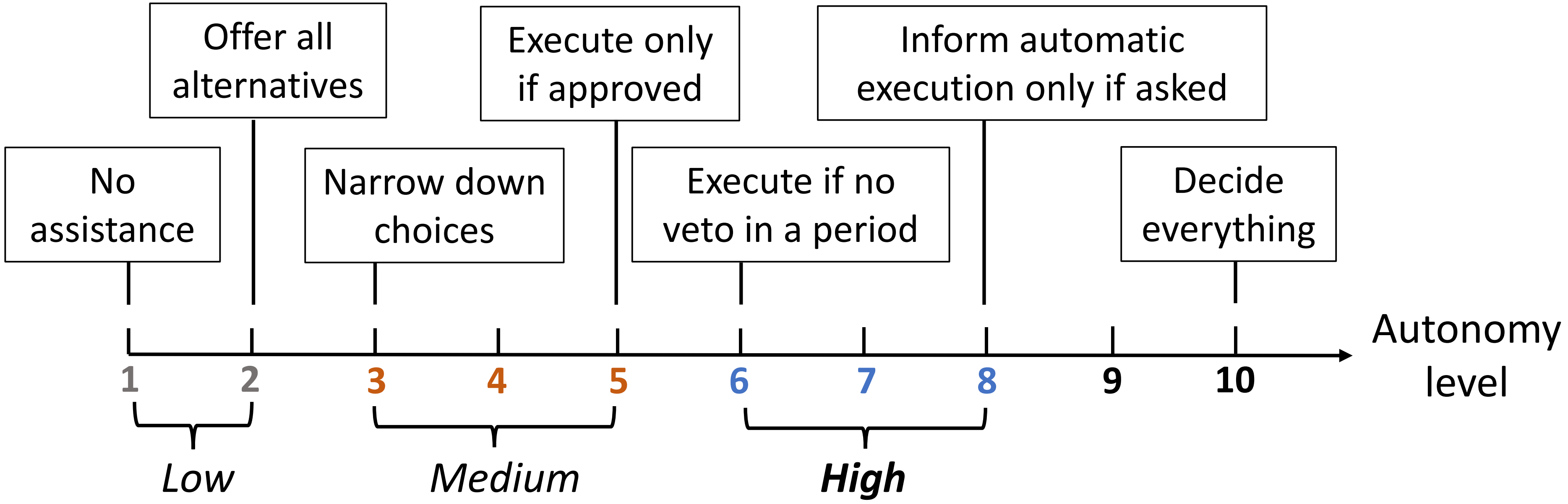

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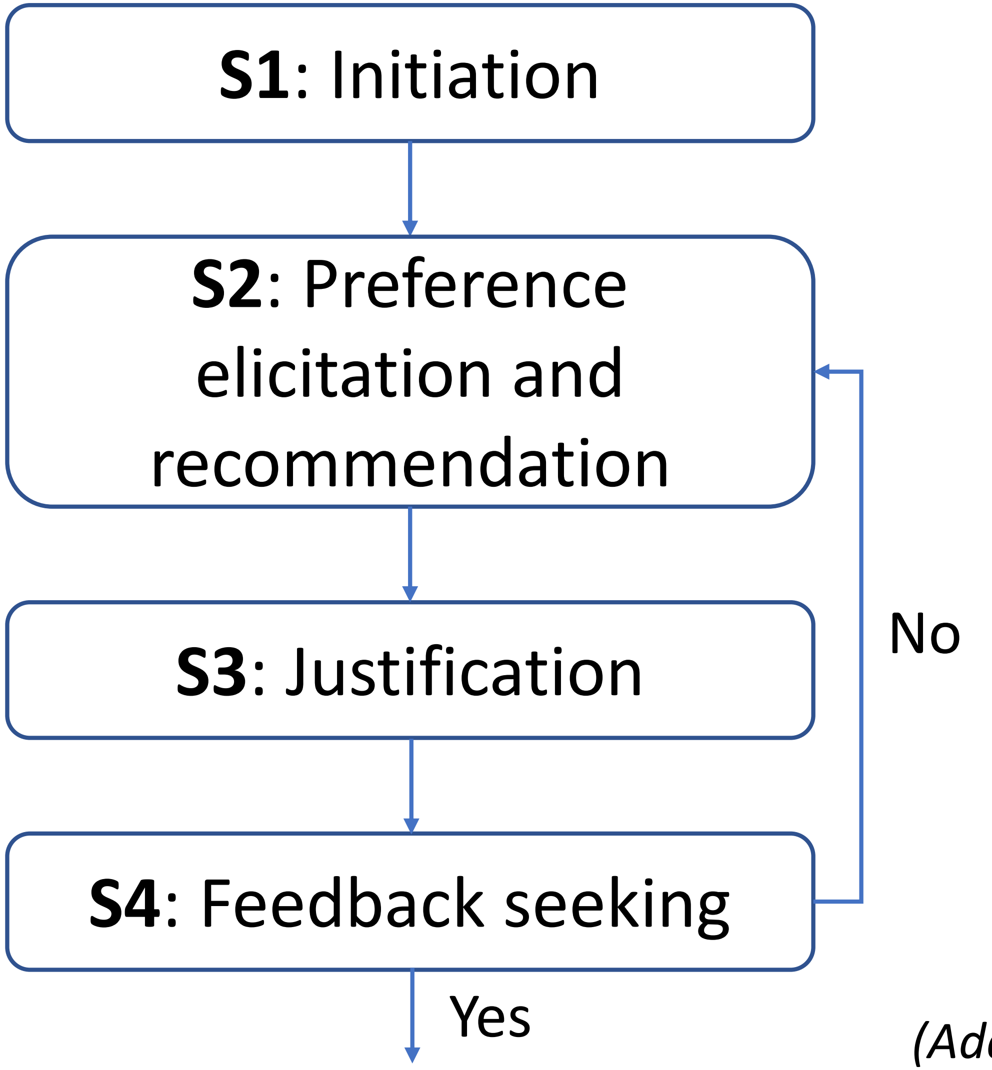
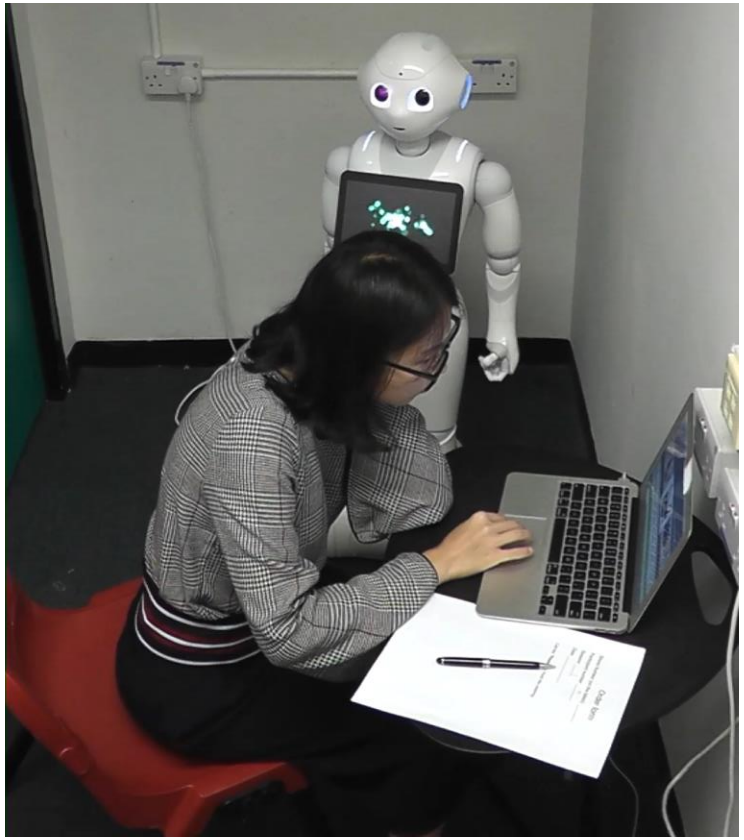
A Structured DMS Process

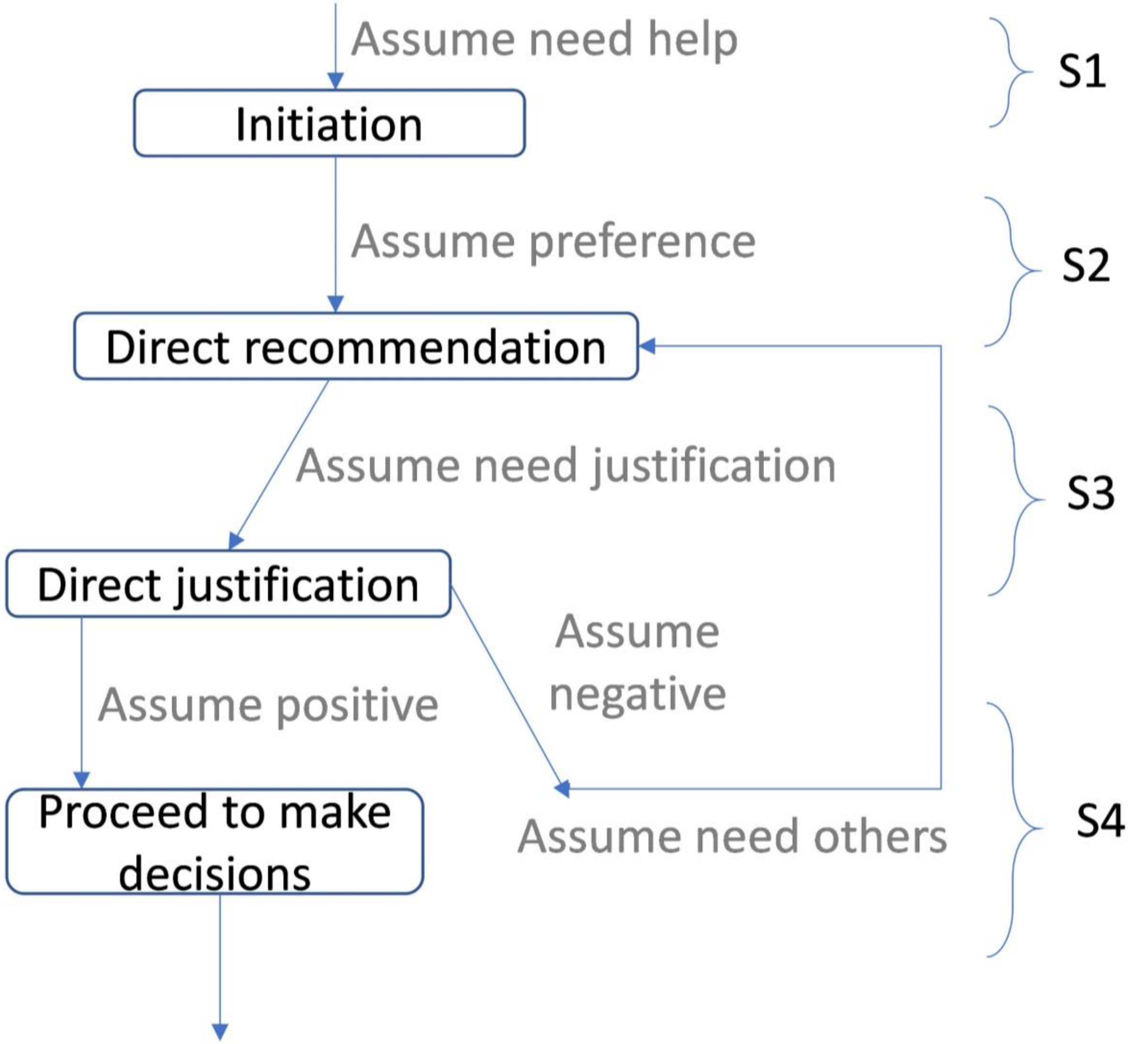


(Adapted from Chen et al., 2012)

High-proactivity Robot Behavior Policy

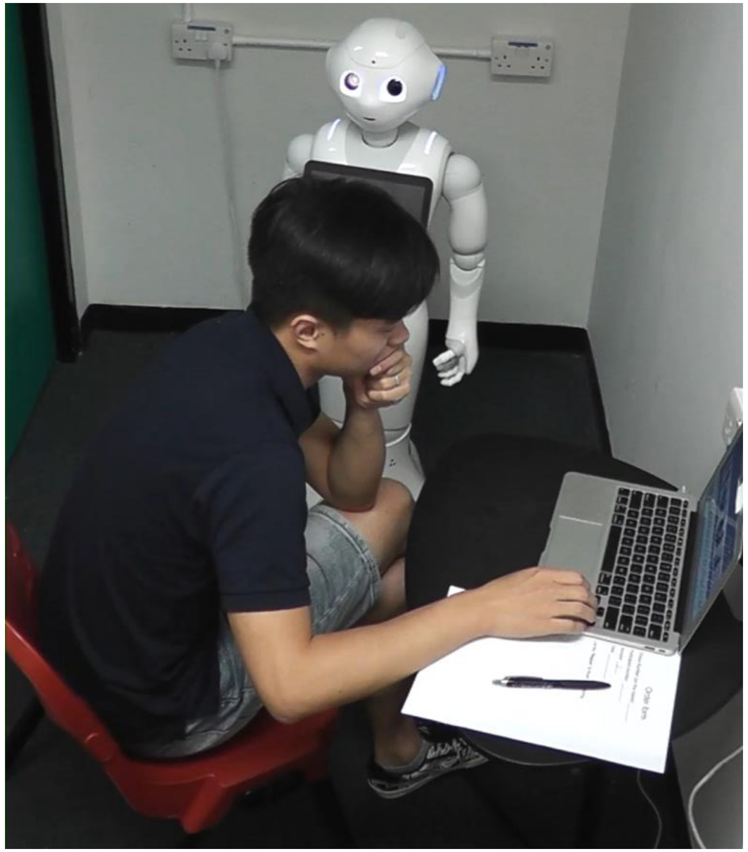
- Strong assumptions, actively offer help
- *High* autonomy

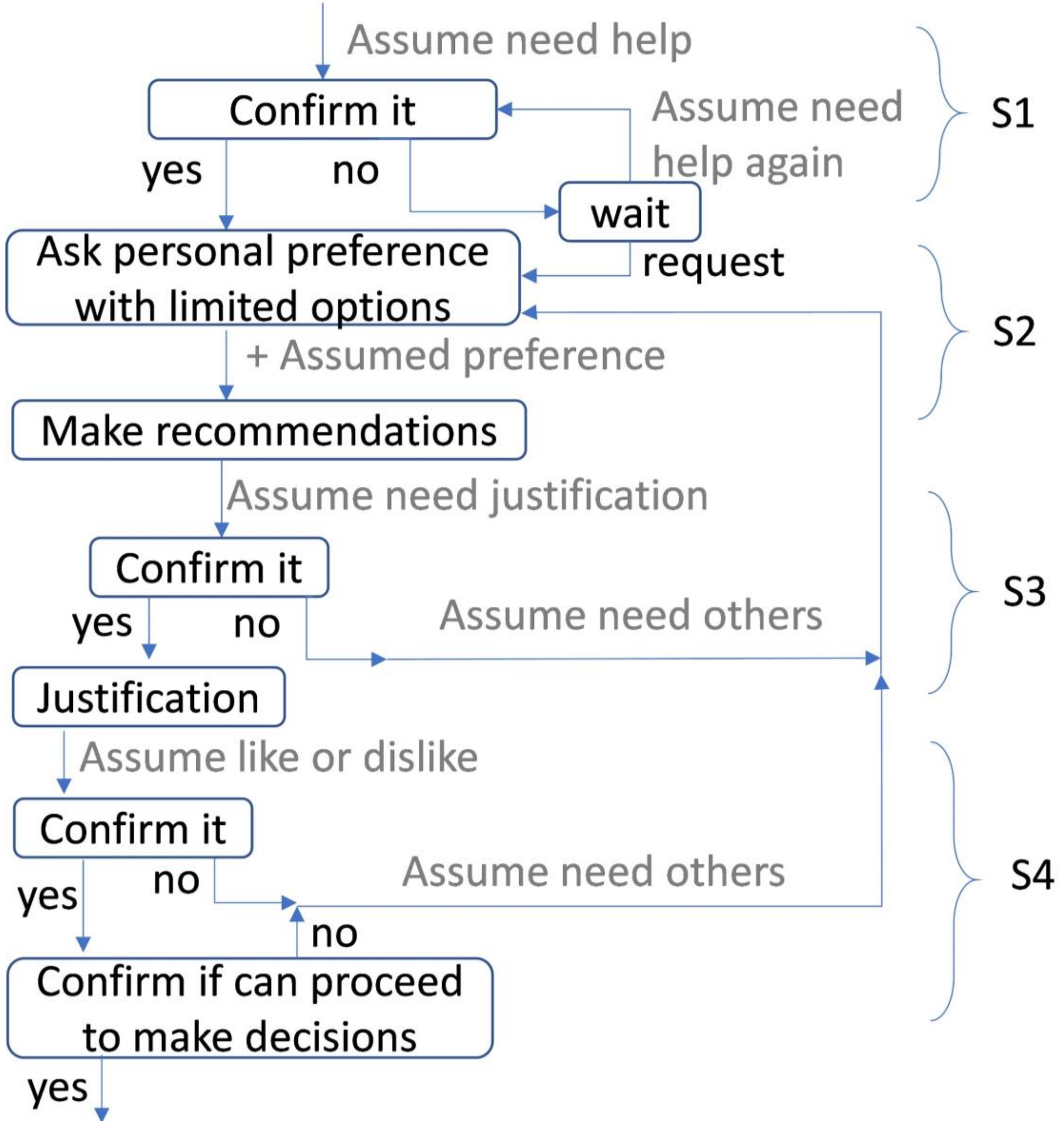




Medium-proactivity Robot Behavior Policy

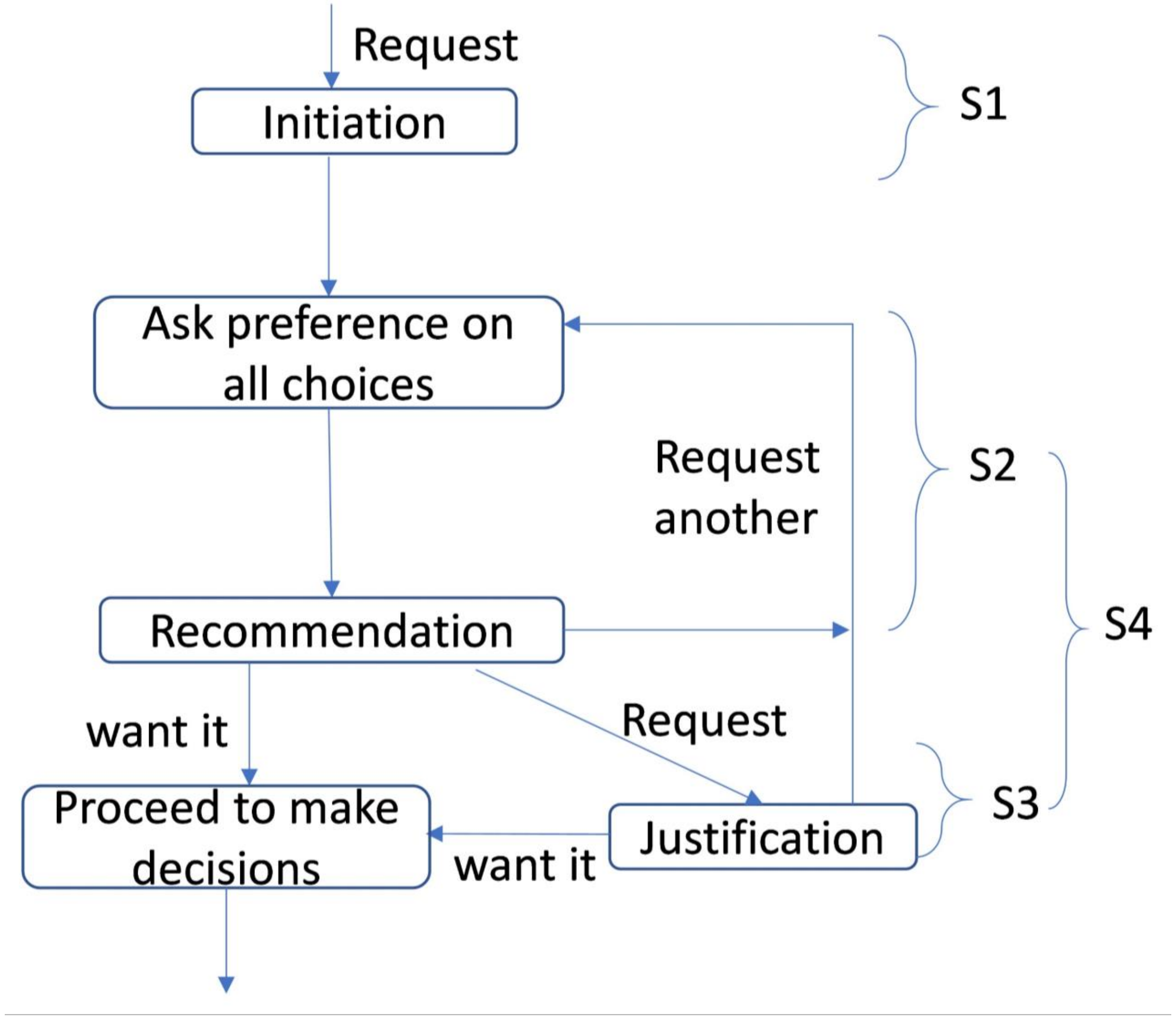
- Some assumptions, let user verify them
- *Medium* autonomy





Low-proactivity Robot Behavior Policy

- No assumptions, need user to tell what they want
- *Low* autonomy



Experiment to Evaluate the Effects

Settings

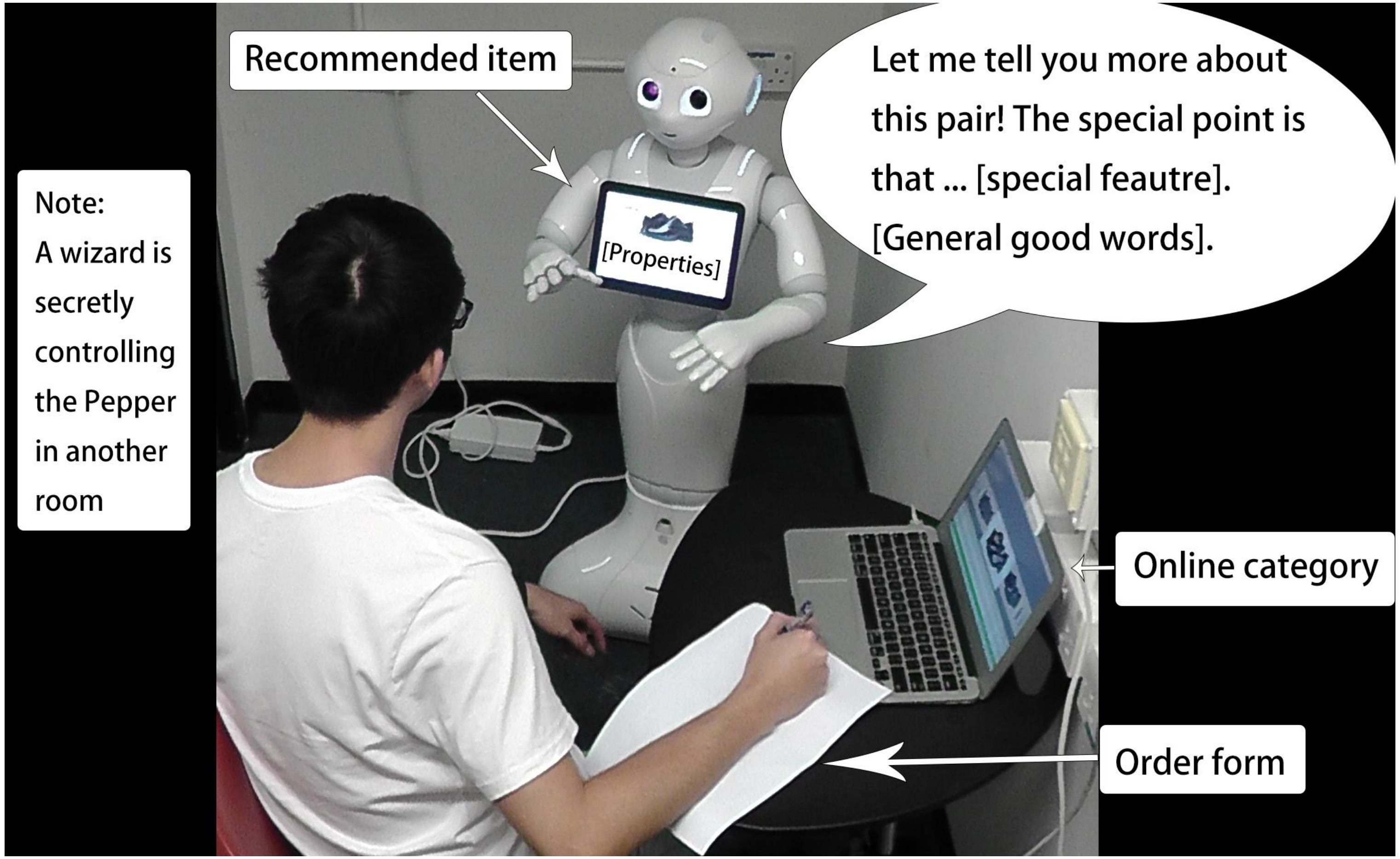
- Shoe shopping
- Robot assistant
- Laptop for browsing online category

Hypotheses

- Appropriateness
- Helpfulness

Behavior Analysis

- Turn-taking behaviors
- Purpose of users' turn
- Attitudes to recommended item



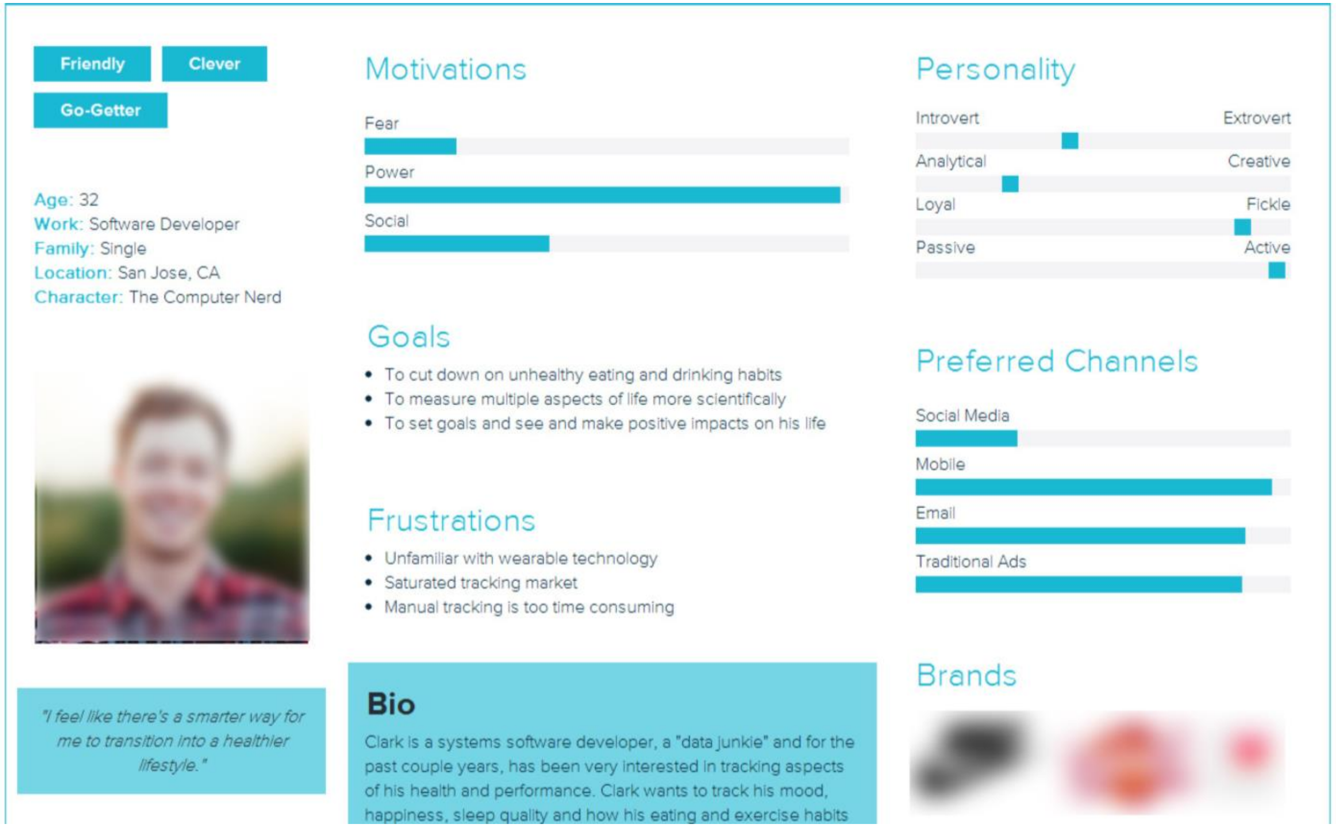
Experiment Details

Three conditions
- *High-*, *medium-*, *low*-proactivity

Tasks
- Buy a pair of suitable shoes for a persona
- Reason needed
- Counterbalanced

Participants
- 36 (avg. age: 23.75)
- Gender-balanced
- ~ 40 mins / person

Persona	Shoe type	Color	Occasion
Men	Oxfords	Black or Brown	Dress or Casual
Women	Heels	Black or Beige	Dress or Casual
Teens	Sneakers	Black or White	Skate or Running



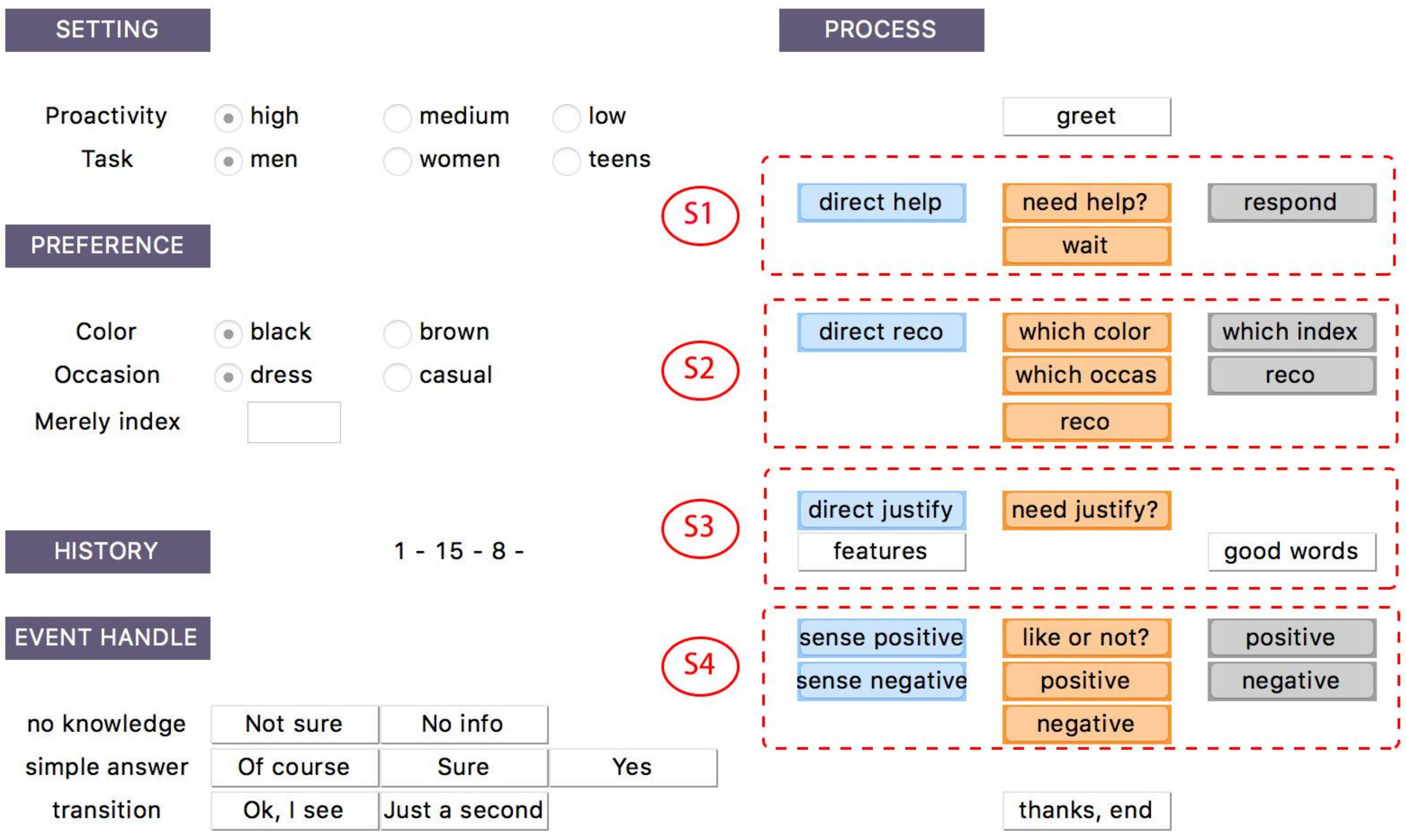
Experiment Details

Wizard-of-Oz

- Infer intentions
- Trigger robot responses
- Button-based interface

Data Collection

- Questionnaires
- Post-study interview
- Video recording



Robot's Script Samples for Justification

- Modified from shoppers' reviews
- Test all the scripts in a pilot study

Feature & good words
Suitable for walking
Stylish and fashionable
Water proof, easy to clean
Latest design
Best materials
General good words

Results – on User Perceptions

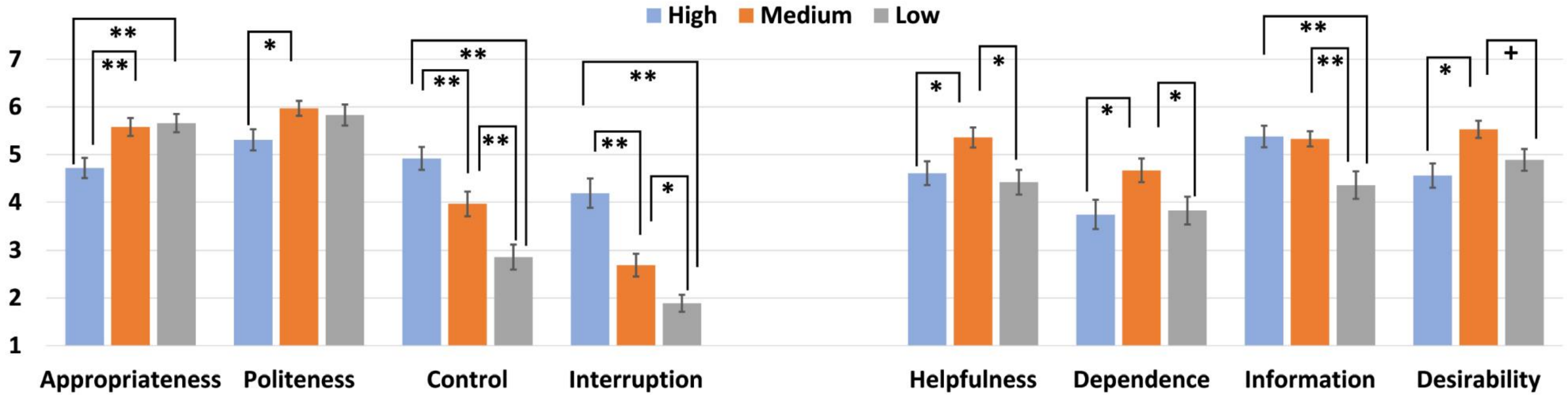


Figure 4: Means and standard errors of the user perception of the robots in terms of appropriateness (left) and helpfulness (right) on a 7-point Likert scale ($+ : .05 < p < .1, * : p < .05, ** : p < .01$).

***High*-proactivity robot**

- Least appropriate, though it can provide rich information

***Medium*-proactivity robot**

- Most helpful, more desirable to be served by it in the future

***Low*-proactivity robot**

- More user control, less interruptive

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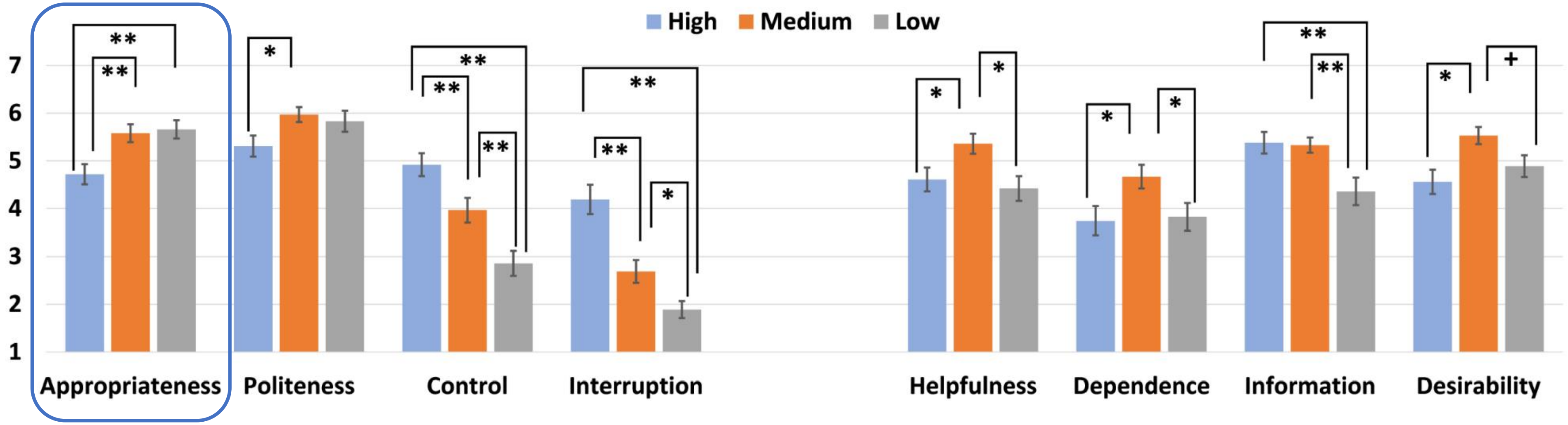

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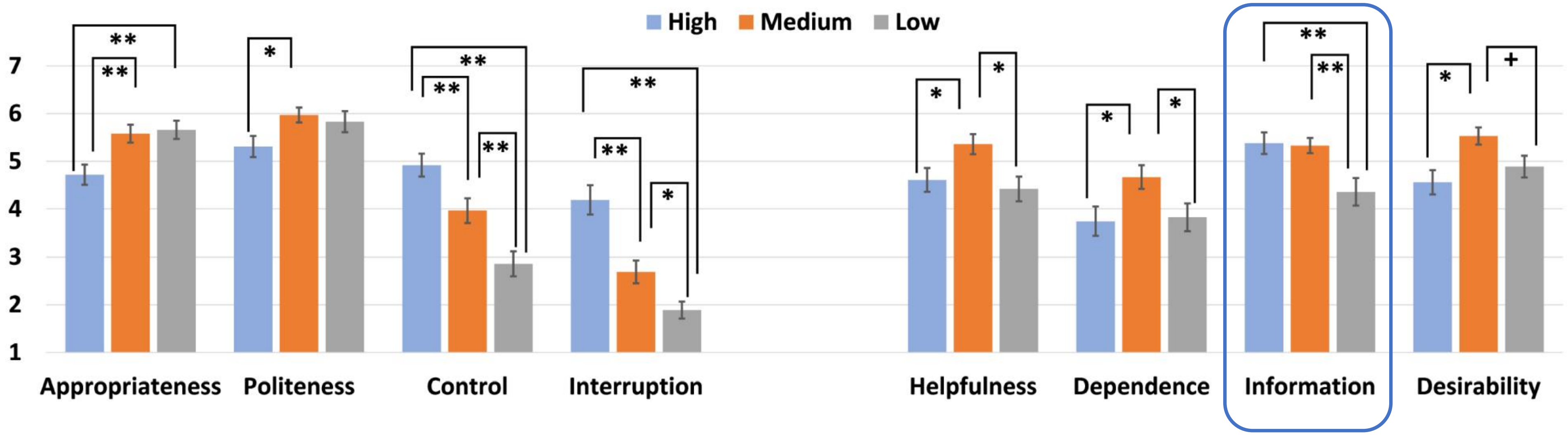

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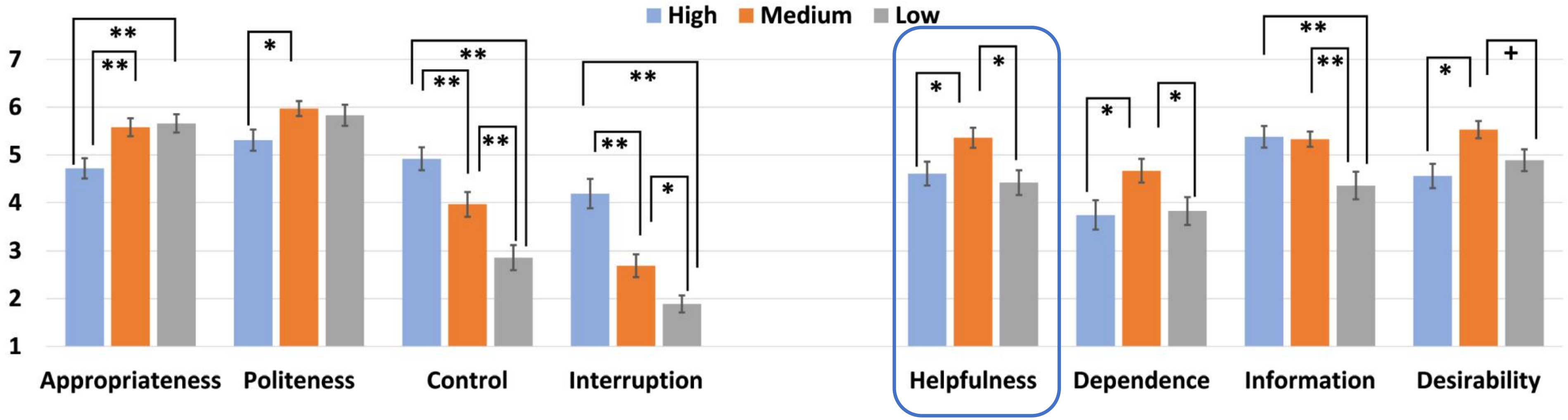

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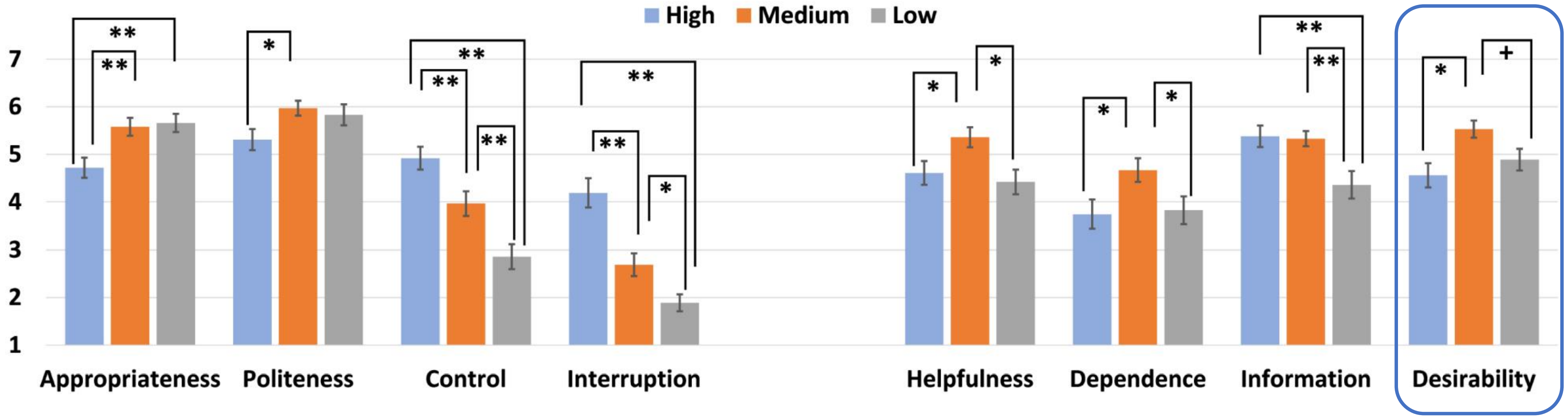

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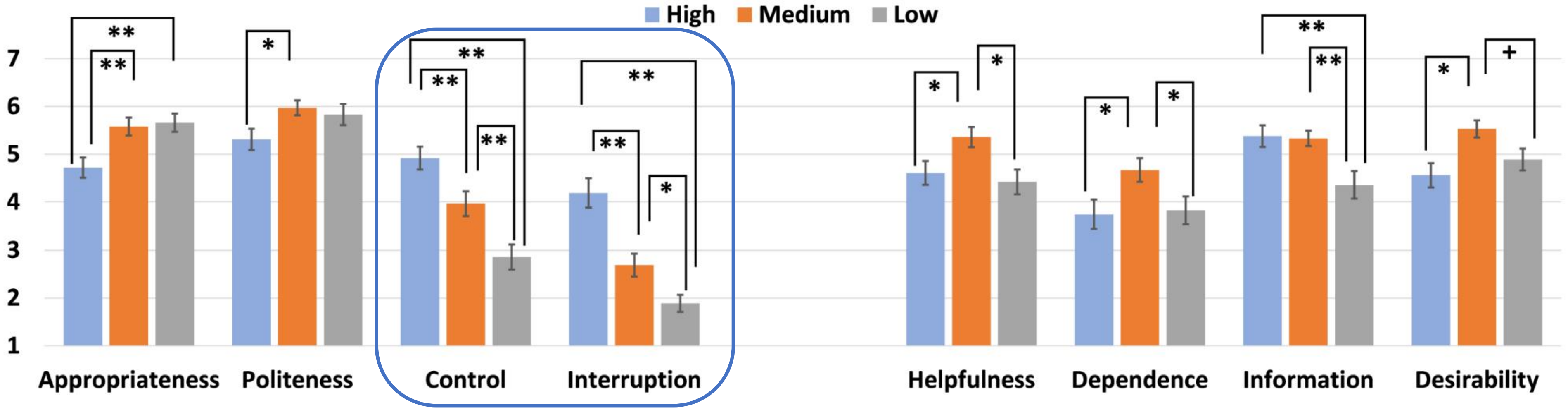

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Results – on User Behaviors

Table: **Average occurrences** of users' behaviors during interaction

Theme	**Turn-taking behaviors**	
Category	**Initating the turn**	**Competing for the turn**
Code example	(Robot is waiting) "I have a friend […] do you have any recommendation?"	(Robot is justifying the shoes) "No, I don't want this one"
High	2.3 (2.02)	2.5 (2.09)
Medium	3.0 (2.62)	2.0 (1.84)
Low	**6.2 (5.09)**	**0.7 (0.97)**

Adapt turn-taking behaviors to robots' manner

Results – on User Behaviors

Table: **Average occurrences** of users' behaviors during interaction

Theme	**Purpose of users' turns**	
Category	**Making requests**	**Asking questions**
Code example	"Could you recommend me another pair?"	"Do you think it is suitable for a very busy woman?"
High	2.5 (2.73)	0.8 (1.42)
Medium	3.7 (3.09)	1.0 (2.16)
Low	**4.5 (3.65)**	**1.5 (2.22)**

More control over the conversation in *low* condition

Results – on User Behaviors

Table: **Average occurrences** of users' behaviors during interaction

Theme	**Attitudes to recommended item**	
Category	**Positive**	**Negative**
Code example	(Robot gives recommendation) "Okay, I like this pair."	(During recommendation) "Give me another pair."
High	2.2 (2.25)	1.8 (1.65)
Medium	**3.3 (2.35)**	**3.1 (3.08)**
Low	0.8 (1.02)	0.8 (0.95)

Engage better in *medium* condition

Some Insights

Robot should maintain a mental model of human

- Things important for decisions: e.g., goal, preference, knowledge
- More considerate to verify the model before taking actions

Robot should express its capability

- For correct expectation
- Interactively help user obtain an correct metal model of robot, e.g., show uncertainty, explain the cause of communication failure, etc.

Robot behavior policy should be adaptive

- Context dependent, e.g., familiar with the items or not, in a hurry or not, etc.
- Sensitive to users’ emotional reaction

Future Work

Test the generality of robot's proactivity design

- On diverse tasks
- In real-world settings
- With different user population

Consider different aspects of interaction dynamics

- E.g., action timing and robot's tones

Automate robot anticipation

- Multi-modality algorithm, e.g., gaze, face expression, gesture, head pose, etc.
- Decision-makers' mental model

Summary

Service robot in decision-making support (DMS)

Define robot's proactivity in DMS settings

- Anticipation-autonomy policy framework
- *High-, medium-, low*-proactivity

Evaluations

- Perceptions: appropriateness and helpfulness
- User behaviors

Future design considerations for robot's manner

- Infer user's mental model
- Express its capability
- Adapt policy to context and user emotional reactions

Questions?

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