From Distraction to Interaction
Leveraging Robot-Driven Interplay for Effective Technical Education Amid Interruptions

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The Challenge of Interruptions

Have you struggled with interruption?
• High monetary costs:
  • For example, in airline transportation and logistics, Gontar et al. (2017).
  • Over $32 billion in losses, Ball et al. (2010).
• Injury:
  • 49% of 38,063 errors in administering medication, Johnson et al. (2017)
• Death:
  • Errors result in preventable deaths, Pereira-Lima et al. (2019)…
Wellbeing:

• Lost work productivity, Dabbish and Kraut (2004).
• Social alienation or anxiety, Ramnauth et al., (2022)
Robots can augment learning environments to support technical education by managing interruptions.
Outline: Robotics and Human Adaptivity

Study 1:
- Modeling the Effects of Interruptions

Study 2:
- Robot-Assisted Interruption Training for ASD Adults

Study 3:
- Supporting Recovery from Distractions
Outline: Robotics and Human Adaptivity

Study 1:
Modeling the Effects of Interruptions

Study 2:
Robot-Assisted Interruption Training for ASD Adults
Investigate how interruptions affect learning/performance and the role of teaching strategies in reducing these impacts.

How can we train people to better deal with interruptions?
Hard Problems: Modeling the Effects of Interruptions

• Key Challenges:
  • It is unclear what factors are important
  • It is unclear what training method should be used
Structured training enhances interruption management, improves learning, and lowers errors*:

**H1:** Practice is sufficient.

**H2.** Interruptions skills are generalizable, not specific.
   - **H2-1.** Skill transfers to different primary tasks.
   - **H2-2.** Skill transfers to different interruptions.

**H3:** Training outcomes depend on the primary task's memory load.

Task Analogues for Interruption Management

**Tower of Hanoi Task**

- **Start**
- **Goal**

**Path Recall Task**

- 3
- 2
- 1
- 4
Task Analogues for Interruption Management

Tower of Hanoi Task

Path Recall Task
Task Analogues for Interruption Management

**Tower of Hanoi Task**

**Path Recall Task**
Task Analogues for Interruption Management

Tower of Hanoi Task

Path Recall Task

start

goal
Task Analogues for Interruption Management

Tower of Hanoi Task

- **Start**: 4 x 4
- **Goal**: 3 x 7

Path Recall Task

- **Meaning**: red
- **Text Color**: black

Comparative Math Interruption

Stroop-like Interruption
Method: Study Design Overview

• 16 Groups across 3 phases:
  
  • Group 1: Varied Tasks, Same Interruptions:
  
  • Group 2: Same Task, Varied Interruptions:
  
  • Group 3: Sequential Tasks (Like Group 1):
  
  • Group 4: Sequential Tasks (Like Group 2):

Tasks in Blue and interruptions in Red
Sample Population and Metrics

• 240 participants
  • 50/50 male/female, English-speaking, no color blindness.

• Resumption Lag

• Interruption Lag

• Accuracy Metrics:
  • Strategic Problem-Solving:
  • Memory* Retention and Recall

• Response Speed

These results support H1: Practice is sufficient.
These results support H2-1: Skill transfers to different primary tasks.
Findings: Transfer Hypothesis (Novel Interruptions)

These results support **H2-2**: Skill transfers to different interruptions.
Findings: Task Type Hypothesis

These results support **H3**: Training outcomes depend on the primary task's memory load.
Takeaways

• Practice is effective.
• Transferability to different primary tasks.
• Adaptability to different interruptions.
• Task type consideration in training design.
Outline: Robotics and Human Adaptivity

Study 1: Modeling the Effects of Interruptions

Study 2: Robot-Assisted Interruption Training for ASD Adults
Tailored technology-based interventions boost work skills and job independence in adults with ASD - Johnson et al. 2020.
• Key Challenges:
  • Operate in the home.
  • Fully autonomous system.*
  • Operates over weeks.

Goal: Explore the impact of social robotic training systems on enhancing interruption management skills in workplace settings.

Key Objectives:

- Robotics for Interruption Management.
- Response to Different Types of Interruptions.
Method: Study Design Overview

• Iterative Development & Feedback (Eval 1):
  • Surveys with adults with ASD and employers, focusing on: *
    • Interruption frequency and recovery time.
    • Acceptance and usability of robots for training.

• Final Deployment & Training (Eval 2):

Objectives of the Iterative Design Development

• In User’s Homes
  • Familiarity and Destigmatizing

• Autonomous
  • Modular
  • Schedule Flexibility
  • Connectivity
  • Self-Charging

• Training Sessions
  • 2 hours of daily interactions

• Robot: The Interruptions Skills Training and Assessment Robot (ISTAR).
Interruptive Interactions with ISTAR

A. Primary Task
B. Identifying the interruption
C. Responding to the interruption
D. Resuming the primary task
E. Resumption of the primary task

Interruption Lag
Resumption Lag
Interruptive Interactions

A

Primary Task

Interruptive Interaction

Are you going to the meeting today?

No, but I will be at the meeting tomorrow.

Great, thank you!

Resuming Primary Task

Interruption Lag

Resumption Lag
Interruptive Interactions

Are you going to the meeting today?

Primary Task

Interruptive Interaction

Resuming Primary Task

A

B

C

D

E

Are you going to the meeting today?

No, but I will be at the meeting tomorrow.

Great, thank you!
Interruptive Interactions

No, but I will be at the meeting tomorrow.
Interruptive Interactions

D

Primary Task

Interruptive Interaction

Resuming Primary Task

A

B

C

D

E

Are you going to the meeting today?

No, but I will be at the meeting tomorrow.

Great, thank you!

Interruption Lag

Resumption Lag
Interruptive Interactions

Primary Task

Interruptive Interaction

Resuming Primary Task

A

B

C

D

E

Interruption Lag

Resumption Lag

Are you going to the meeting today?

No, but I will be at the meeting tomorrow.

Great, thank you!
We present the Interruptions Skills Training and Assessment Robot (ISTAR).

ISTAR is an in-home autonomous robot that provides training by allowing users practice handling work-related interruptions.
Sample Population and Metrics

• 10 participants
  • 8/2 male/female, Ages: 20-42 (Mean = 26.3, SD = 6.9), 80% college/vocational.
  • 10-14 days

• Resumption Lag

• Interruption Lag

• Handling Different Types of Interruptions

Interruption Management and Responses to Types

• Interruption Management
  • Predicted reduction in interruption lag
    • 0.01 seconds for each additional interruption experienced (p=0.01)

• Predicted reduction in resumption lag
  • Decrease associated with specific interruption types (reduction of 11.1 seconds, p≤0.001)
Interruption Management and Responses to Types

Handling Different Types of Interruptions

![Bar chart showing appropriate response rates for different types of interruptions: Environmental (40%), Social (100%), Task (100%).]
Takeaways

• Operate in the home.
• Fully autonomous system.
• Operates over weeks.
Outline: Robotics and Human Adaptivity

Study 1:
Modeling the Effects of Interruptions*

Study 2:
Robot-Assisted Interruption Training for ASD Adults

Supporting Recovery from Distraction

Enhancing Performance and Outcomes Amid Intermittent Interruptions with Interactive Methods
Hard Problems

• Key Challenges:
  • Real-time Processing of Multimodal Data.
  • Designing recovery support actions.*
  • Methodology for Evaluating Task Complexity.

Implementing robotic assistance* will significantly improve the management of interruptions during technical troubleshooting tasks via the following measurable outcomes:

**H-1**: Longer interruptions leading to quicker resumption of primary tasks.

**H-2**: The imposition of a time cost by interruptive tasks leads to an increase in errors.

**H-3**: Robotic assistance more significantly reduces errors in complex tasks.

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Method: Study Design Overview

- **Scenario:**
  - 4 Maintenance tasks
    - Temperature, Fan, Cooling, and Heating
    - 2 interruptions per participant

<table>
<thead>
<tr>
<th>Group</th>
<th>Robot Assists (Task 1)</th>
<th>Robot Assists (Task 2)</th>
<th>Complexity (Task 1)</th>
<th>Complexity (Task 2)</th>
<th>Task 1</th>
<th>Task 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>No</td>
<td>Simple</td>
<td>Simple</td>
<td>Identify faulty Condenser Fan</td>
<td>Identify faulty Compressor</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>No</td>
<td>Complex</td>
<td>Complex</td>
<td>Identify faulty Wire from Contactor Relay</td>
<td>Identify faulty DPDT Relay</td>
</tr>
<tr>
<td>3</td>
<td>No</td>
<td>No</td>
<td>Simple</td>
<td>Simple</td>
<td>Identify faulty Condenser Fan</td>
<td>Identify faulty Compressor</td>
</tr>
<tr>
<td>4</td>
<td>No</td>
<td>No</td>
<td>Complex</td>
<td>Complex</td>
<td>Identify faulty Wire from Contactor Relay</td>
<td>Identify faulty DPDT Relay</td>
</tr>
</tbody>
</table>
Objectives of the Study Design

• In Laboratory
  • Technical Subject
  • Embedded Learning

• Robot Features:
  • Contextual Cueing
  • Intuitive Guidance *
  • Targeted Indication

• Further Aims:
  • Adaptive Learning Paths
  • Engagement and Motivation

Intuitive Guidance
Sample Population and Metrics

- 65 participants
  - 55/10 male/female, English-speaking, no color blindness or auditory impairments.

- Interruption Response Time

- Task Resumption Time

- Errors

- Time-on-task Efficiency*  

Findings: Supporting Recovery from Distractions

These results support **H1**: Longer interruption tasks time inversely affect resumption lag, leading to faster primary task resumption.
These results partially supported **H2**: Time-intensive interruptions increase errors in primary task.
Findings: Supporting Recovery from Distractions

These results support H3: The impact of robotic assistance on mitigating errors varies task complexity, with more complex tasks showing a greater benefit from robotic intervention.
• Expansion to diverse educational settings.
• Strategic use of environmental cues.
• Evidence of differential impact based on task complexity.
• Enhanced technical education through robotic interplay.*

Integration of Findings: Key Insights

• Study 1: Interruption and Task Performance
  • Interruptions impact task performance, emphasizing the need for effective attention management strategies.

• Study 2: Robot-Assisted Interruption Management
  • Tailored robot assistance reduces interruption impact, enhancing task management and learning in training.

• Study 3: Supporting Recovery from Distractions
  • Robotics boost task performance and learning outcomes, bridging abstract and technical knowledge effectively.
Q&A