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User Multitasking as a Design Challenge for Mobile Multimodal Systems

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Introduction

- More than just driver distraction

Theoretical analysis

- Problems with a well–designed example system

Empirical Methods

- Demo of mobile eye tracker

Adaptivity

- How can a system automatically recognize resource constraints?

Examples of Multitasking

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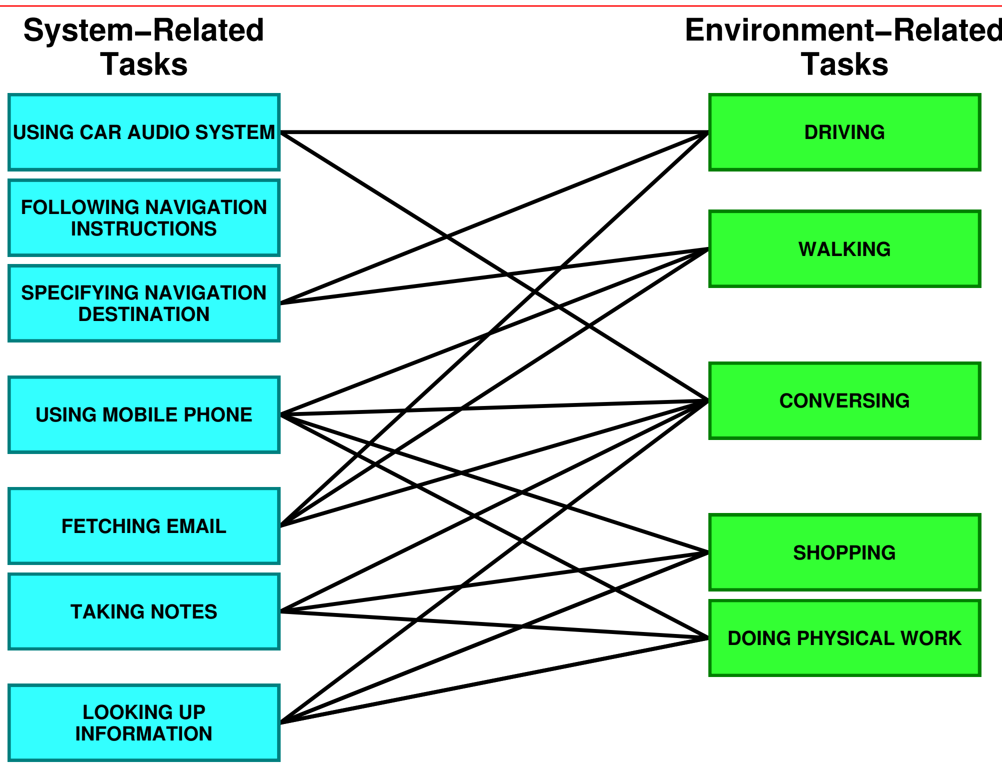

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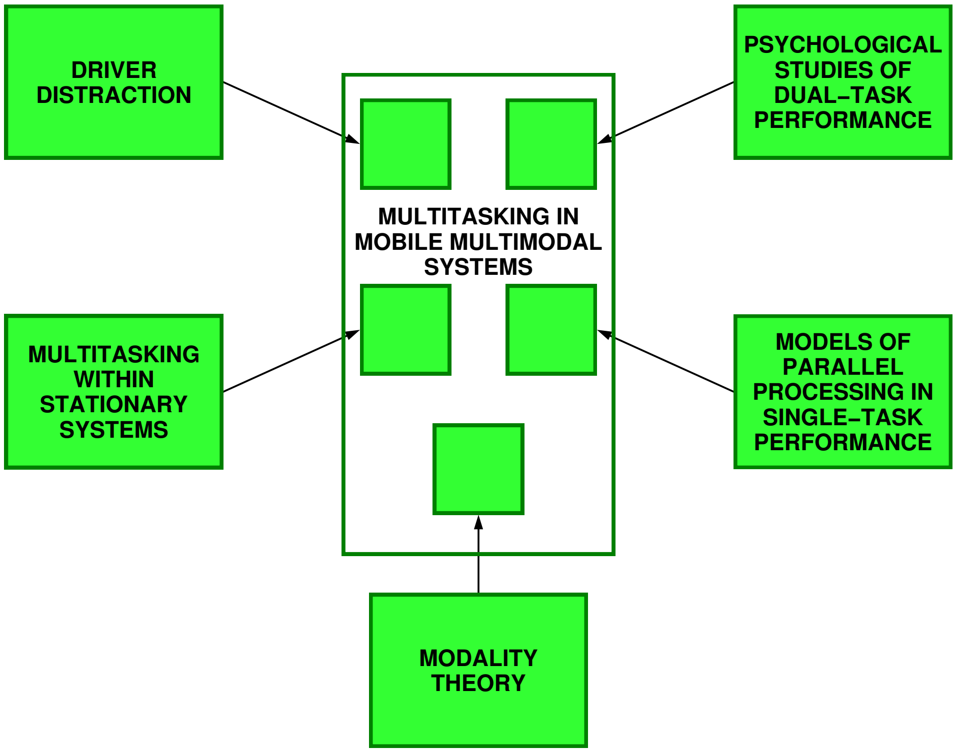
Some Relevant Fields



Example System and Task Analysis

The Siemens S35i Mobile Phone

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Instructions for Voice Dialing

From the manual:

In standby:

To select, press the lower key on the left side of the phone

or use the soft key (setting, see page 17)

Then say the name. The phone number will be dialed automatically.

S35i User's Guide. Available via http://www.my-siemens.com/MySiemens/CDA/Index/.

Eye-Based Dialing

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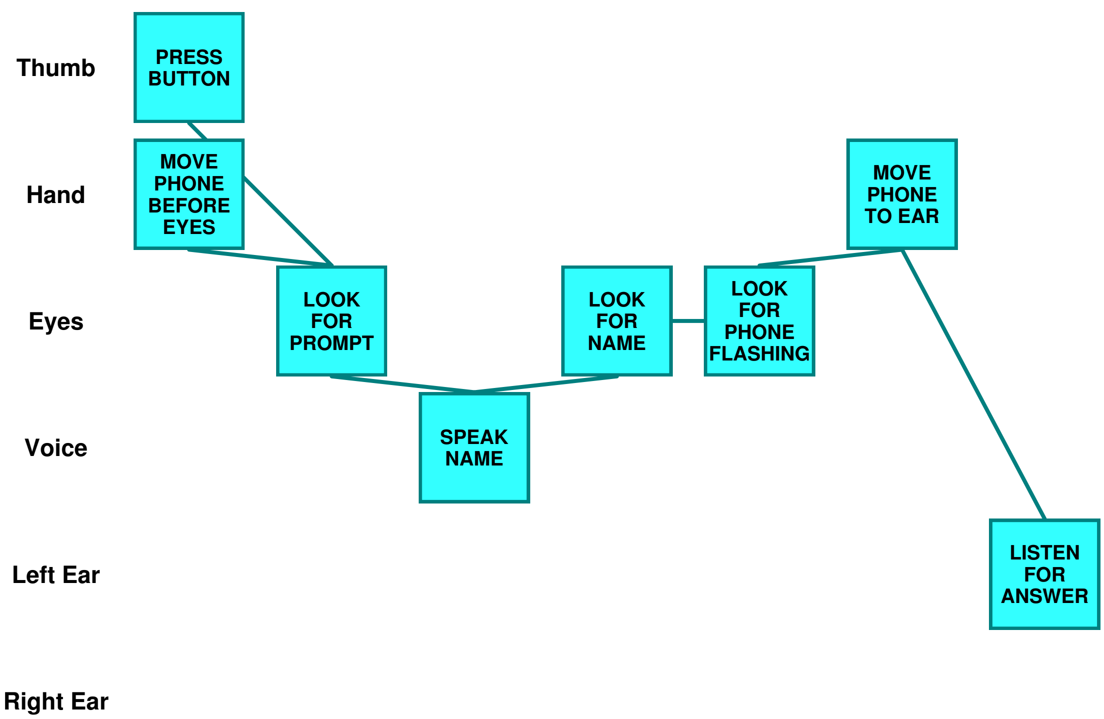

Questions

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- How can $\mathcal{U}$ learn that the first two actions can be performed in parallel?
  - Frequent practice?
  - Explicit thought?
- How can $\mathcal{U}$ learn what to look for?
- How can $\mathcal{U}$ learn that fully eye–based dialing is possible?
  - Assuming that everything proceeds smoothly?
  - Considering that unusual events may occur?

Ear–Based Dialing

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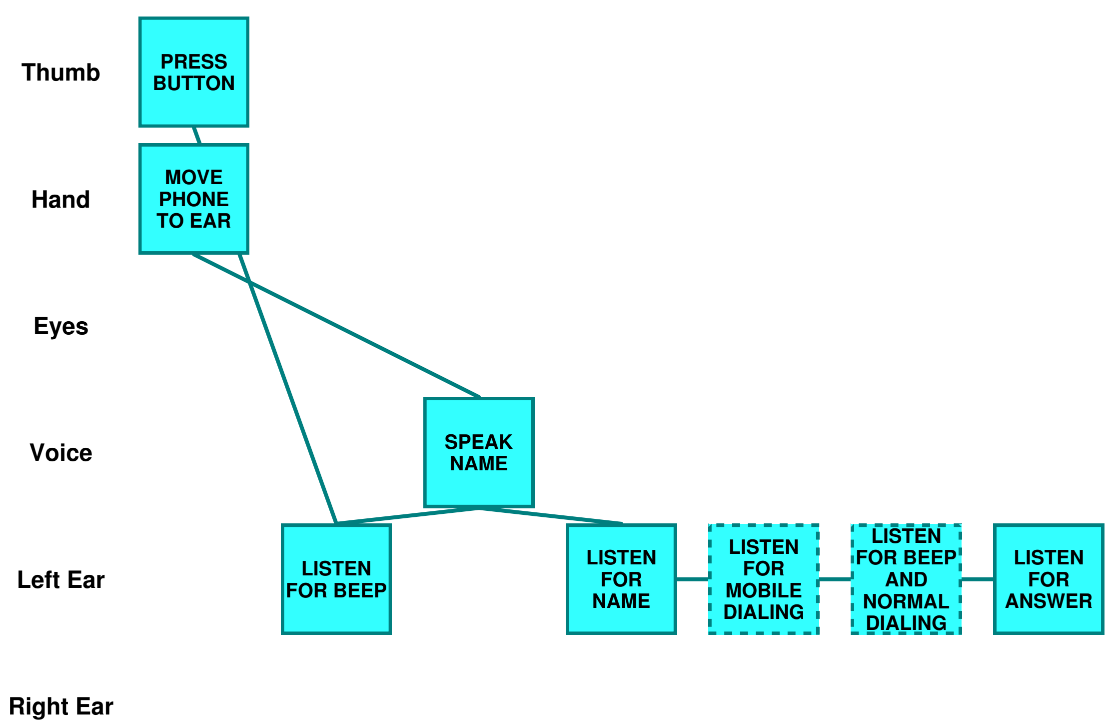

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Questions

- How can $\mathcal{U}$ learn what the sounds mean?
  - First beep?
  - Repetition of name
  - Dial tones
- How can $\mathcal{U}$ learn that ear–based dialing is possible?

Conversing

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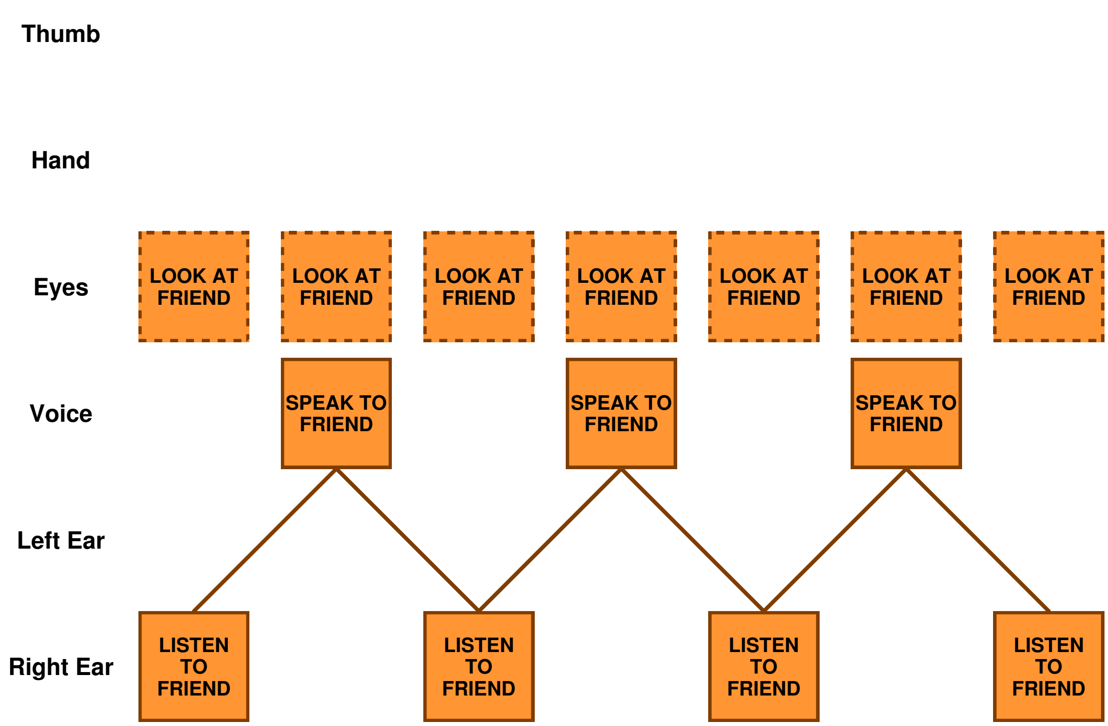

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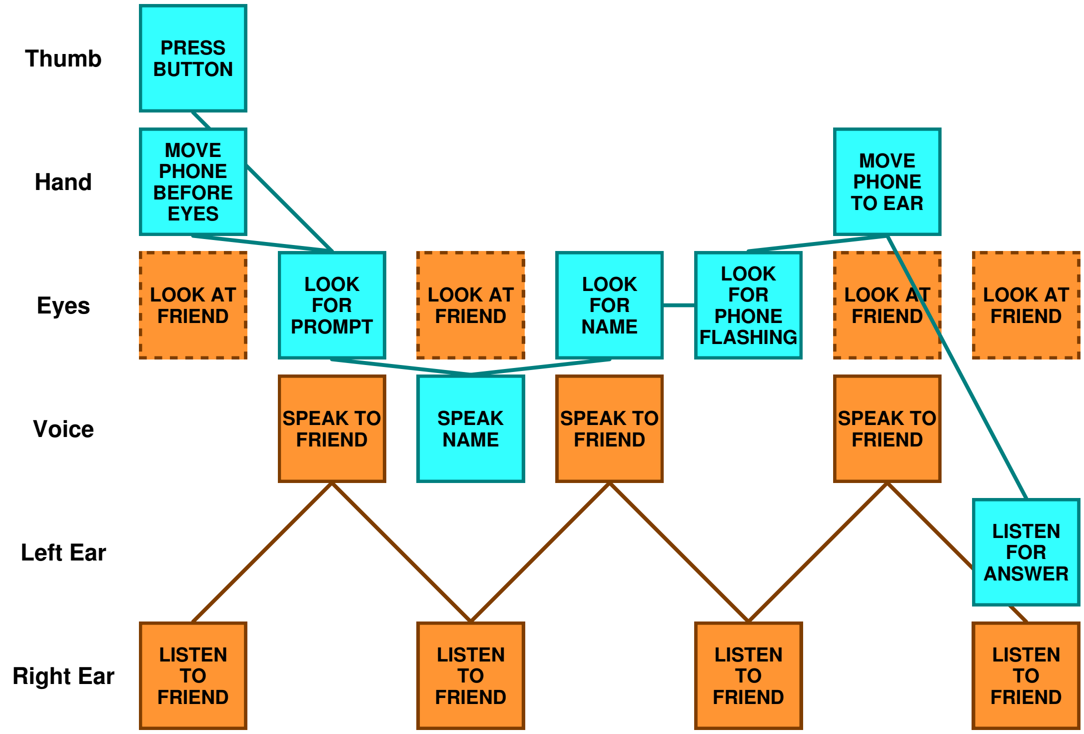
Eye–Based Dialing and Conversing



Possible Resource Conflicts

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Type of Conflict	Dialing	Conversing
Same input channel	Looking at display	Looking at friend
Same input encoding	Name on display	Utterance of friend
Excessive working memory load	Recalling form of stored name Checking displayed name for correctness	Listening or speaking to friend
Same output encoding	First utterance of person answering phone	Own utterance or utterance of friend
Same output channel	Speaking of name	Speaking to friend

One framework for analyzing resource conflicts like those listed here is Multiple Resource Theory – cf. Wickens, C. D. (1984). Processing resources in attention. In R. Parasuraman & D. R. Davies (Eds.), *Varieties of attention* (pp. 63–102). Orlando, FL: Academic Press.

Questions (1)

- Will $\mathcal{U}$ be aware of potential resource conflicts on the basis of
  - past experience with each of the specific conflicts?
  - theoretical analysis?
- Can $\mathcal{U}$ deal with each resource conflict when she encounters it
  - or will the damage already have been done?

Questions (2)

- If $\mathcal{U}$ is aware of a potential conflict in advance, how can she avoid it?
  - by postponing, interrupting, or aborting some action?
  - by choosing another multitasking strategy?
- Can $\mathcal{U}$ anticipate in advance how well she will be able to deal with any resource conflicts that may arise?

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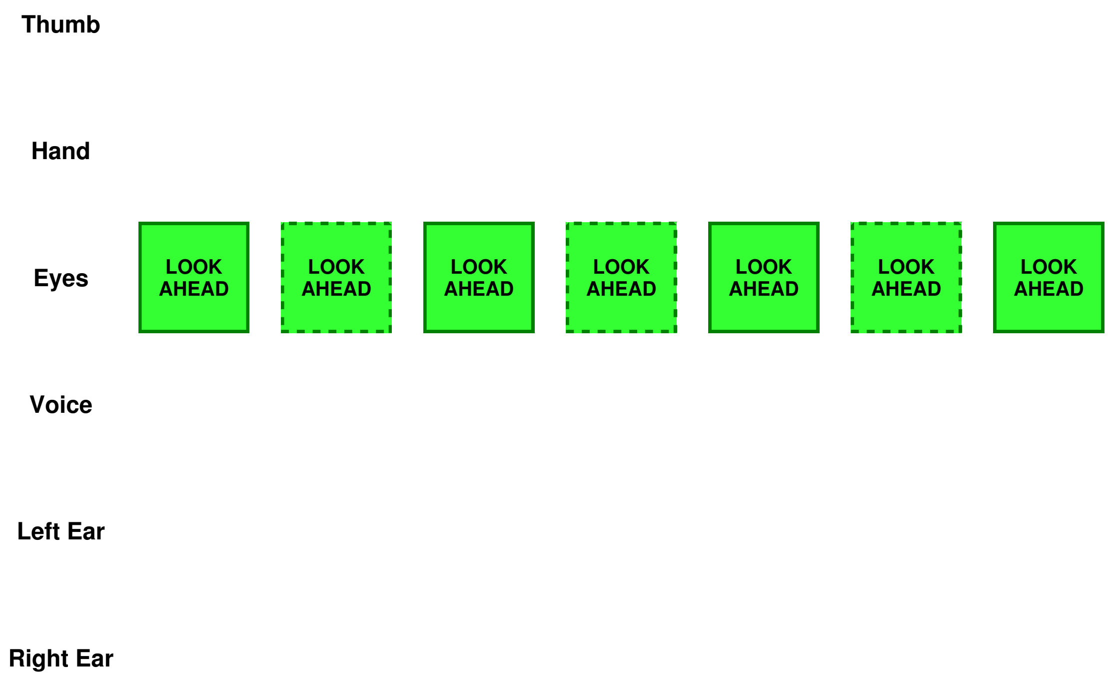
Walking



Ear–Based Dialing and Walking

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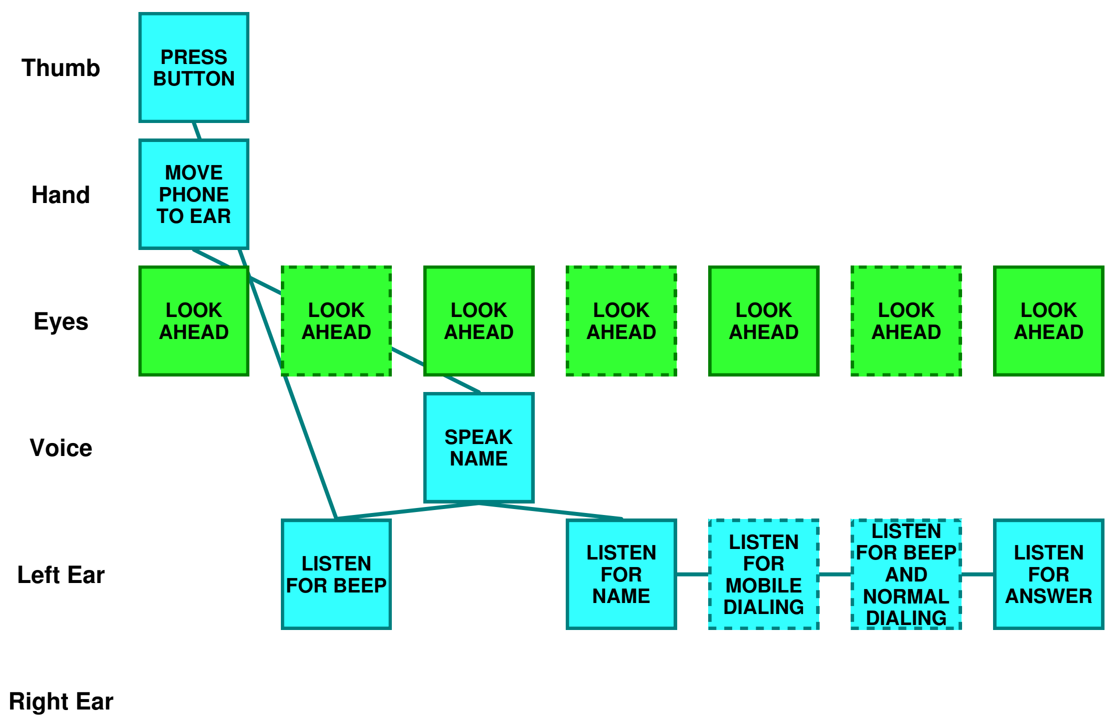

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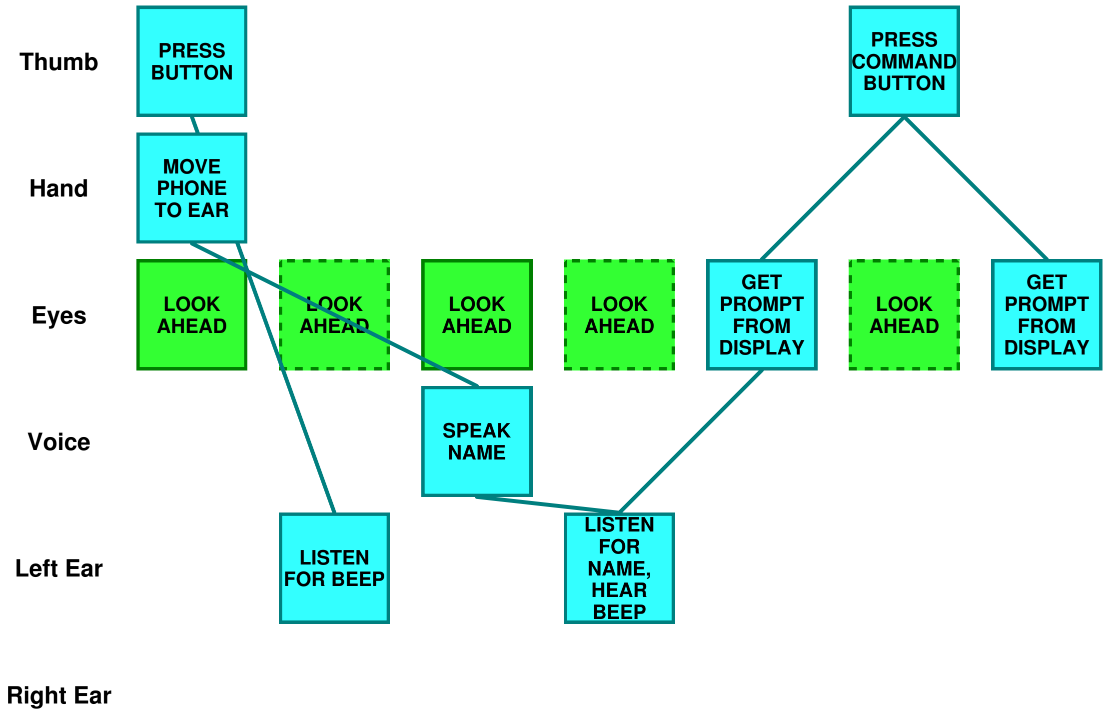
Deviating from Planned Modality



Questions

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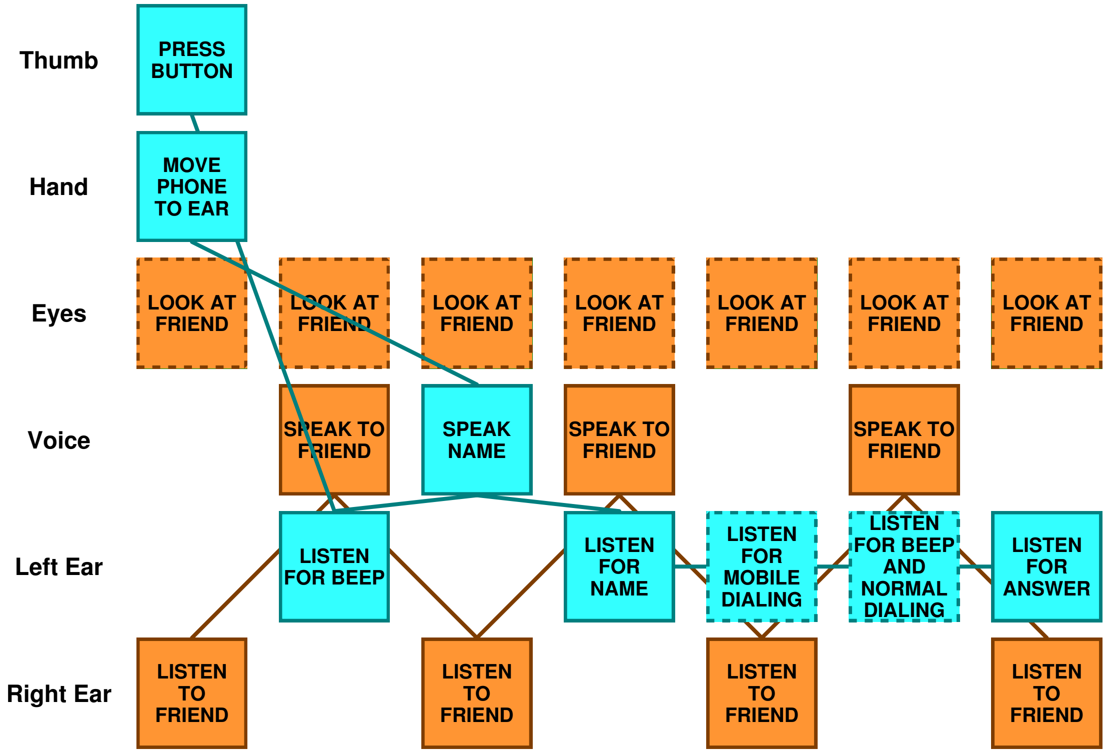
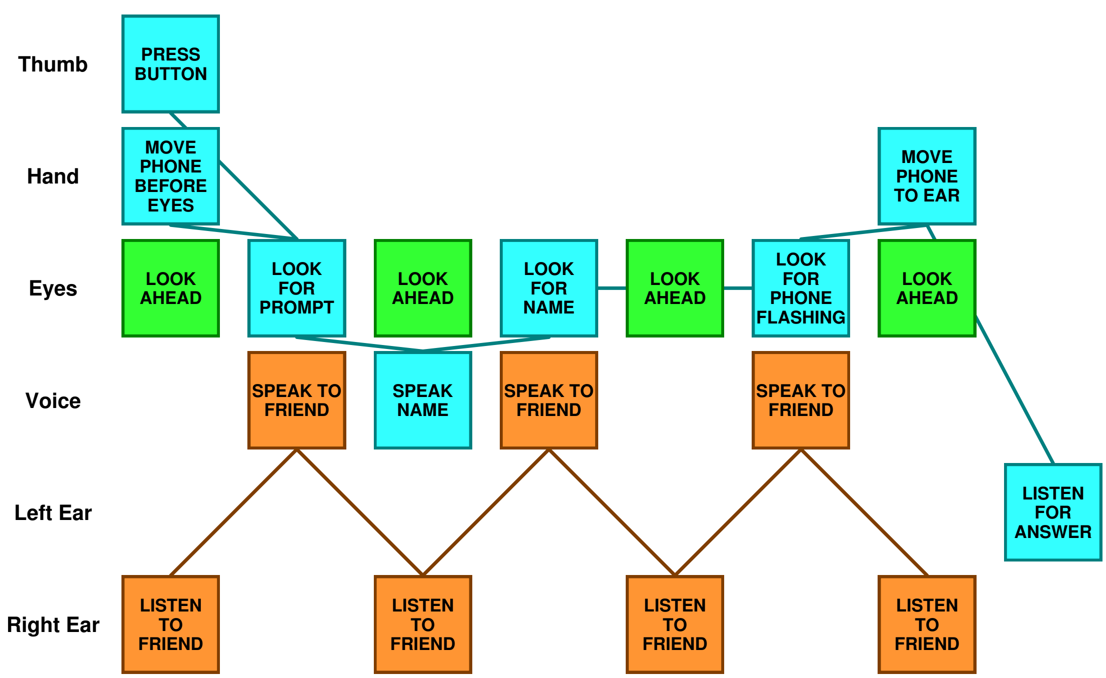
- Is it possible for $\mathcal{U}$ to anticipate resource conflicts that may arise through changes in the course of the dialog
  - if $\mathcal{U}$ considers the change too unlikely to be worth thinking about?
  - if $\mathcal{U}$ does not know what happens after such a change?

23 Ear–Based Dialing, Walking, and Conversing



Eye–Based Dialing, Walking, and Conversing 24



Largely Premature Guidelines

Make Desirable Multitasking Possible

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- Consider likely combinations of system–related and environment–related tasks

- If possible, ensure that $\mathcal{S}$ supports these combinations
  - Even when exceptional events occur

- Otherwise, provide convincing prohibitions (how?)
  - "Never use this device while Xing, because ..."

Avoid Obstacles to Multitasking [1]

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Obstacle	Why a problem
User actions whose duration and/or cognitive resource demands cannot easily be assessed by $\mathcal{U}$	$\mathcal{U}$'s decisions must be based on assessments of resource demands
User actions that have to be performed with a limited time window	$\mathcal{U}$ may want to postpone the action in order to cope with a concurrent task
User subtasks that cannot be suspended (for later resumption) or aborted	$\mathcal{U}$ may need to leave a subtask in order to return to another task

Cf. Miyata, Y., & Norman, D. (1986). Psychological issues in support of multiple activities. In (Ed.), *User centered system design: New perspectives on human–computer interaction* (pp. 265–284). Hillsdale, NJ: Erlbaum.

27 Avoid Obstacles to Multitasking (2)

Cf. Cutrell, E., Czerwinski, M., & Horvitz, E. (2001). Notification, disruption and memory: Effects of messaging interruptions on memory and performance. *Proceedings of Interact 2001*, Tokyo. http://research.microsoft.com/~horvitz/Abstracts.htm See also Bernsen, N. O., & Dybkjær, L. (2001). Exploring natural interaction in the car. *Proceedings of the CLASS Workshop on Natural Interactivity and Intelligent Interactive Information Representation*, Verona, Italy. http://www.nis.sdu.dk/~nob/

Obstacle	Why a problem
Tasks where there is no reminder of the current state of progress	When $\mathcal{U}$ returns to such a task, she may not remember where she was
Stimuli that tend to attract more attention than they deserve • They are redundant, but $\mathcal{U}$ does not recognize this fact • They are perceptually salient	$\mathcal{U}$ may neglect more important stimuli in another modality and/or another task

Support Learning of Multitasking Strategies 28

An approach similar to the third strategy listed can be found in: Pieraccini, R., Carpenter, B., Woudenberg, E., Caskey, S., Springer, S., Bloom, J., & Phillips, M. (2002). Multi–modal spoken dialogue with wireless devices. *Proceedings of the ISCA Tutorial and Research Workshop on Multi–Modal Dialogue in Mobile Environments*, Kloster Irsee, Germany.

- Provide minimal but adequate instruction
  - "To use this device while walking, keep it held to your ear"
  - "If you hear a beep, start over"
- Apply general learnability principles
  - Concerning predictability, transparency, familiarity, consistency
- Provide limited system modes that are suitable for combination with particular environment–related tasks
  - "walking mode", "meeting mode", ...

Observing Multitasking

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CHCC Data Collection Infrastructure

Adapted from Figure 2 of Oviatt, S. (2000) Multimodal system processing in mobile environments. *Proceedings of the 13th Annual ACM Symposium on User Interface Software and Technology*, pp. 21–30.

Mobile Eye Tracking (1)
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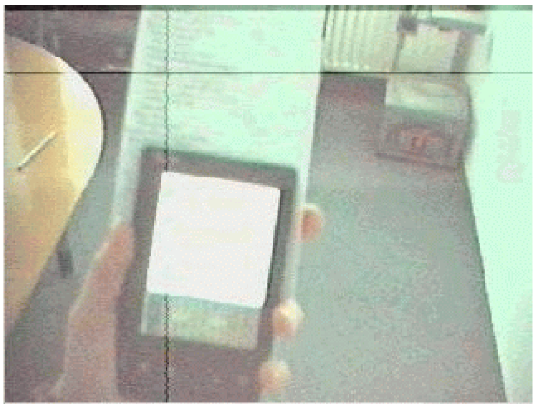
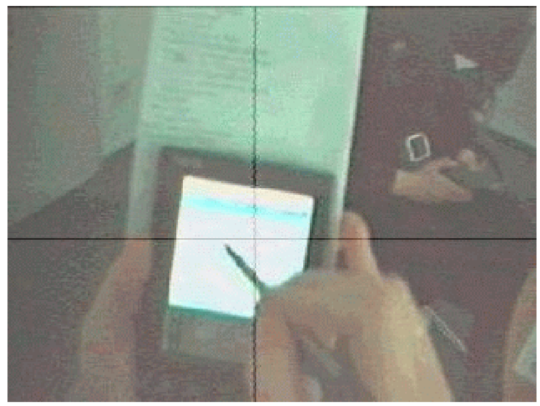
Mobile Eye Tracking (2)

During the talk, videos and a live demo were shown illustrating the use of an ASL 501 Mobile eye tracker to track the gaze of a user of a handheld computer and a mobile telephone.





Roles for Adaptivity
Potential Benefits of System Adaptation

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See, e.g., Jameson, A., Großmann–Hutter, B., March, L., Rummer, R., Bohnenberger, T., & Wittig, F. (2001). When actions have consequences: Empirically based decision making for intelligent user interfaces. *Knowledge–Based Systems, 14*, 75–92. http://w5.cs.uni–sb.de/~ready/

- What can $\mathcal{S}$ know that $\mathcal{U}$ doesn't know?
  - How $\mathcal{S}$ works, in all situations
  - Typical resource demands of system–related and environment–related tasks
  - Effective control strategies for multitasking
- How can $\mathcal{S}$ adapt?
  - Recognize $\mathcal{U}$'s concurrent tasks (or resource limitations)
  - Offer suitable modalities for $\mathcal{U}$'s input
  - Produce its output in a suitable modality
  - Adapt other aspects of its behavior

    E.g., shift to a more conservative dialog style

33 What Can $\mathcal{S}$ Recognize Automatically?

See, e.g., Müller, C., Großmann–Hutter, B., Jameson, A., Rummer, R., & Wittig, F. (2001). Recognizing time pressure and cognitive load on the basis of speech: An experimental study. In M. Bauer, P. Gmytrasiewicz, & J. Vassileva (Eds.), *UM2001, User Modeling: Proceedings of the Eighth International Conference*. Berlin: Springer.

Resource demand	Example evidence	Example source of evidence
Settings or tasks with typical resource demands	Participating in meeting	Use by $\mathcal{U}$ of setting–specific software
Demands on perceptual channels	Auditory stimuli	Microphone
Processing of material with a particular type of encoding	Speech apparently directed at $\mathcal{U}$	Microphone, camera
Working memory demands	Symptoms in $\mathcal{U}$'s speech	Speech recognizer

Usability Goals for User–Adaptive Systems (1) 34

These and other usability challenges are discussed in Section 4 of Jameson, A. (2002). Adaptive interfaces and agents. In J. A. Jacko & A. Sears (Eds.), *Human–computer interaction handbook*. Mahwah, NJ: Erlbaum.

Predictability

- Users often need to predict what $\mathcal{S}$ will do
  - especially in connection with frequently performed and/or automatic actions of $\mathcal{U}$

Transparency

- Users want to understand to some degree
  - why $\mathcal{S}$ has made a particular adaptation or recommendation
  - how $\mathcal{S}$'s adaptive mechanisms work

35 Usability Goals for User–Adaptive Systems (2)

Controllability

- Users want some degree of control over
  - the individual adaptations that $\mathcal{S}$ makes
  - the general parameters that determine $\mathcal{S}$'s adaptation

Unobtrusiveness

- $\mathcal{S}$'s adaptations should not lead to constant distraction
  - even in the service of the above three goals

Summary

Summary 36

- Designing for multitasking raises special issues when
  - users have little experience with the tasks and/or the task combinations
  - the tasks are inherently partly unpredictable
- Multimodality tends to increase the number of possible strategies for successful multitasking
  - but it does not guarantee that users will discover and effectively use these strategies
- Automatic adaptation can take some of the burden off of the user
  - but careful attention to key usability issues is required