Can letter-position uncertainty account for lateral masking?

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Introduction

- Lateral masking (crowding) is the decrease in identification accuracy of a visual stimulus when it is flanked by other visual stimuli.
- When the targets are letters, errors in the lateral-masking paradigm are of two types: identification errors or uncertainty in the position of letters within strings.
- This research argues that letter-position uncertainty accounts for most of the lateral-masking effect.

Questions

- Can letter-position uncertainty explain lateral masking?
- When strings of letters are presented, does information about letter identity and letter position follow the same or different time course?
Method

Participants:
• 2 normally sighted.

Stimuli:
• 3 stimulus conditions:
  o isolated letters (1 random letter in each presentation)
  o trigrams (random strings of 3 letters)
  o pentagrams (random strings of 5 letters)
• Letters were the 26 lowercase letters of the English alphabet in Courier font.
• The x-height of the letters was constant at 0.5°.
• Stimuli were presented in central vision and at 0, 2 and 4 character spaces to the left (-) and right (+) of central fixation.
• Each character space subtended 0.7°.
• 6 exposure times ranging from 8 to 800 msec.
Design

- Measured % correct recognition as a function of exposure time.
- Percent letter position and letter-identity errors were computed.
- Letter-position errors = reporting a letter in the string not at the cued location (e.g., scv→target = c→response = v).
- Letter-identity errors = reporting a letter that was not present in the string. (e.g., scv→target = c→response = o).
- Subjects' responses were scored in two ways:
  1) The response was correct if the letter occurred anywhere in the string (excludes letter-position errors).
  2) The response was correct only if the letter in the cued position was named (includes letter-position errors).
Procedure

- Before a block of trials participants knew the stimulus condition, eccentricity and position of the letter to be reported (e.g., "identify the middle letter of the trigram in the next block").

Trial sequence

- Blank screen with fixation target
- Block pre cue Indicates eccentricity (on for 3 sec.)
- Target (8-800 msec.)
- Mask (on for 100 msec.)

- The participants reported only one letter (e.g. “c”) using the keyboard
Can letter-position uncertainty explain lateral masking?

Hypotheses

- The decrease in identification accuracy of a letter when it is in a string is due to errors in the assignment of position in the perceptual encoding of letter strings, here termed “position uncertainty”.

- High number of letter-position errors implies high position uncertainty. If this is true then:
  1) Thresholds for performance excluding letter-position errors should be faster than thresholds for performance including letter-position errors.
  2) Thresholds for performance excluding letter-position errors should be equal to thresholds for isolated letters presented at the same eccentricity.
Results

• The accuracy data were fit with Weibull functions

\[ \delta = \text{offset of upper asymptote from 100\%} \]
\[ \alpha = \text{threshold: time required for 64\% correct} \]
\[ \beta = \text{Slope- indicates the rate at which accuracy increases per millisecond} \]
\[ \gamma = \text{guess rate} = 1/26 \]

• \( \alpha, \beta \) and \( \delta \) were free to vary
Psychometric functions for single letters were different from functions for performance including letter-position errors but equivalent to performance excluding letter-position errors.

These are fits for the middle letter:

- **Performance including letter-position errors**
  - single
  - trig
  - pent

- **Performance excluding letter-position errors**

Proportion correct

Exposure time (msec.)
Thresholds for performance excluding letter-position errors were faster than thresholds for performance including letter-position errors and equivalent to the isolated-letter thresholds.

These are thresholds for the middle letter.
Raw data (20 msec. exposure time)
(These are percentages for the middle letter)

-4 -2 0 2 4
Percent Correct
Letter spaces away from center

Includes letter-position errors
Trigrams
Pentagrams
Isolated letters

Excludes letter-position errors
When strings of letters are presented, does information about letter identity and letter position follow the same or different time course?

Letter-identity errors decrease with increasing exposure time but letter-position errors remain constant.

![Graph showing the relationship between exposure time and percent errors for letter identity and letter position. The graph shows a decrease in letter-identity errors with increasing exposure time, while letter-position errors remain relatively constant.](image-url)
Letter-identity errors remain constant for all letter positions in strings but letter-position errors increase for the inner letters of strings.
Conclusions

- The decrease in identification accuracy of a flanked letter can be explained almost entirely by position uncertainty.
- Position uncertainty shares characteristics with lateral masking; it increases with eccentricity and string length, peripheral flankers produce more position uncertainty than foveal ones.
- The time courses of letter identity and letter-position processing in letter recognition are different.
- These results are consistent with the idea of two separate processing subsystems (what and where) working at the level of letter recognition.

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