

Reverse asymmetry for whole-letter confusions in crowding

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Introduction

- Letter crowding is not a uniform process, and several **sources** have been proposed
 - letter **confusion** vs. letter **substitution**
 - within-character vs. between-character crowding
 - feature-source vs. letter-source confusion, etc.
- We re-analyzed letter-crowding data for inward-outward **asymmetry of confusions of the target with a flanker**.

Asymmetry Literature

Papers reporting **"standard" asymmetry**

Wagner (1918), Mackworth (1965), Bouma (1970), Estes & Wolford (1971), Estes et al. (1976), Krumhansl (1977), Chastain (1983), Bex et al. (2003), Petrov et al. (2007), and others.

"A pilot experiment indicated that ... the adverse interaction is stronger if the interfering /x/ is at the peripheral side" (Bouma, 1970).

"the peripheral-central asymmetry of the lateral interference effects exerted by other letters on a target letter in a nonfoveal location" (Estes et al. 1976).

"performance on the peripheral letter higher than on the central letter (Krumhansl 1977)"

Papers reporting **inverse asymmetry**

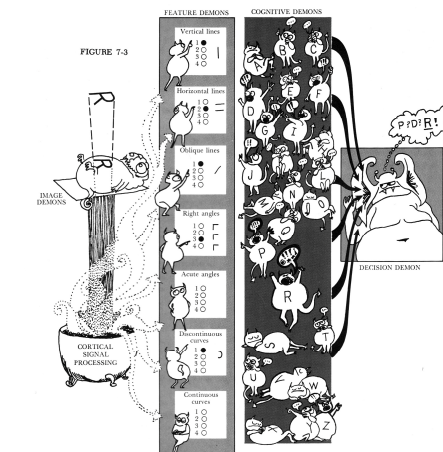
Chastain (1982), [Krumhansl (1977)], Huckauf & Heller (2002), Strasburger & Malania (2013)

"confusability between members of a parafoveally exposed pair of letters affected accuracy of identifying the peripheral, but not the central, letter" (Chastain 1982) ... (i.e., similarity to central letter is more important)

Korte (1923)

"It has already been mentioned that the perceptions are extra-ordinarily wavering. They do not keep still for their regard but are permanently moving. This goes as far as that subjects frequently speak of a "dance". Particularly erratic are the horizontal strokes, the ticks, the arches etc. They aimlessly buzz around, so to say. One minute up, next minute down, then right ..."
"... to the fleetingness of the ... elements the bouncing of whole characters is added ... Two dancing manikins' ... Two "o" that jig about."

Computational Pandemonium Model

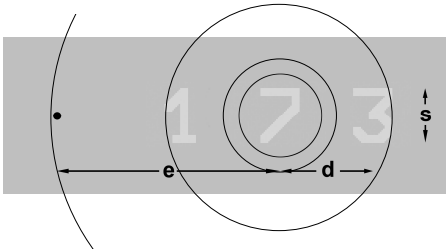


... of feature integration:

Demons are recognizing the letter "R".

(Lindsay & Norman 1977, Selfridge 1959, Illustration: Leanne Hinton)

Methods

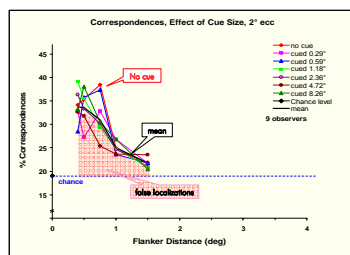


Contrast thresholds by ML-PEST

- Cueing 150 ms before stimulus
- Testing at three eccentricities: 2°, 4°, 6°
- for a range of flanker distances (0.4°–4°) and cue sizes (0.3°–8.3°)
- 20 subjects × 40 conditions × 60 trials = 48,000 responses

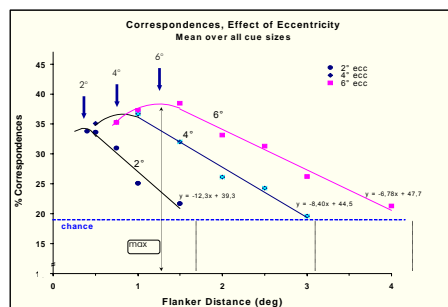
Ancillary Results

Transient attention (=cue) had **no effect** on flanker confusions:



target
2° ecc
0.4° size

Generalized Bouma Rule for confusions:



$$d_{crit,thr} = 0.7 E + 0.3^\circ$$

$$d_{max,thr} = 0.125 E + 0.25^\circ$$

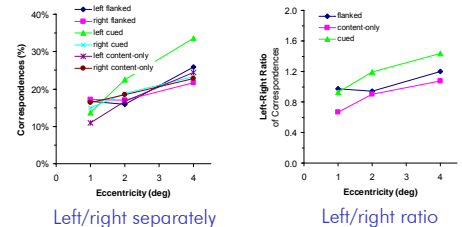
$$d_{crit,corr} = 0.625 E + 0.48^\circ$$

$$d_{max,corr} = 0.188 E + 0.07^\circ$$

- Source confusion increases with eccentricity and occurs at larger flanker distances
- Critical distance is 80% of eccentricity (1.7° / 3.05° / 4.2°)
- Maximum at 20% of eccentricity (0.4° / 0.8° / 1.3°)
- Maximum is 38% (chance 19%)
→ > 19% false localizations

Main Result

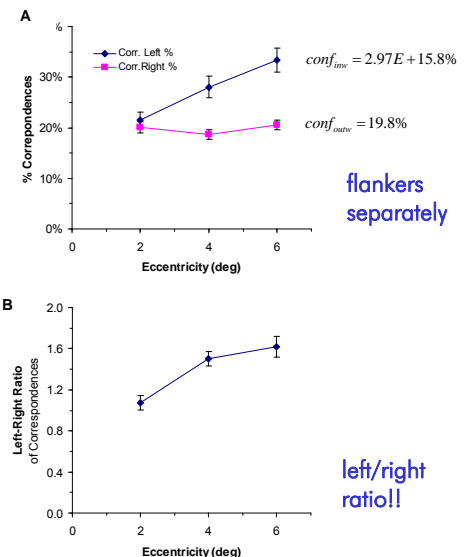
Confusions were asymmetric in a direction **opposite** to asymmetries reported for masking:



Left/right separately

Left/right ratio

Correspondences of the subject's report with a flanker data of Strasburger (2005)



flankers
separately

left/right
ratio!!

Correspondences of the subject's report with the left or right flanker. (A) left and right separately; (B) the resulting left/right ratio. Error bars show SEM (n=42) (Str. & Mal. 2012)

→ The **inward flanker** was increasingly confused at increasing target eccentricities.

Conclusions

- Suggests separate neural coding of pattern content and position, i.e., of **what and where**.
- Confusions vs. flanker distance scale with eccentricity. They are described by a **generalized Bouma critical-separation rule**.
- We propose underlying mechanisms to letter crowding where **feature-binding decreases with eccentricity** such that free-floating letter parts intrude from the periphery, whole letters from the center.