mental models
human abilities
cognition
Announcements

• TCPS needs to be finished before you run human subjects
• Evaluation plan due this week, starting on piloting during workshop
Quiz results

Q1 – 87%
Q2 – 88%
Q3 – 86%
Q4 – 78% ← *might have been a little too tricky with nearly identically written answers*
Q5 – 99%
mental models & cognitive frameworks

where else we’re covering it

by now (W06 pre-readings)

• intro to internal + external cognitive frameworks
  **updated learning goals on external for clarity
• mental models

upcoming workshop + assignments

• apply mental models, external representations in designing/evaluating prototypes
  (starting with project).
cognitive frameworks today

why and how cognition is relevant to HCI design

mental models: what they are, how we get and use them, and ways they can fail

exploratory learning: applying norman’s 7-stage model. (one way we generate and build MMs of new situations)

benefits/tradeoffs of external representations
learning goals

define mental models, describe their characteristics.
  give examples of how a mental model can be acquired

explain what Norman’s 7-stage model is good for:
  use gulfs/stages to analyze interactions with a system

be able to identify a mismatch in mental models
  give examples of situations or interfaces where mismatch occurs

explain the difference between internal and external cognitive frameworks
  ➔ give examples of the types of factors or representations that could be important when analyzing distributed/external cognition
  ➔ give examples of external representations that help with memory load reduction, computational offloading and cognitive tracing
why look at cognition?

part of doing good design is understanding how people **reason** and **react to** interface experiences

cognitive frameworks: help us do this!
  – theoretical models that provide **predictive** and **explanatory** power for understanding user behaviour
  – based on theories of cognition

internal frameworks: about the mental process inside users head
→ **mental models** a (particularly useful) example

external frameworks: account for interactions with technologies, environment, context
mental models

"In interacting with the environment, with others, and with the artifacts of technology, people form internal, mental models of themselves and of the things with which they are interacting."

-Norman (in Gentner & Stevens, 1983)

people use their mental models to:

• reason about a system
  - how to interact with it; how it works
• figure out what to do when things go wrong
mental models vs. conceptual design

mental models: something the **user** has (forms)

• users “**see**” the system through mental models
• users **rely** on mental models during usage
• there are various **forms** of mental models
• mental models can **support** users’ interaction

**coming:** conceptual models and conceptual design

• this is what the **designer** does, to foster good mental model formation by the user.
recall our design concepts:

the basics: (elements of these in many of the others)
- affordance
- visibility
- feedback

other concepts:
- mapping
- findability
- constraints (perceptible)
- transfer effects
- cultural associations
- individual differences

→ all inform a user’s mental model
an object that helps you form a mental model: scissors

affordances:
• holes for something to be inserted

constraints:
• big hole for several fingers, small hole for thumb

mapping:
• holes-for-fingers suggested / constrained by appearance

positive transfer and cultural idioms:
• learnt when young; constant mechanism

mental model:
• physical object implies how the operating parts work

A reasonable mental model can be formed by just looking at and perhaps holding the object.
• Some things you don’t understand you do anyway: why big blade down?
• Model’s not perfect: what about “glide” style of cutting?
acquiring mental models

during system usage:
• the user’s own activity leads to a mental model
• explanatory theory, developed by the user
• often used to predict future behavior of the system

observing others using the system:
• casual observation of others working
• asking someone else to “do this for me”
• formal training sessions

reading about a system
• documentation, help screens, “for Dummies” books

this is done by the user (not the designer)
model mismatches

**misconceptions** happen when user’s model differs in critical ways from how the system actually works.

e.g., “more is more” belief about interactions.
- high oven temperature makes oven heat faster
- press ‘walk button’ repeatedly -> light changes faster

e.g., folk theories and remedies for computing
- reboot when computer “gets slow”
- reboot computer to make projector work

We do these things because it feels like it makes a difference, *but we don’t have a correct model of how they work!*
models are often “runnable”: perturb system to figure out how it works

includes a notion of **causality**
  - “doing this will result in this”

used for **explanation**
  - to understand why the system responded as it did
  - part of Norman’s 7-stage model (**interpretation**)

used for **prediction**
  - to select an appropriate action
  - also part of Norman’s model (**intention**)
Mental simulation helps you ‘get’ the problem – “if I pick it up, what will happen …?”

Jacques Carelman: Catalog of unfindable objects
how can exploratory mental model formation break down?

**Intention** failure: Make plan based on bad information

**Execution** failure: accidental scroll with oversensitive touchpad

**Goal** failure: lack of feedback -> unaware of need to “fix” a problem

- Intention to act
  - Sequence of actions
    - Execution of the action sequence
      - Establishing goals
        - Evaluation of interpretations
          - Interpreting the perception
            - Perceiving the state of the world
              - Failure to perceive/interpret state: doesn’t realize an error has occurred

the world
How does a bike work?
Will it work?  Why seven?
How does the drive train work?  Which wheels steer?  …

Our mental model of a bike isn’t as good as we think it is … … but it’s good enough to recognize this as a bike!
an object that **hinders** mental model formation: “old style” digital watch

affordances - mixed:
- four buttons are clearly for pushing and the screen shows a number – but unclear what the entire object affords
telling time? setting alarms, timers, viewing heart rate, other data?

visibility – lousy
- what will happen if you push each button? what mode is watch in?

constraints and mapping - unknown:
- no visible relation between buttons, possible actions and end result

transfer effects:
- little relation to analog watches. But, maybe from other digital devices.

cultural idiom:
- some standardized core controls and functions but others variable

mental model:
- must be taught, or learned by trial/error
some characteristics of mental models

• incomplete
• constantly evolving
• not accurate representation (contain errors and uncertainty measures)
• provide a simple representation of a complex phenomena
how does a phone call work?

dial → ring → pickup → talk

What’s missing?
some characteristics of mental models

• incomplete

• constantly evolving

• not accurate representation (contain errors and uncertainty measures)

• provide a simple representation of a complex phenomena

• can be represented by a set of if-then-else rules
how does a phone call work?

Mental model

System image
Mental Model of a Telephone Call

This is a *representation* of a mental model. Where might it come from?

What happens between “circles” in this flow chart?

On your own: Compare it to Norman’s 7-stage, which is theoretical; is it the same thing?

Newman & Lamming
Fig 13.5
Norman’s seven-stage model

*a description of human goal-oriented action*

1. establish goals

2. form intention to act

3. decide on sequence of actions

4. execute the action sequence

5. perceive the state of the world

6. interpret perceived state

7. evaluate system wrt goals

the difference between the intentions and allowable actions

the difference between *actual* system state and *user’s understanding*

the gulf of execution

the gulf of evaluation

the world
what mental models tell the user

what do I want to do with the system next?

what can I do next?  what if I do this?

to do it, I’ll do this, then this

establishing goals

intention to act

sequence of actions

execution of the action sequence

the world

what did I do to make the system do that?

evaluation of interpretations

interpreting the perception

perceiving the state of the world

what am I now seeing?

what will I see as a result?

what if I do this?

what can I do next?

what do I want to do with the system next?
activity 1

watch a video of a little boy attempting to figure out a puzzle
- he knows that ‘yellow’ lights it up; red doesn’t
- presented with an anomaly – how does it work?

will stop video at various points...

➡️ on worksheet: describe his mental model formation using the gulfs
full video

*what babies think (excerpt)*

https://youtu.be/Dy9_OTFpMwE?t=1m7s

portion from class starts at ~1 minute
limitations of internal frameworks

can never *really* know exactly what’s in a user’s head
• will always be a simplification

do not account for external factors, e.g.,
• environment
• external representations
• other people
• etc. . .
Example (on your own)

Example task: you are an OSX user using Windows.

“Execution” steps might look like this:

1. **Goal:** I need to change my account’s password

2. **Intention to act:** There must be a control panel somewhere, but I don’t know where. I’ll have to poke around.

3. **Decide on actions:** I’ll start by clicking on the program-launch icon in lower left corner, then see if I can find something in there.

4. **Execute:** Okay, here goes… [click]

→ The world.
activity (on your own)

1. Figure out how to set an alarm clock on a cell phone that runs on a different system than yours (e.g., IOS ↔ Android).

2. Observe yourself as you do this → try to apply the 7-stage model.
Norman’s seven-stage model

*what is it good for?*

internal framework: best for *exploratory learning*

- but this is just one way to form a mental model of a system

less applicable to highly learned, semiautomatic behavior

- user has already developed strong expectation of what will happen/how it will happen
- gulfs in these cases tend to be very small
- unless something unexpected happens!
mismatch: why does it happen?

Sometimes a **poor model is fostered**.
- e.g., Norman’s fridge: controls imply fridge/freezer controlled separately
mismatch: norman’s fridge?

user’s mental model would reasonably look like this . . .
mismatch: norman’s fridge?

but actually the system works like this. . .

two controls interact to control one cooling unit
running a mental model: ‘doing x will result in y’

1. Establish the goal to be achieved
2. Form the intention for action to achieve goal
3. Specify the action sequence corresponding to the intention
4. Execute the action sequence
5. Perceive the system state resulting from the action sequence
6. Interpret the perceived system state
7. Evaluate the system state with respect to the goal and the intentions
information processing

another way of thinking about internal cognition
• metaphor: human like an information processor

ordered processing stages (with input/output)
• within each, processes (e.g., comparing, matching) act on mental representations

useful for making predictions, identifying bottlenecks

human processor model (after the break)
• combines information processing with perceptual senses for input and output
external cognition:
the use of the external world to achieve cognition
cognitive/attentional load

**Load:** the amount of mental resources it takes to process information

*Cognitive load:* how much “brainpower” does a task take?

*Attentional load:* how much attention does a task take?

What’s the difference? Think *flow state.*
computation == cognition?

Computation is state change (hello CPSC 421)

Cognition is state change?

Does cognition == computation?
external cognition frameworks

considered with how representations and factors in the environment help and hinder cognition

distributed cognition: the idea that cognition happens across individuals, artifacts, and time, is embodied

external cognition: the act of using external representations (e.g., books, maps, diagrams, etc.) to work with your internal representations

embodied interaction: concerned with how someone’s experience of the world and the meaning they create is shaped through physical and social interactions
benefits of external representations

externalizing information – notes, todo lists, alarm clocks – very helpful for remembering

- basically: encode information in your environment
- reduces internal memory load (either long or short term)

computational offloading: using tools and devices to carry out computations, other tasks

- e.g., doing math problems on paper
- allows you to see the change, come back to it later, share it with others, etc.
computational offloading
example: using whiteboards for discussion with multiple people
computational offloading
example: interactive information visualization for browsing genetics data
modification

reflecting changes or intention by modifying external representations by:

annotation:
- ✔✔ checking
- crossing things off lists
- circling something

Cognitive tracing: manipulating objects into new orders and structures. e.g.,
- rearranging cards in a poker hand
- rearranging scrabble letter to think of words
expressive channels of user communication. Over multiple iterations, we designed both human-actuated and mechanized prototypes that go beyond the mobile device’s existing form factor by augmenting it with life-like gestures. We present four prototypes that explore a combination of visual and haptic gestures including breathing, curling, crawling, ear-flexing, and vibration. Through two evaluations of these prototypes, we find that users are receptive to the idea of a living phone metaphor and the use of physical gestures to enrich their communications. Further, we find that physically rendered gestures have the potential to express common notifications (e.g., incoming calls), as well as communicate basic emotional content. Finally, we present several design guidelines for future work in the design space of gestural mobile devices.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces.

General terms: Design, Human Factors Experimentation.

Keywords: Biological metaphor, body language, human-robot interaction, mobile computing, affective computing, ambient display.

2. INTRODUCTION[2][3]

Compared to a decade ago, today’s mobile devices are small and powerful. A combination of innovative interaction...
cognitive tracing
example: (re)arranging sticky notes into affinity diagrams
why external representations

we often do use external representations naturally

sometimes people don’t realize they need them
• e.g., actual checklists for doctors performing operations;
  - lots of resistance initially
  - research shows they improve patient care a lot!
  - Checklist Manifesto, Gawande 2009

can often be set up in very personal ways
→ looking at the external representations people use tells you a lot about them & how they work
downsides to external representations

when reminders are too frequent, don’t match what user needs reminding about...people may start to ignore them!

Example: electronic systems that remind pharmacists about drug interactions

– interactions vary in severity;
– system shows alerts for all interactions, even those they judge ‘unimportant’

⇒ result is alert fatigue — pharmacists miss reminders and make mistakes!
mental models (& cognitive frameworks)

summary

why and how cognition is relevant to HCI design

mental models: what they are, how we get and use them, and ways they can fail

exploratory learning: applying norman’s 7-stage model. (one way we generate and build MMs of new situations)

distributed cognition, benefits (drawbacks) of external representations
human abilities

memory and perception
part 1: some theory:
  • model of mind – memory, attention, input and output
  • perception examples
    → humans have *limits*; models to organize understanding

part 2: capabilities and implications for design
  • modality-specific attributes, examples of design
learning goals

- **List and describe** models we have of human abilities (cognitive resources and memory, sensory processing)
  - Model human processor, theories of memory
  - related concepts: interference, reasons for forgetting, change blindness, S-R compatibility, etc.
- **Describe** implications and considerations for design that result from these models, and that consider both visual and physical attributes;
  - e.g., recognition vs. recall, facilitating retrieval, time limitations. chunking, visual attributes (grouping, proximity, differentiation, separation, progression)
- **Give examples** of interface features that illustrate these implications; critique interfaces using them
- **Give examples** of impairments and individual differences that impact human abilities (visual, motor, cognitive, etc.)
model of mind?

Too simple!
modular model of mind - simplest
the *serial* aspect of the pipeline

3-stage model of human information processing

processing time associated w/ each block: *additive*

functions happen in neurologically separate parts of brain, connected by electrical pathways

*attention* provides backwards pathway

- perception (sensory)
- decision (cognition)
- response (motor)
perception & action subsystems

subsystems may operate in parallel (theory):
input (perception modalities):
  • **visual** subsystem for what we see (*most studied*)
  • **echoic** subsystem for what we hear
  • **haptic** subsystem for what we feel through touch
output (action):
  • **motor** subsystem for how we move
    – **vocal (articulatory)** subsystem for what we speak
analogies to a computer system

can be a helpful way to think about it:

perception, audition, motor control = *system I/O*
  - each has associated memory ("cache")
  - limits on input speed ("sample rate") and throughput capacity

cognition = **CPU**
  - includes multi-level main memory
  - multithreading? *we don’t really understand how this works in people*

use analogy with caution:
some systems do NOT work this way.
the memory pipeline: stage theory

working memory is small
- temporary storage: decay, displacement

maintenance rehearsal
- rote repetition
- information must be meaningful to learn information well

answer to problem is organization:
- e.g., strong passwords:
  - Dc911utiaE!: “Don’t call 911 unless there is an emergency!”
human memory: types

sensory memory

- buffers: iconic (visual), echoic (auditory), haptic (touch)
- “allowed” into short-term memory by attention (filtering)

working memory is short-term

- rapid access (~70ms) & decay (~200 ms)
- limited capacity (“scratch-pad”): 7 ± 2 “chunks”
- “flush” when finished with a task
- or, move into long-term via conscious rehearsal

long-term memory is slower, larger

- virtually unlimited capacity (how many words do you know?)
- slower access time (~100 ms) with little decay
- access is complicated operation that depends on recent past
Model Human Processor (MHP): one model for perception → memory → cognition

Cognitive Processor

Long-term Memory (LTM)

Working Memory (WM)

Visual Image Store

Auditory Image Store

Haptic Image Store

Perceptual Processors

Motor Processor (action)

Attention filters what gets through…

WORLD

forgetting in Long Term Memory

causes for not remembering an item?
1) never stored: encoding failure
2) gone from storage: storage failure
3) can’t get out of storage: retrieval failure

interference model of forgetting
• one item reduces ability to retrieve another
• forward (proactive) interference (3)
  – earlier learning reduces ability to retrieve later info
  – e.g., drive to your old house instead of the new one
• backward (retroactive) interference (3 & 2)
  – later learning reduces the ability to retrieve earlier info
  – e.g., change telephone numbers, can’t remember original
attention: a filter on perceptual input

What is cognition?

What is attention?

Attention is Cognitive Unison—Mole, 2010

Attention is Neural Synchrony—Ward, 2006
attention: different kinds?

Visual
Haptic (touch)
Audio

...more??

In/voluntary?
Pre/post-cognitive?
attention: how does the brain work?

Very simple model

A network of neurons that communicates through action potentials

some neurons excite other neurons
some neurons inhibit other neurons

Attention is a process of excitation and inhibition.
part 1a summary:

cognition = **CPU**
  - includes multi-level main memory

perception, audition, motor control = **system I/O**
  - each has associated memory

attention is **limited** and regulates sensory input
activity II

You’ve been hired to design the notification system for a ‘smart’ car with the ability to alert the driver of certain traffic events. For simplicity, the system is only active for driving at speeds over 50km/h.

The detection system can:

– detect other cars
– detect lanes
– detect bad traffic

In small groups, brainstorm the different kinds of driving situations and attentional loads that each type of detection would demand. What do you need to pay attention to? What is most important?

E.g. Changing lanes on a clear highway: need only lane detection, low attentional load, priority is staying on the road/changing lanes

Vs. Changing lanes with cars around you: need both lane and car detection, high attentional load, priority is not hitting other cars
[break]
part 1b: consider a **examples** of perceptual limitations

The following is intended to illustrate just how bad our senses really are
example 1: change blindness

in upcoming images,

- image will blink or flicker
- image changes with each blink

raise your hand as soon as you identify change

images from O’Regan, Rensink & Clark 1999
(Ron Rensink of this dept)
airplane
diners
airplane without blink:
diners without blink:
vision system: like a camera?

seems like it:

camera: keep steady, adjust focal lens length

eye: focal point always moving, yet we perceive the world as being sharp and in focus.

but how does it really work?

camera: film is exposed all at once by light from scene

eye: electrical signals travel to brain, which gradually + selectively updates a mental image of a scene

→ camera is a poor metaphor for vision!
vision is really more like touch:

Imagine creating a mental model of room layout & furnishings by touching it when blindfolded or in the dark

↳ model is built up serially (over time)

If we start with a memory of what was in the room last time we were there, process speeds up

If the memory is inaccurate/not reflective of current state:
  • may take us longer to find the changes
  • because *we believed in an incorrect model.*
how does this relate to interface design?

• what are some everyday situations where ‘change blindness’ occur?

• for those situations, how might you help by changing the design?

• When the problem is divided attention, not blocked vision, would you handle it differently?

• can you consider changing the interface to encourage different behavior on the user’s part?

Think about these things as we look at others…
example 2:
S-R (stimulus-response) compatibility connecting perception to action

task difficulty determined in part by:
• the particular sets of stimuli and response used, or
• the way in which individual stimuli and responses are paired with each other
simple experiment

name the color of the text

• *go through list as quickly as possible*
• *measure response time*
• *3 trials*
Green
White
Yellow
Red
Black
Blue
simple experiment …

do it again…
simple experiment …

do it again…
other kinds of S/R incompatibilities ... to consider in interface design

• spatial pairing
• directional
• limb to limb
• sensory / motor channels
• ...
example 3: perceptual causality

how soon must red ball move after cue ball reaches it?

does it make a difference if:
• you’re holding the cue?
• can hear the ball?
perceptual causality

• two distinct stimuli can fuse if the first event appears to cause the other

• events must still occur in the same perceptual cycle

lip synch: is the voice really coming from that person?
touchscreen button: did my touch really make that click?
perceptual fusion

stimuli that occur within one perceptual processing cycle fuse into a single percept:

• frame rate necessary for movies to look real (*visual*)?
  – time for 1 frame must be < $T_p$ (*Time for perception*)
  – $T_p=100$ ms $\rightarrow$ rate must be $\geq 10$ frame/sec (better to double)

• max Morse code rate can be similarly calculated for *audio* perception times

**practical examples:**
• lip synch on an old movie (not a frame rate issue!)
• press button on a touchscreen: audio click comes late
characteristic cycle times

each subsystem has a typical **processing time**

<table>
<thead>
<tr>
<th>subsystem</th>
<th>average</th>
<th>range</th>
</tr>
</thead>
<tbody>
<tr>
<td>perceptual</td>
<td>100 msec</td>
<td>50-200 msec</td>
</tr>
<tr>
<td>cognitive</td>
<td>70 msec</td>
<td>25-170 msec</td>
</tr>
<tr>
<td>motor</td>
<td>70 msec</td>
<td>30-100 msec</td>
</tr>
</tbody>
</table>

we can use these to estimate performance

- e.g. “keystroke-level analysis” (covered in cpsc 444)
Model Human Processor:

- Cognitive Processor
  - Sensory buffers

Long-term Memory (LTM)

Working Memory (WM)

- Visual Image Store
- Auditory Image Store
- Haptic Image Store

Perceptual Processors

Motor Processor (action)

On your own… what is the role of memory / attention in:
- Change Blindness?
- SR Compatibility?
- Perceptual fusion and causality

part 1: high level lesson

our initial perception has many limitations

• conveyance of info from perceptual to cognitive centers is constricted

• attention and external factors are central to what we finally “perceive”

→ our “mental image” of a scene, object or situation is a constructed model

periodically updated with isolated, incomplete and directed observations.

→ ignoring roles of perception and attention can cause problems during interface design and testing.
part 2: translate models into implications for design

Human capabilities in …. 

• memory and attention 
• perception and motor capability - especially 
  o visual 
  o physical 
  o multimodal

influence what we perceive and remember. Knowing this, we can design more wisely…
but – needs often contradict.
→ must consider task context
activity III

You’ve been hired to design the notification system for a ‘smart’ car with the ability to alert the driver of certain traffic events. For simplicity, the system is only active for driving at speeds over 50km/h.

The detection system can:

– detect other cars
– detect lanes
– detect bad traffic

Knowing what you now know about human abilities and perceptual limitations, choose one of the detection types (e.g. lane detection) and design a notification system for it. Makes you don’t add to the cognitive load and can justify it!
[break]
back to less dangerous examples…

Not every design brief has such clear implications for human safety…

But a lot of the same lessons work for notifications on your laptop or phone

Keep notifications in mind as we go through the next set of slides…
attributes from memory and attention

• recall and recognition
• time limitations: persistence in memory stores
• chunking: effective limits to short-term (or working) memory
recognition versus recall: different ways to retrieve memory

recall
- info must be reproduced from memory

recognition (reminding)
- presentation of info provides knowledge that info has been seen before
- still some recall, but easier because of cues to retrieval

e.g., command line interfaces (recall) vs. GUI (recognition)
facilitating retrieval: cues

• cue = any stimulus that improves retrieval
  – example: giving hints
  – other examples in software: icons, labels, menu names, etc.

• anything related to
  – item or situation where it was learned

• can facilitate memory in any system

Design heuristic: “Recognition rather than recall”
But, why not ALWAYS design for recognition?
time limits in memory

→ need for visual persistence

short-term memory may persist 30s *ideal conditions*
then ... you will forget a brief message
if you don’t rehearse or otherwise learn it.

- alerts – when should they require confirmation?

- status indicators should usually stick around
  – available for reference when needed

... a toolbar can both indicate status in **attentional background** (go look for it when you’re ready), and a way to **follow up** on a status change.
Memory chunking

Remember: 7±2 is our limit.

Chunking extends capacity of WM:
- 6174591765 vs. (617) 459-1765
- DECIBMGM vs. DEC IBM GMC

When: Memory chunking is useful when you need to support people in remembering things
- especially for short periods of time.

Example: Emergency room nurses work in a distracting environment (visual, auditory stimuli, interruptions)
They need to quickly look up then briefly remember and use information – e.g. drug dosage. → Help them to chunk this info
The following are **things to consider:**

- to avoid problems
- or use to advantage
- often, design involves **tradeoffs** between competing desired effects

The point: have some idea of how the eye (or hand) will respond to what you show it.

Examples of some follow.
Won’t be able to go over all in class – please **look at all of them, and ask if you don’t understand**.

*Now: visual. But also think physical, multimodal*
visual attributes in interface design

many kinds of visual attributes that can be employed/manipulated in creating interfaces

particular visual cues especially useful to:

• support (or impede) finding and seeing, direct search
• communicate organization and hierarchy of information
• impact affective response – e.g., energetic vs. calmness

we’ll discuss in more depth in visual design lectures…
findability and search
what perceptual attribute is at work here?

it’s not about

dependency on memory chunking (how much you can remember), but

visual search: quicker to find things when there is structural
organization, e.g. hierarchical, color, visual texture

source: minecraft
visual cues

visual proximity and separation

• use *whitespace* to indicate grouping information

```
Button1  Button2  Button3
```

```
  Button1  Button2  Button3
```

visual differentiation

• vary the *visual characteristics* of groups to make them distinctive
  e.g. with color, *saturation*, patterns, textures, fonts

```
Button1  Button2  Button3
```

```
  Button1  Button2  Button3
```

visual progression

• rely on visual and cognitive cues to guide *order* in which users perceive information

button example from: http://www.tobyrush.com/software/imob/articles/200109/200109-ar0002.shtml
more visual cues: visual grouping

use proximity to build connections between related things:
more visual cues: organization/hierarchy from **grouping**

hierarchies can also indicate **visual progression**:

<table>
<thead>
<tr>
<th>Fish</th>
<th>Fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMWs</td>
<td>Lemons</td>
</tr>
<tr>
<td>Doors</td>
<td>Apples</td>
</tr>
<tr>
<td>Numbers</td>
<td>Pears</td>
</tr>
<tr>
<td>Friends</td>
<td>Grapes</td>
</tr>
<tr>
<td>Armchairs</td>
<td>Vegetables</td>
</tr>
<tr>
<td>People</td>
<td>Cucumbers</td>
</tr>
<tr>
<td>Drums</td>
<td>Lettuce</td>
</tr>
<tr>
<td>Computers</td>
<td>Celery</td>
</tr>
<tr>
<td>Singers</td>
<td>Carrots</td>
</tr>
<tr>
<td>Monkeys</td>
<td>Meats</td>
</tr>
<tr>
<td>Beers</td>
<td>Mutton</td>
</tr>
</tbody>
</table>
more visual cues: visual separation -- in menus

Not enough groups

Too many groups

Just right?

*lines* separate and create groups

Menubar example from: http://www.tobyrush.com/software/imob/articles/200109/200109-ar0002.shtml
example of visual progression and use of movement

how was movement animation just used to indicate progression? what did your eye do?
visual attributes and cues

Most of these can support (or impede) finding and seeing:

- **directed search and findability** of items in a page
- “pop” – making something stand out. also called **salience**
- at a high level, easily perceiving the **organization** of information
- many also impact **affective response** – e.g. energy vs calmness

Consider:

- **item spatial relations** – to imply (or obfuscate!) grouping and similarity vs. differentiation; or continuity and progression
- **relative size** – tends to suggest importance, hierarchy
- **color and saturation** – of individual items, and palette of entire view. can indicate grouping, or conversely, item salience
- **overall density** – completeness of information vs. clutter, distraction;
- **spatial stability** – things that stay in same place are more findable.
- **movement** – salience, directionality, affect; or distraction?

we’ll cover some of these in more depth later
activity: visual detail critique
in “microtask” contexts: finding things in a file browser

1. consider file-operation “micro tasks”:
   Like … navigate (from what to what?), browse, search → write them down

2. examine handout – images of several file browser ‘modes’

3. relate browser views vision, memory support of a specific microtask.
   E.g., for a given micro task, do you need …
   • an item to be salient, or simply available
     (i.e., in attentional foreground or attentional background?)
   • to find something, or remember something?
   • to provide focus (hide distractions - reduce visual clutter), or context (big picture)?

4. write down/circle at least 3 visual attributes, and how they support or impede a microtask.

Look for tradeoffs that have been made:
some views will be good for one microtask but bad for others.
consider these two file browsers:

(older versions -- don’t worry about it)
more browser "modes"
full group: discuss

Examples?

What about…

• what perceptual / memory principles differ between them?

• what kinds of tasks do the different modes best support?

• examples of tradeoffs?

• individuals tend to prefer some over others… why?
part 3: more design implications

more to cover on human abilities:

• visual (done)

• physical (touch) and motor attributes

• multimodal attributes
physical (touch) attributes - summary

Most of the following examples support …

• indications of **affordance** what is it for? what can it do? how do I hold it?
• **findability** of controls rather than primary information display
• **feedback** and confirmation of control actions
• **ambient** awareness
• easy **manual execution** of commands – constraints, learnability
• **affective** (emotional) response
• are often seen as well as felt! physical design is also visual design

Consider:

• **shape** – affordances; fit to hand or other body element; orientation for use
• **texture and material properties** – tactile findability, purpose, identification
• **location and feel of manual controls** – *spatial* findability; feedback
• **muscle memory, patterns** – supported by spatial stability, learnability
• **behavior and feel of active elements**
physical cues: *shape*

- fit to hand
- location of controls
- which end is active?
- button findability and purpose without looking!
shape: when it can change, \textit{how} should it change?

bendy devices are coming. What should bending tell us?
physical: findability & status feedback

• spatial stability: stays in same place; muscle memory

• physical constraints: allow it to move only in acceptable way

• physical feedback can feel engagement, completion
informative textures
motor patterns

sequence of actions completed automatically once set in motion
• e.g., typing the word “the”
  – single gesture for experienced typist
  – three gestures for novice typist
• e.g., keying in phone numbers, passwords

neuromuscular learning

UI guideline: facilitate gestures/phrases that result in learnable, ergonomic physical gestures and patterns
exploiting motor patterns

Dvorak keyboard layout facilitates chunks:
• common pairs become “rolls”: t-h
• other pairs alternate hands: th-e-m

recall from week 1: muscle memory – deliberately interfering with spatiomotor learning
tactile findability: “touch” keyboards

“soft” keys have other benefits

physical keys

tactus “bubble” keyboard: best of both?
active tactile elements: informative, timing salience

... what’s in a buzz?
multimodal attributes

Mostly beyond our scope in 344, but a few things:

increasingly, we can / must

- design in **multiple** sensory dimensions
  visible, touchable, hearable
- or choose **between** them
  which modality is the best one for, e.g., a given information display?

Consider:

- **appropriateness for context of use** – what is user doing? which modality makes most sense?
- **reinforce vs. complement vs. conflict** – across modalities, you can repeat information or distribute it (e.g. some visual, some auditory). Impacts both **immediate** perception, and **learning over time**.
  **Inconsistency** is usually bad.
- **masking** – display in one modality can **distract** from info in another – just as it can within a modality
- **stimulus/response compatibility** – within or across modalities
multimodal learning

when I gave you this *image* to help understand memory,

you’d already *seen* the main idea of this model in *words*

What was the value of getting it graphically too?

- different kinds of learners
- multimodal reinforcement
individual differences and impairments
accommodating diversity when human abilities are different

short-term memory
long-term memory & learning
problem solving
decision making
attention & set (scope of concern)
search & scanning
time perception

limitations in these abilities affect performance
kinds of human diversity to accommodate

• physical abilities (e.g. size, strength)
  – ergonomics

• cognitive & perceptual abilities (*covered earlier*)

• personality differences (Myers-Briggs Type Indicator)
  – extroversion vs. introversion
  – sensing vs. intuition
  – perceptive vs. judging
  – feeling vs. thinking

• cultural & international origins
  – customs, metaphors, etiquette, patterns of usage

• disabilities (permanent, temporary)
other factors affecting perceptual & motor performance

arousal & vigilance
fatigue
perceptual load
sensory deprivation
knowledge of results
monotony & boredom
sleep deprivation
anxiety & fear
isolation
drugs & alcohol
circadian rhythms
example: older adults

aging often comes with a decrease of abilities:

• visual functioning
  – use larger text and higher contrast, minimize glare

• attention
  – older users found to have difficulty shutting out distracting detail
    – reduce clutter
  – older users take advantage of cues (e.g., highlighting) to help with information search
    – help them to find items easily and focus attention on items
example: older adults  
(continued)

• working memory
  – older adults tend to rely more on external support for memory processes
    – *use chunking, recognition over recall*
    – *enforce consistency and standards*

• learning
  – learning computer applications takes significantly longer and is harder for older adults
    – *bad usability may affect older adults more*
    – *help users recognize, diagnose, and recover from errors*
parts 1-2-3 summary: implications for design

human capabilities (memory, perception, motor) dictate that we perceive, remember, and control things in particular ways

how design should take this into account depends on task context and goals