

## **9.65 February 4, 2004 Introduction; How we read HANDOUT**

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### **I. Introduction to 9.65**

We cover human experimental cognitive psychology, the study of human intelligent processing. Includes high-level vision (e.g., object recognition), attention, immediate and longer-term memory, learning, nature of concepts, imagery, language processing, mental codes, reasoning, and problem-solving. Emphasis on experimental methods and evidence.

IT'S ESSENTIAL TO COME TO LABS AND THE QUIZZES. Note the dates on which the lab reports are due. There will be handouts with an outline at the beginning of most lectures, but they will not provide all the information you need: there will be space on the handout to add your own notes during the lecture. (This particular handout is more complete than most and includes some information not in the lecture.)

### **II. Visual acuity and eye movements**

#### **a. Visual acuity:**

We see in fine detail only about the width of our thumb held at arm's length: acuity (grain) falls off very rapidly in all directions, so that we only get gross information outside a 10 degree circle.

In the visual system, the changing grain of acuity corresponds to the density of photoreceptors (cones and rods) and retinal ganglion cells in the retina (the back of the eyeball). (Cones, which are sensitive over a wide range of brightness except for very low levels of illumination, are highly concentrated in the fovea, whereas rods, which are sensitive to very low levels of light but saturate with high levels, are more evenly distributed over the retina.) Likewise, cells in the visual cortex (in the brain) are more numerous in the part that represents the fovea (close to the center of fixation) and thin out in parts that represent the periphery (away from the fovea). This change in density of representation is called the cortical magnification factor.

#### **b. Eye movements and fixations:**

How do we manage to deal with the 360 degree world, when we have such a tiny area of sharp vision? We move our eyes around, to fix briefly on regions that we want more detailed information about: peoples' faces, things that are moving, bright things, parts of the visual field that have lots of contours (such as corners), and words as we read.

Main characteristics of eye movements:

2 kinds of eye movements:

(1) **saccade** (jump, ballistic movement): jump from one spot to another, and make a **FIXATION** on each spot. This is the main way we pick up information. The eyes are attracted to points in a scene with more information--more "complexity."

-the average eye fixation lasts for 200-300 ms, and there is a 20-40 ms saccade or movement to the next spot, so **THREE OR FOUR FIXATIONS PER SECOND**.

-can't see much while eye is moving (saccadic suppression)

(2) **pursuit movement**: fix eye on a moving object and follow it.

### **c. Eye movements and visual acuity in reading:**

Methods for studying:

(1) Eye tracking devices can determine when and to where the eyes go--and how long they stay on each spot. Our basic knowledge about reading comes from these studies.

(2) Moving window (how small a window can be tolerated without affecting reading?)

(3) Mangled text at some distance from fixation: fixation is indicated by the \*.

xwekicnelkivn you are read\*ing this text wlkedimgsmc

-can see specific letter information for only 7-8 characters (letters or spaces) to the right of fixation, less to the left, though can get a little information, including presence of a space, up to about 15 character spaces to the right of fixation.

-Our eye movement pattern while reading is determined by number of characters, regardless of size of print or distance from the page or CRT (unless extremely small or large).

-We ordinarily fixate each longish word at least once

-If we don't directly look at a word, it is probably short and fairly predictable, like some function words such as *and*, *or*, *of*. (About 2/3 of such words may not be fixated.)

-regressions (looking back) to an earlier point on 10-15% of saccades.

-Reading rate: So, for most college students, their net reading rate is something like 5 or 6 words per second, or around 300 to 350 words per minute (although 250 wpm is common).

### **d. Immediacy of processing?**

How immediate is processing? Do we process each word fully while we are fixating it, or do we store up several words and then process them?

"The cotton cloth is made of grows in the south."

A reader may be momentarily **garden-pathed** by that sentence, because when he or she arrives at the word "cloth," it seems to be a noun phrase, "the cotton cloth" instead of "The cotton (that) cloth is made of..."

This and other evidence suggests that we do immediately process each word as we fixate it, as far as the sentence and text to that point allows. How do we know this? By studying the durations of individual fixations on a given word, researchers have found that the duration of a fixation reflects word frequency, appropriateness to context, syntactic difficulty at that point in the sentence, etc. Some of the difficulty created by a given word may "spill over" into longer times spent looking at the next word or two, but most problems show up immediately.

Because the motor planning for the next eye movement reaches a "point of no return" (can't stop the planned movement) about 140 ms before the actual saccade takes place, that leaves only about 160 ms of an average 300 ms fixation for processing the word one is looking at and "deciding" whether to extend the duration of the fixation or move on. That is, for word frequency to have an effect on how long you look at the word, you have to have recognized the word (or know that you've failed to recognize it) within the initial 160 ms of processing.

The time for processing in the brain is actually even shorter than that, because it takes about 40 ms to get information from the eye to the brain: thus, the central processing time for the average word must be less than 120 ms--including not only looking up the word mentally but also understanding its fit to the syntax and meaning of the sentence.

### **e. Are eye movements (plus acuity limitations) a waste of time, in reading?**

Would we read faster and more effectively if we could read without eye movements? With computers it is possible to present each word, one at a time, in the center of the screen so that you get perfect clarity without having to move your eyes. This method, called "RSVP" for *rapid serial visual presentation*, has been used to study just how fast people CAN read if they don't have to move their eyes.

RSVP reading at 10 or 12 words/s is fairly comparable to reading NORMALLY: provided that you give only one sentence in isolation. People can understand the sentence, make a quick judgment as to whether or not it's plausible, and repeat it accurately.

BUT: If you read a paragraph at this rate: you seem to understand each sentence and get the general drift, but the amount you remember is small. We'll return to this issue a little later in the course.

CONCLUSION: RSVP allows fast skimming but only poor memory: so eye movements are not a waste of time. We read the way we do because we need the time for **memory consolidation**, and indeed we adjust the time spent on each word according to the word's intrinsic difficulty, and according to how well it fits the sentence and the discourse.

Therefore: Speed reading? It's not possible and probably not desirable anyway. Skimming, however, may be sufficient for some purposes, and is worth learning how to do.

### **f. Speech recoding and reading:**

There is a lot of evidence in the experimental literature that we DO recode to speech (create the sounds of the words in our head) when we read: for example, Van Orden showed that people can be misled in a task such as this. You are shown a word or phrase, and then a second word, and you have to decide as fast as possible whether the second word is consistent with the first word. For example:

"Animal" POODLE [Yes]

"Part of a building" SELLER

"Flower" ROWS

[Participants may mistakenly say Yes to homophones like seller and rows, when they sound the same as cellar, rose (to which you'd say yes)]

-Is speech recoding a bad feature of reading? Probably not, because a phonological representation may be needed for understanding, for example to hold info. in memory briefly while we process a sentence.

-Does phonological recoding--"hearing" the sounds of words as we read--slow us down? Probably NOT, because we apparently can recode even when reading at 12 words/s (in RSVP).

Petrick experiment:

The boy's pockets were heavy with change which jingled as he walked.

CHAINS? (acoustic) COINS? (semantic) ROPES (unrelated, but related to the acoustic distractor)  
Positive probe CHANGE

Results: people were slower and made more errors to both chains and coins, after reading at 83 ms/word (12 words/sec).

Scrambled sentences: more phonological confusions, fewer semantic.

Is recoding to "sound" only true for alphabetic writing systems? No! it happens in reading Chinese and other logographic systems.

CONCLUSIONS: -acoustic/phonological recoding as one reads is universal, and happens FAST, so probably doesn't slow you down in reading. You just become more aware of the sound if reading is difficult or you are distracted and not concentrating on the meaning.