Scrambled Word Recognition: Implications for Position Coding

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Position coding:

The way in which letters are represented within word-level mental representations.

Traditional view: slot-coding

Each letter's position within a word is part of our mental representation of that word. We recognise the word by identifying both the letters contained and the slots in which they occur.

POST = {1: P, 2: O, 3: S. 4: T}

Problems with the traditional view

- How do we handle spelling mistakes? Often we can read a sentence without noticing these; our lexical access is not impaired.
- How do we process word fragments, in which an initial letter or letters are missing? This displaces all the other letters and should make the word unrecognisable.
- How do we explain the "scrambler effect"?

The "scrambler effect": an internet meme

"It deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnt tihng is taht the frist and lsat ltteer be at the rghit pclae. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe."

This observation is due to Graham Rawlinson (1976). Matt Davis of MRC-CBU discusses this example in more detail at http://www.mrc-cbu.cam.ac.uk/~mattd/Cmabrigde/index.html.

Alternative views

Wickelfeatures (trigrams)

Wickelgren (1969) proposed that the letters in a word are represented with reference to their local context, specifically the preceding and following letter (or word boundary). This view sees words represented as a set of trigrams, a.k.a. Wickelfeatures.

POST = {_PO, POS, OST, ST_}

Bigrams and open bigrams

On the (closed) bigram view, the representation of a word is the set of bigrams within the word. This makes similar predictions to the Wickelfeature model.

POST = {PO, OS, ST}

Open bigrams are ordered but not necessarily adjacent letter pairs. Their relevance is supported by Whitney (1999) i.a.

POST = {PO, PS, PT, OS, OT, ST}

Spatial coding

This view, endorsed by Davis and Bowers (2006), suggests that the letter units are not specified discretely for position, but that words are represented by a pattern of activation over the letter units. This might, for example, be a monotone decreasing sequence of activation levels over the letters of a word.

POST = {act(P) > act(O) > act(S) > act(T) > 0}

Other considerations

Attention has also been given to the idea that the first, middle and last letters might have a privileged status, and that bifocal vision might be relevant in anagram solving (i.e. that letters switched across the middle of the word might prove especially troublesome).

Predictions

From these theories, I developed a set of predictions about the relative 'difficulty' of various possible word permutations. This is quantifiable in terms of each theory. It is then possible to investigate whether the time taken to recognise the word is related to this apparent difficulty.

Consider for example the strings HLOIDAY and HOLADIY as derangements of HOLIDAY. Their relative difficulty might be assessed as follows.

	HLOIDAY	HOLADIY
Position coding	2 violations	2 violations
Position coding (movements)	2 movements	4 movements
Closed bigram coding	3 violations	4 violations
Open bigram coding	1 violation	3 violations
...	...	...

Applying this to a selection of different derangements, it is possible to derive distinctive predictions about relative difficulty from each position coding theory.

Anagrams and word recognition

The limiting case of the scrambler effect is anagram solving. If the letters of each word are randomly jumbled, a text cannot be decoded at anything approaching normal reading speed.

However, anagram solvers do sometimes achieve a performance level that resembles visual word recognition. In these cases, the process is characterised by

- sub-second solution times
- "pop-out", subjectively sudden solutions (Novick and Sherman 2003)
- apparent independence from computational complexity. For example, solution time is not factorially related to word length, as we might expect (Kaplan and Carvellas 1968).

I assume here that the process underlying pop-out anagram solution is the same as that used in standard VWR. If this is the case, then the effect on permutation on pop-out anagram solving arises because of the way in which position coding is implemented.

General hypotheses

- Expert anagram solvers will be able to give pop-out solutions for some 7-letter words.
- There will be patterns at this length which are both
  - appreciably more difficult than normal, non-scrambled words, and
  - appreciably easier than random rearrangements.
- The existence of different difficulty levels will shed light on position coding theories.

Methodology

Words were presented in the following conditions, taking the word HOLIDAY as an exemplar. Each word-condition was used once in the experiment. Eight participants were each shown 96 word-conditions, in four blocks of 24. Latencies and accuracies were tabulated and compared.

1. HOLIDAY (correct)	2. LOHIDAY (1st & 3rd switched)
3. HILODAY (2nd & 4th switched)	4. HOLADIY (4th & 6th switched)
5. HOLIYAD (5th & 7th switched)	6. HOAIDLY (3rd & 6th switched)
7. HDAIOLY (2nd & 5th, 3rd & 6th switched)	8. ODHIYLA (quasi-random)

Note on the participants

The eight participants, members of the local Scrabble club, were tested on the following anagram list, originated by Novick and Coté (1992). Performance in 10 minutes ranged from 15-20 correct, far above the mean for undergraduates (8.6) tested by Novick and Sherman (2003).

SINUM	LAVEG	MELIP	YAILG	OXMIA
GUNSE	SOULE	MENGO	LIMYK	VANIE
WROPE	WATEK	EVIRT	MYKOS	CUTHE
PRUNS	MYLAD	SUROC	DOEPT	BROEP

Analysis of results

For each participant, an order of difficulty emerges based on time taken and accuracy obtained. The unscrambled case was the best in every case; the worst was either case 7 or case 8.

For a given pair of conditions, each theory predicts which will be easier. I performed sign tests to check whether these predictions are met. For example, the prediction that "A is easier than B" is met with high significance if A was easier than B for each of the 8 participants, and with lower significance if A is easier than B for 7 of the participants.

Conclusions

Conditions 3-6 are all harder than condition 1 and easier than condition 8. This supports the assumption that these forms could be instructive to our understanding of position coding.

Considering the pairwise comparisons of conditions under test, we find the following.

- Wickelcoding view consistent with all statistically significant findings
- Open bigram theories also performed well, using the rectilinear metric.
- A spatial coding theory can be parameterised in such a way as to concur with these results (e.g. by emulating Wickelcoding or open bigram predictions).

This methodology appears useful in the investigation of position coding. In particular pop-out solutions are generated, and significant differences between rearrangement conditions can be obtained. The methodology can be used to explore more sophisticated position coding theories.

References

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