Attention

What do we need it for?

- **Processing** limitations
  - Finding friend at airport
    - Finite processing resources @ given time
- **Motor** limitations
  - Can only move in one direction
  - Pick up finite # of things
  - One word at a time (unless you have 2 heads)

Functions of attention

- **Focusing**
- Perceptual enhancement
- Binding
- Sustaining behavior
- Action selection (central executive)

1. Focusing

- Where’s the cutoff for selecting a subset of information?
- What’s a “channel”? (What can attention be allocated to?)
I’m going to show you some letters, and then ask you to report them back.

A F G M
Q R Z P
C N T D

Write them down!

1. Focusing

• Span of apprehension: max 4-5 letters
• Where’s the limit?
  – Unable to perceive +5 letters at a time
  – OR,
  – can perceive but memory fades during report
• Sperling (1960)
  – Full report vs. partial report
1. Focusing

- Sperling (1960)
  - 3 x 4 array of letters
  - Full report: 4-5 letters from whole array
  - Partial report:
    - Display flashes
    - Then, tone to indicate row (1, 2, 3)
    - Result: 3.3 letters per row * # of rows
    - Iconic (sensory) memory is high-capacity
    - Limitation must be higher up

- Channel selection (note IP term)
  - At what point do you pick some info to process in more depth?
  - E.g. listening to a conversation
    - Some things don’t get tuned out
      - Extreme stuff (redirect attention)
      - Relevant stuff (hmm…)
    - Want to focus on/fully process important stuff, but keep an ear out for relevant stimuli

- Dichotic listening
  - Hear two ‘channels’, one per ear
  - Follow only one (shadow to ensure attn)
  - Test for material in attended/unattended
    - To what degree is unattended info processed?

- Cherry (1953): voice & its attributes, but no content
- Moray (1959)
  - Attended message, unattended word list (<=35)
    - No recognition of word lists!
- No shadowing, just report digits
  - L: 1, 4, 2
  - R: 6, 9, 3
  - Report each channel (142/693), not interleaved
1. Focusing

- What's a channel?
  - Ear?
  - Location in space? (visual, auditory)
  - Object?
  - Location in time?

1. Focusing

- Attention to objects
  - “Spotlight” metaphor; multiple spotlights??
  - Multiple Object Tracking (MOT) task
    - Storm & Pylyshyn, 1988
    - Cavanagh & Alvarez, TICS 2005--v. readable
    - http://research.yale.edu/perception/oba/MOT.mov
    - http://research.yale.edu/perception/oba/MOT-RB-dumbbells.mov

1. Focusing

- What's a channel?
  - Kahneman, Treisman, & Gibbs (1992): objects

<table>
<thead>
<tr>
<th>Name the letter</th>
<th>Faster</th>
</tr>
</thead>
<tbody>
<tr>
<td>same</td>
<td></td>
</tr>
<tr>
<td>different</td>
<td>Slower</td>
</tr>
<tr>
<td>no match</td>
<td>Slower</td>
</tr>
</tbody>
</table>

So objects can be ‘channels’

1. Focusing

- M. R. Jones et al. (2002):
  - Tone sequence
    - A X X X X X B
  - Compare pitch of B to A
    - On-beat B more accurate than off-beat B
  - Focal attending to location in time!

Point on stopwatch is a channel
1. Focusing

- Auditory attention (Bregman, 1990)
  - Stream segregation
  - Can focus on auditory ‘streams’

2. Perceptual enhancement

- “Paying attention” to better process
  - Like turning up the volume
- Signal in noise (again, IP terms)
  - External noise
  - Internal noise (variability in neurons)
- Lu & Dosher (1998)
  - Does attending to location help?
  - Only when low external noise
  - This looks like turning up external
- Internal noise reduction may help

Where do the limits of attention occur?

- Bottleneck theories
  - Somewhere in the system, there’s a ‘cutoff’
- Capacity theories
  - You can only devote limited resources to so much stuff but no cutoff point

Where are limits located?

- Broadbent (1958) Filter model
Where are limits located?

容许范围位于何处？

- 感知输入
- 物理属性的分析
- 典型处理
- 意义的分析
- 对象和句子的编译

Where’s the “bottleneck”? 

- 后期选择
- 早期选择
- 过滤模型与优先级
  - 永久优先级
  - 当前优先级
  - Moray 1959 结果
  - Liberty/Death 示例

- 德国与德国 (1963)，诺曼 (1968): 无注意力极限，极限在短期记忆

Capacity theories

- 无瓶颈: 有限资源
- 可以“花费”所需
- 变异: 多个资源理论
- Pashler (1998):
  - 或许瓶颈与每个模态的容量分配
  - 可以同时处理视觉对象，听觉对象

Functions of attention

- 重点
- 感知增强
- 绑定
- 维持行为
- 动作选择（中央执行）
3. Binding

- Treisman & Gelade (1980): Feature Integration Theory
- Attention may link visual attributes processed in different brain areas
- Evidence: visual search
  - Single feature (green)
    - Don't need to bind, fast search
  - Feature conjunction (green + circle)
    - Must "move attention around" the array

3. Binding

- Evidence for role of attention in binding:
  - Visual search
    - Slower if conjunction search
    - Also, T&G found that conjunction searches at chance w/o location info
  - Illusory conjunctions
    - Snyder (1972)
    - See T\textsuperscript{N}
    - Report T
3. Binding

4. Sustaining behavior

- ADHD and attention
  - Ceci & Tishman (1984)
    - ADHD vs nonADHD kids
    - NonADHD learned materials better
    - ADHD learned distracting stuff better
    - Not intellect: problem is sustaining behavior
  - Additional consideration: switch cost

Automaticity

- Practice makes task less demanding
  - Uses less capacity
- What kind of practice reduces capacity?
  - Consistent vs. varied mapping
  - Consistent: B is always target, Q distractor
  - Varied: B, Q each can be either

Automaticity

- Consistent vs. varied: Schneider & Shiffrin (1977)
  - Memory set: J, D, K, M, J
  - One trial
  - With consistent mappings, looked like parallel search
Automaticity

- Shiffrin & Schneider (1977)
- Is automaticity cost-free? NO
- After consistent training, use old target as a distractor: **22% drop** in detection of real target
- Stroop task: the automatic response isn’t the correct one
  - Dyslexic & ADHD children—apparently worse
  - Issue of executive control?

Automaticity

- Or Not-omaticity?
- Hirst et al. (1980)
  - Read while dictating sentences
  - No consistent mapping, so no automaticity
  - Nonetheless could write & comprehend
  - Pashler (1998): people are getting better at capacity sharing

Automaticity

- Logan: **instance theory** of automaticity
  - Do effortfully vs. retrieve from memory
  - 39 * 39; driving to friend’s house

Automaticity

- Logan: **instance theory** of automaticity
  - A “race” model (these are everywhere!)
  - After you’ve done it effortfully so many times, it’s faster just to retrieve the answer
  - But what’s an *instance*?
Automaticity

- The Stroop effect
- You read words automatically
- But you don’t name colors automatically
- Naming the font color when you’re trying to suppress reading the word itself is hard!
  - When the font color mismatches the word
  - Easy when the font color matches the word

5. The central executive

- (= action selection)
- Picks what you’re going to do
- Ability to shift attention
- “Cognitive control”
- Pashler: a true central bottleneck is response selection
  - PRP task

5. The central executive

- Psychological Refractory Period
  - Task A: L hand--respond high or low tone
  - Task B: R hand--respond letter X or C
- Some stuff can happen without “fighting for resources,” but planning a response requires executive control
5. The central executive

• Psychological Refractory Period

Stim A process → PLAN → respond
Stim B process → PLAN → respond

Task A hard

Stim A process → PLAN → respond
Stim B process → longer delay in B → PLAN → respond

Task B hard

Stim A process → PLAN → respond
Stim B process → longer delay in B → PLAN → respond

5. The central executive

• Why this bottleneck?
  – Avoid interference (pat head, rub stomach)
  – Pick an action
  – Revise an action

Bottlenecks on the road

• Things you do while driving
  – Talk to passengers
  – Listen to radio/sing along
  – Eat
  – Dial phone
  – Talk on phone
    • Handheld
    • Hands-free

Bottlenecks on the road

• Strayer & Johnston (2001)
  – Radio, book on tape OK
  – Shadowing via cell OK
  – …EXCEPT word-generation variant
  – Unconstrained conversation (±hands) bad
    • 2x increase in missing traffic signals!
  – S&J: cell “divert[s] attention to an engaging cognitive context
other than the one immediately associated with driving.”
Bottlenecks on the road

  - PRP paradigm
  - Braking (single-response, well-practiced)
  - A/V identification with A/V response (2AFC)
  - Modality independence? No
    - (Maybe auditory will interfere less)
    - Strongest delay was at shortest IOI
    - Regardless of modality, braking was delayed

More on visual attention

Chun, 2000

Visual search

- It’s everywhere.
  - Driving.
  - Walking around pedestrians.
  - Cupboard, fridge.
  - Desk. Room. Closet.
- It’s usually serial.
  - No pop-out benefits.
  - Does serial search ever get better?

Visual search: class data

- Feature, target present
- Feature, target absent
- Conjunction, target present
- Conjunction, target absent
Serial search

- Effortful
- Requires focused attention
- Speed scales with # of distractors
  – ≈ complexity of visual scene
- What would help?
  – Learning contingencies of environment
Making serial search easier

• Practice.
  – But remember consistent vs. varied mapping—not automatic unless targets are consistent
  – What counts as consistency?

Layout familiarity

• Distractor sets
  – Repeated layouts
    • Cued target position
    • Didn’t cue target identity (left-T or right-T)
  – New, random layouts
    • Did not cue target position
    • Target positions restricted to subset (like repeated layouts)
Layout familiarity

- Repeated & new layouts
  - Get better at task overall
- Repeated layout
  - Additional speed-up in performance
  - Not just knowing likely target locations

- Most interesting: people couldn’t pick out repeated vs. new layouts!
  - Implicit learning

Object cooccurrence

- Display of unfamiliar objects
- Find the vertically symmetric object
- Again, old (repeated) and new displays
  - Old: same sets of objects in different arrangement
  - New: target appears with randomly selected set of objects
Object cooccurrence

- Faster for cooccurring than random
  - Even though random spatial layout
  - Even though distractor sets equally familiar
- Again, overall improvement
- Again, can’t explicitly distinguish old from new
Path familiarity

- Moving T among moving L’s
- L-movement
  - Recurring
  - Random
- Familiar trajectories aided target ID
- Good skill for team sports

Brains

- The hippocampus
  - Contextual learning
    - Relational/configural processing
    - Spatial navigation
  - Amnesics with damaged hippocampi
    - Get better at Chun’s visual search task
    - But don’t benefit from repeated layouts

Speeding up serial search

- Familiar layout
- Familiar object set
- Familiar movement directions
- Dependent on (implicit) memory

Attentional blink

- Related to bottleneck
  - Task 1: press button to red letter
  - Task 2: did X appear after red letter?
- Really fast
- Vary delay between red letter & X
- How long to ‘recover’?
Did you see an X?

Learning attention?

• Green & Bavelier (2003), *Nature*
  – Tested action video game players (VGPs) on visual attention tasks
  – Tasks:
    • Peripheral attention task
    • Attentional blink

Learning attention?

• Green & Bavelier (2003), *Nature*
  – Peripheral attention task
  • VGPs better than non-VGPs
  • Even far outside the video game field of view!

Learning attention?

• Green & Bavelier (2003), *Nature*
  – Attentional blink
  • Got shorter
Learning attention?

• Green & Bavelier (2003), *Nature*
  – Effects held with ±trained non-VGPs
  – Experience drastically alters attention
    • Plasticity
    – Generalizes outside the ‘training area’
    – Why? How?
      • Forcing attention to multiple objects
      • Highly motivating context?

• Bavelier, Neville & colleagues
  – Deaf participants show better peripheral attention than hearing
  – *Not* true for bilingual (signed & spoken) hearing participants
  – Effect of experience?
    • Not exposure to signed languages
    • Perhaps *sensory* exposure to sight-only