# Monkey See, Monkey Read: Orthographic Processing in Baboons (Papio papio)

Grainger et al., 2012

September 17, 2013

Okay, so this presentation is based around an experiment that's definitely a learning experiment, but is probably more located in the field of reading, so what I thought I'd do was go over the procedure for the experiment first, just treating it as a learning experiment and maybe seeing what people think about it in those terms, and then get on to the language aspects of it later on.

## Word Recognition and Lexical Decisions

- Pretty simple task: present a word, ask the subject "is this a word?"
- The "no" trials are nonwords: character strings that don't form real words

The basis of a lot of reading research has been the lexical decision experiment, where you basically present a subject with a string of characters and ask them "is this a word?". The words are presented along with nonwords, strings of characters that are hopefully similar enough to words that you can't immediately dismiss them. Accuracy is generally high enough that you can't really get much useful information from it, so what you're typically measuring is reaction times.

# Levels of processing

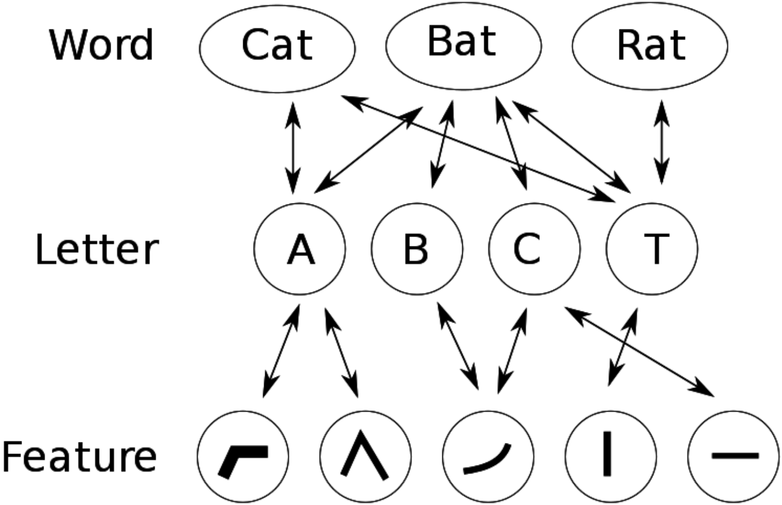



Figure: Interactive activation model- McClelland and Rumelhart, 1981

## Does the lexical decision task actually require this?

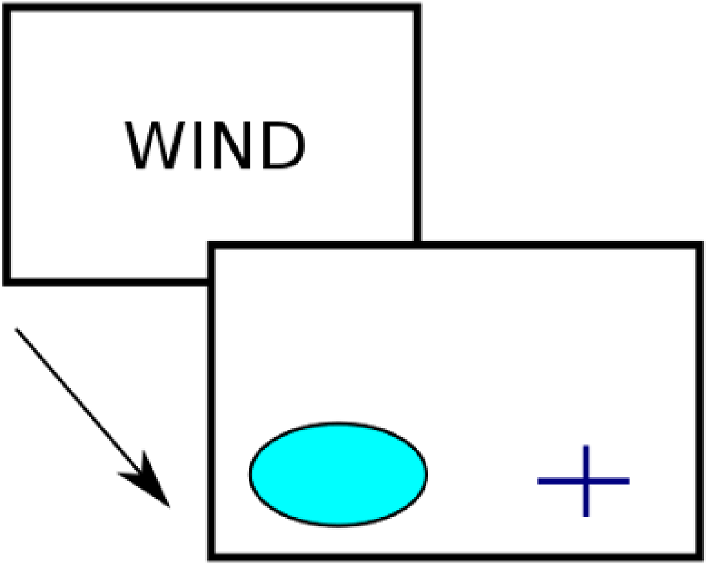
- Do you need to access your internal representations to make decisions about:
  - ‘COOK’ and ‘XUNQ’?
  - ‘LEAP’ and ‘RIST’?

So at this point, the main question you’re left with, is does the lexical decision task actually involve that level of processing? And that’s what the experiment I’m going to talk about gets at.

## Teaching monkeys to read

- 6 socially-housed baboons with no prior exposure to written language
- Starting testing sessions whenever they want.
- Testing sessions are blocks of 100 trials: all monkeys did 40,000+ trials across the whole experiment

So here's the experimental setup that Grainger and his colleagues were using: there are 6 baboons with microchips in their arms, and they have free access to computer testing booths. I think in the actual monkey habitat there are lots of monkeys, all potentially part of different experiments at different times, so when they enter a booth, the microchip identifies them and the computer sets up the appropriate experiment. This seems to work fairly well: in the one and a half months that the experiment ran for, all the monkeys did forty to fifty thousand trials.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## Testing blocks

Each 100 trial block consists of:

- 25 presentations of a new word
- 25 previously learned words
- 50 nonwords

Words are considered learned when the monkey reaches 80% accuracy for that word within a block.

Note: for the baboons, a word is something they've seen before, a nonword is something new (or only seen very rarely).

So within each 100 trial block, there's a new word to learn that is presented 25 times, 25 words that are randomly chosen from the set of words the monkey has already learned, and 50 nonwords, randomly chosen from a pool of 7,000+.

## Example words and nonwords

| Words | Nonwords |
|---|---|
| born | sner |
| make | onfs |
| pane | knec |
| week | hilb |
| limp | grig |

So, here's some examples of the words that the monkeys are learning in this experiment, and we'll come back to exactly how these were constructed later.

Obviously words are being seen much more often than nonwords, which are only going to be seen every once in a while, so from the baboon's perspective, what they're responding to is basically a

# The Overall Results

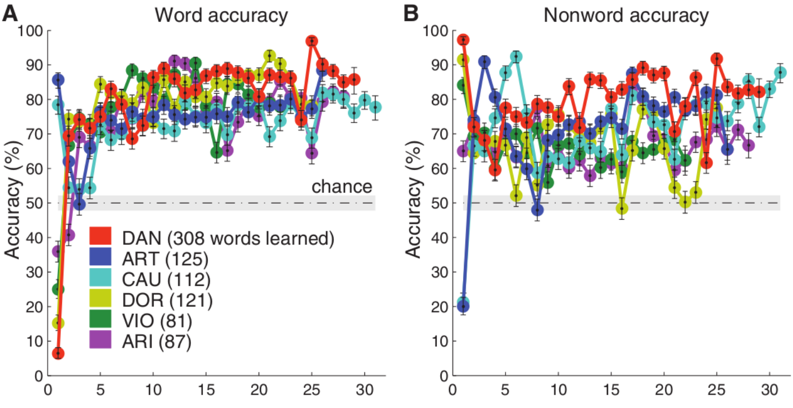



Figure: Results graph from Grainger et al., 2012

Okay, so we've covered the basic design, and this point I want to kind of jump ahead to the results, because although this graph is sort of the main result in terms of the monkeys learning to do the

## Some preliminary conclusions

- Monkeys are capable of learning the kinds of detailed visual information that is required for reading.
- Human reading might be built on capacities that were already present in chimps, rather than abilities that were evolved more recently.

*The primate brain might therefore be better prepared than previously thought to process printed words, hence facilitating the initial steps toward mastering one of the most complex of human skills: reading*

Even from these broad results, there's some quite interesting conclusions you can draw- the most important thing these results show is that our capacity for reading is probably based in large part on capacities that were already present earlier in our evolutionary history. One of the things that's quite interesting about reading is that it appeared so recently and spread so quickly that it's not likely to be something that's evolved through being specifically

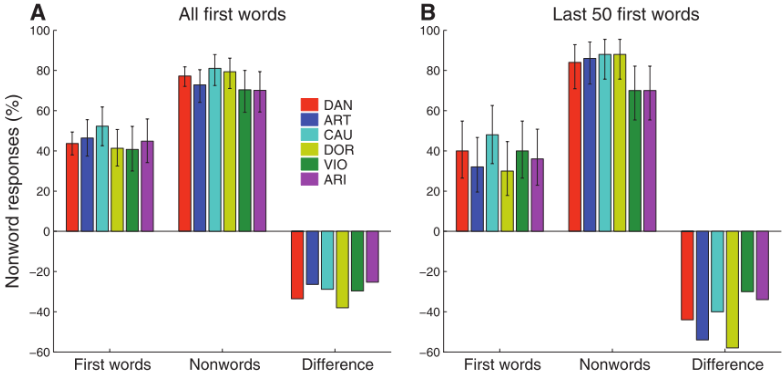



Figure: Responses to new words

## The interesting parts

- Towards the end, monkeys were more likely to classify novel real words as words.
- Monkeys obviously aren't making decisions about these stimuli based on whether they're "real English words"
- So, what sources of information *are* they using to make these decisions?

So, now we're getting to the parts of the experiment that are more interesting from a language perspective. As well as learning to respond "word" to stimuli that they'd already seen, the baboons seemed to learn something about what words and nonwords look like, because when new words were presented for the first time, the baboons were more likely to classify them as words than novel nonwords. The reason they're able to do this has a lot to do with the specific way the nonwords and words in this experiment were chosen, so I've sort of cheated by witholding that from you up to now.

## Word-like words and nonword-like nonwords

Bigrams: `wasp -> wa, as, sp`

Bigram frequency: how often each pair of letters occurs in English words/text.

- Mean bigram frequency for words in the experiment: $3.6 * 10^{-4}$
- For nonwords: $5.96 * 10^{-5}$

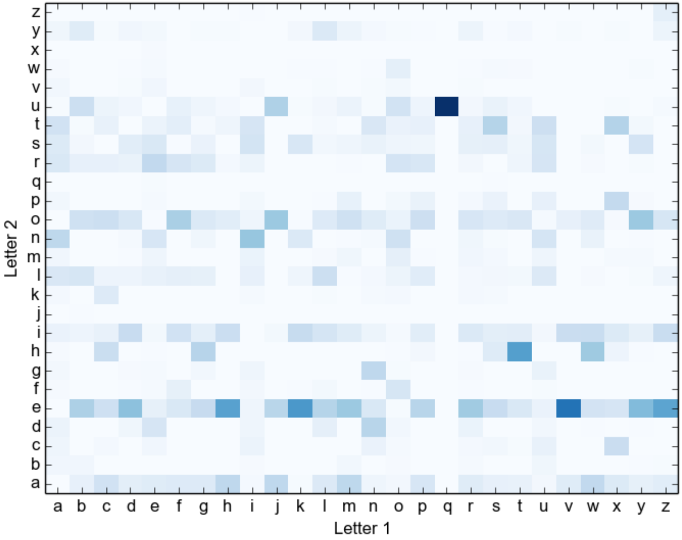
One of the simplest ways you can measure “wordlikeness” for these purposes is to look at the “bigram frequency”, how often each pair of letters occurs in English words. This is a very simple way of quantifying how a string of letters compares to real English text, but it’s surprisingly effective.

The words and nonwords in this experiment were specifically chosen so that their distributions of mean bigram frequency had no overlap, so if the monkeys *were* able to pick up on this statistical difference in the stimuli, that probably helped a lot in their ability to make some kind of guess about novel words and nonwords

## Statistical structure in language

- Language is too complex and inconsistent to be easily captured by rules
- *But:* there are clear patterns and consistencies that appear when you examine large amounts of text.

What this is getting at is there are some fairly consistent statistical patterns in language that are probably making it more learnable. If you look at any large sample of text (here I've got Moby Dick, because it's an obvious place to get a lot of words), you'll see consistent (but not necessarily identical) patterns in which letters are paired together, which words are paired together, and so on.



Letter 2
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a b c d e f g h i j k l m n o p q r s t u v w x y z
Letter 1

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200 ES ELOHRNDE OHRNO UOVEOULOSU O UOVEO HR OITO HEOQAET IUSOPHE HELO ITOSUVDEL
300 ES ELOHANDE OHANO UOVEOULOSU O UOVEO HA OITO HEOQRET IUSOFHE HELO ITOSUVDEL
400 ES ELOHINME OHINO UOVEOULOSU O UOVEO HI OATO HEOQRET AUSOWHE HELO ATOSUVMEL
500 ES ELOHINME OHINO UODEOULOSU O UODEO HI OATO HEOQRET AUSOWHE HELO ATOSUDMEL
600 ES ELOHINME OHINO UODEOULOSU O UODEO HI OATO HEOQRET AUSOWHE HELO ATOSUDMEL
900 ES ELOHANME OHANO UODEOULOSU O UODEO HA OITO HEOQRET IUSOWHE HELO ITOSUDMEL
1000 IS ILOHANMI OHANO RODIORLOSR O RODIO HA OETO HIOQUIT ERSOWHI HILO ETOSRDMIL
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1700 ESTEL HAMRET HAM TO BE OL SOT TO BE THAT IN THE QUENTIOS WHETHEL TIN SOBREL
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1900 ENTER HAMLET HAM TO BE OR NOT TO BE THAT IS THE QUESTION WHETHER TIS NOBLER
2000 ENTER HAMLET HAM TO BE OR NOT TO BE THAT IS THE QUESTION WHETHER TIS NOBLER
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Figure: Codebreaking with bigram frequencies

Diaconis, P. (2008). The Markov chain Monte Carlo revolution. Bulletin of the American Mathematical Society, 46(2), 179–205.