UNIVERSITÄTSMEDIZIN GÖTTINGEN : UMG

Source confusion is a major cause of crowding

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Crowding Effect (C=5%)

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Outline of Talk

- (A) The origins

  Korte (1923)

- (B) Our paradigm

  JOV 2005

- (C) A parametric study

  (eccentricity, flanker distance, cue size)

  Effect of cue size
  Cue effect on contrast threshold
  Characteristics of source confusion

- (D) Conclusions

Introduction

In 1936, the danish ophthalmologist Ehlers first described what was later by Stuart & Burian called the „crowding effect“ *as we define it today*. Ehlers noted that in the acuity charts in use some children and adults had particular difficulties recognizing the optotype when other optotypes were close by.

A natural paradigm to study that effect would thus be measuring the recognizability of a letter surrounded by others.

In a rather different strain of thought, the German Gestalt psychologist Korte (1923) earlier described the perceptual phenomena of reading in indirect vision.

His introduction reads rather contemporary:

Lange Zeit hindurch hat das Vorurteil geherrscht, dafs das indirekte Sehen dem direkten gegenüber unvollkommen und relativ bedeutungslos sei, und erst ganz allmählich hat sich die Erkenntnis von der fundamentalen Bedeutung des seitlichen Sehens für die gesamten optischen Prozesse durchgesetzt. Im Jahre 1889 zeigte A. KIRSCHMANN [1], dafs beim Lesen nicht etwa alle Buchstaben nacheinander fixiert werden, sondern dafs der Fixationspunkt sprungweise weiterverlegt wird, d. h. also, dafs die meisten Buchstaben nur extrafoveal gesehen werden.

For a long time the prejudice was prevailing that indirect, compared to direct vision, is imperfect and irrelevant, and only very slowly the insight of the fundamental importance of seeing sidelong has prevailed. In 1889 Kirschmann has shown that in reading the individual letters are not fixated one ofter the other but that the fixation point jumps, which means that most letters are seen extrafoveally only. (Korte 1923)

In his 64-page paper Korte describes the perceptual process of reading letters and words as happening in three phases from which he extracts general perceptual rules.

The first and second phase are of interest to us.

Diese 1. Phase des Erkennungsprozesses bringt also eine Auffassung der allgemeinsten Eigenschaften des Sinneseindrucks als eines Ganzen, also etwa der Rundung, Eckigkeit, Verworrenheit, Länge usw.

This 1st phase of the perceptual process thus brings about a notion of the most general characteristics of the sensation as a whole, i.e. for example roundedness, angularity, obscurity, length etc.

The 2nd phase is the emergence of detail. Korte describes it most extensively

Die 2. Phase setzt dann ein, wenn sich aus dem Wechsel der Empfindungen etwas Charakteristisches heraushebt, sei es objektiv richtig oder falsch. Nun greift der durch die Phantasie beflügelte „Gestaltungsdrang“ ein und schafft aus dem relativ klar Erkannten und dem diffus Gebliebenen das Bild eines Buchstaben.

The 2nd phase sets in when, out of the change of sensations, something characteristic singles itself out, be it right or wrong. Now, winged by phantasy, the “*Gestaltungsdrang*” sets in (desire of figuration) and creates, from the clearly perceived and the diffusely remaining, the image of a character.

2nd phase: floating of details („features“)

Es ist bereits erwähnt worden, daſs die Wahrnehmungen auſserordentlich schwankend sind. Sie halten der Beachtung nicht still, sondern sind ständig in Bewegung. Das geht so weit, daſs die Vpn. nicht selten geradezu von einem „Tanze“ reden. Ganz besonders unbeständig sind die wagerechten Striche, die Häkchen, Vorbogen usw. Sie schwirren sozusagen ziellos umher. Bald sind sie oben, bald unten, bald rechts,

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 …

2nd phase: floating of whole characters

Bei Wörtern tritt zu der Flüchtigkeit einzelner Elemente der Buchstaben ein „Herumhüpfen“ ganzer Buchstaben hinzu. Feste Lokalisierung von Einzelheiten ist äußerst schwierig. Sie ist möglich höchstens für den ersten und in geringerem Maße für den letzten Buchstaben. Immer wieder kommen Aussagen wie: „Irgendwo ist ein i-Punkt“, „irgendwo ist dieser oder jener Buchstabe“. Bei „fä“ hatte Vp. R. den Eindruck: „Es sind zwei kleine Männchen, die miteinander tanzen“. Bei „vaiſ“ sagte dieselbe Vp.: „Zwei o hüpfen in dem Wort herum“. Vp. Wd. sagte bei „mauß“: „Das ganze Wort springt

In the (perception of) words, to the fleetingness of the constituent elements the bouncing of whole characters is added. Firm localization of detail is extremely difficult; it is possible, at most, for the first and, less so, for the last letter. … With “kä” subject R reported “Two dancing manikins” … “Two “o” that jig about.” … “The whole word jumps”

2nd phase: "f) perceptual shortening"

"It is as if there is a pressure on both sides of the word that tends to compress it. Then the stronger, i.e. the more salient or dominant letters, are preserved and they quasi 'squash' the weaker, i.e. the less salient letters, between them."

(Levi, 2008, cites this as the first description of crowding in his recent review)

Here are examples of perceptual shortening given by Korte:

meaningless syllable: perceived as

sif: ff (4 ×), ss (2 ×), sf, sl, if.
läunn: läum (3 ×), läun (2 ×), länn.
diecro: dero, diro, dirro, dedi, diero (4 ×).
goruff: guff, gouff (2 ×), geuff.
läuff: läff (2 ×), läss, lüff (2 ×), hüff.

Seven Gestalt phenomena in indirect reading (Korte 1923)

a) Absorption and false amendment
Aufsaugung und falsche Ergänzung

b) False localization of detail ← for features and letters
Falsche Lokalisation von Einzelheiten

c) Puzzling intermediate perceptual states
Rätselhafte Zwischenstadien

d) Prothesis und Methathesis
(letters added in front or at the end of the word)

e) Shortening of the perceptual image in a certain zone
(of the v.field)Verkürzung des Wahrnehmungsbildes in einer bestimmten Zone

f) Change of detail from the impression of the whole
Veränderung von Einzelheiten unter dem Eindruck des Gesamtkomplexes

g) False cognitive set
Falsche Einstellung

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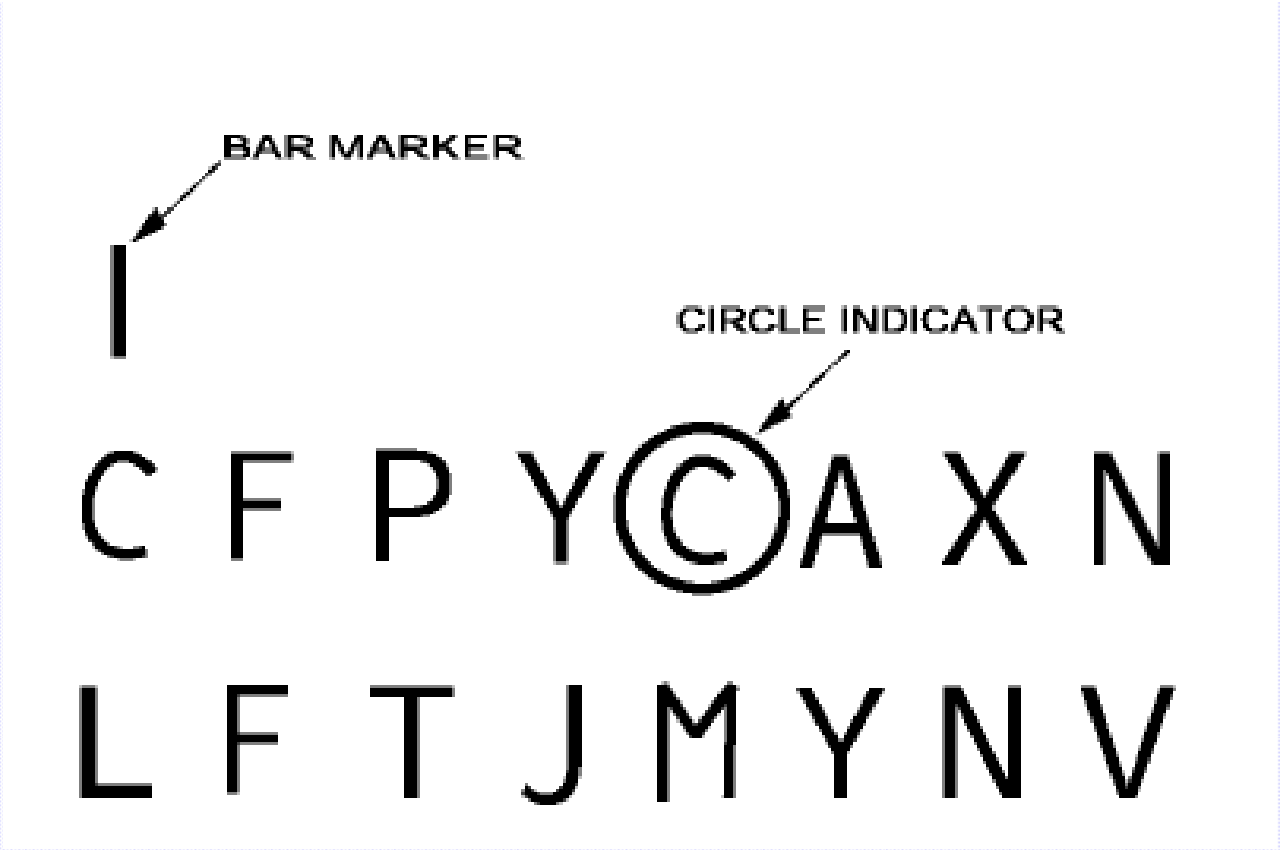
(eccentricity, flanker distance, cue size)

Effect of cue size
Cue effect on contrast threshold
Characteristics of source confusion

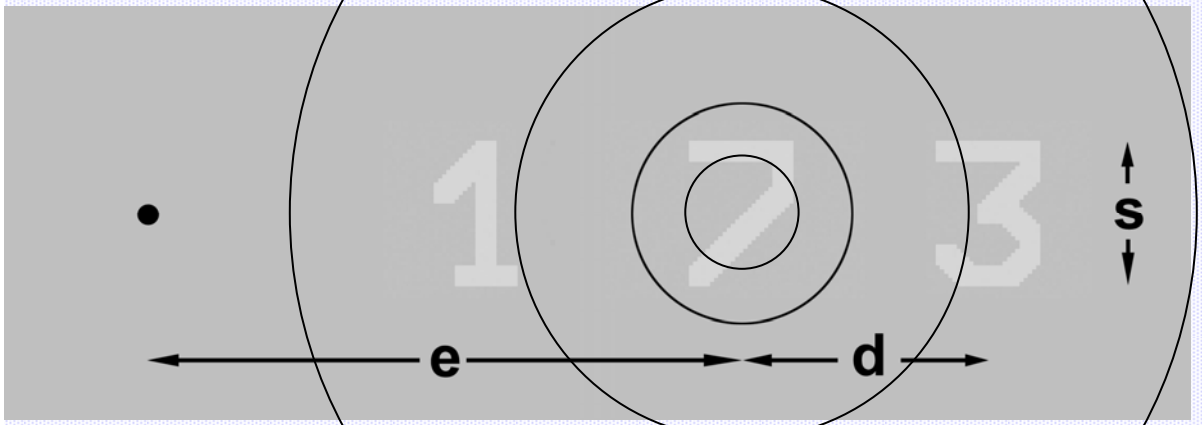
(D) Conclusions

Stimulus configuration of Averbach & Coriell (1961)



- Cues are considered to attract attention (Eriksen 1970, Posner 1985)
- Optimum SOA is 150 ms (Eriksen & Johnson 1968)
- Short term cue steers transient (involuntary) rather than sustained (voluntary) attention (Nakayama & MacKeben 1989)

Crowding Effect: Methods



Stimulus arrangement

A) Recognition contrast thresholds by max. likelihood forced choice procedure

Flanking condition: the target is surrounded by a neighboring character left and right, of same contrast.

Cueing condition: A circle appears 150 ms before the stimulus.

B) Correspondences = errors where a flanker is reported

False localizations: correspondences – chance

10 subjects × 40 conditions × 2 × 30 trials = 24,000 responses.

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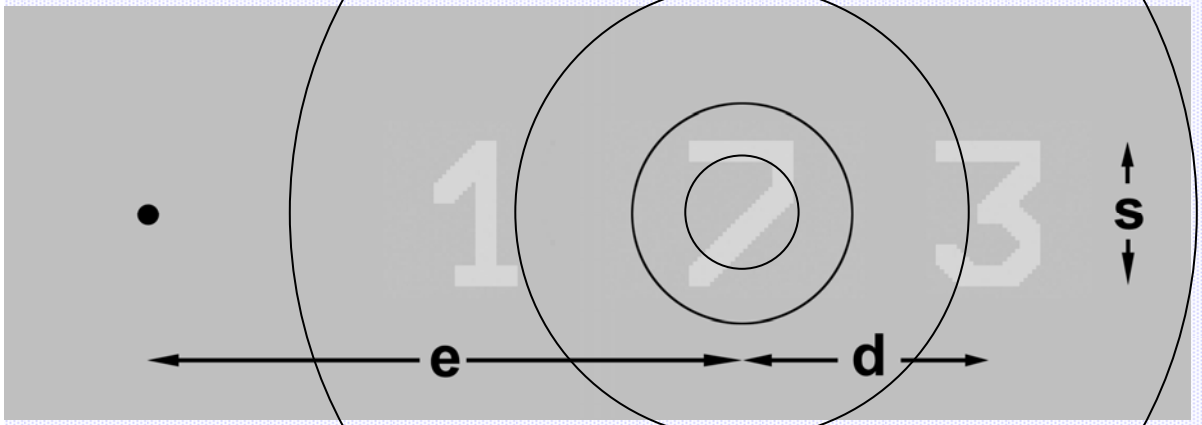

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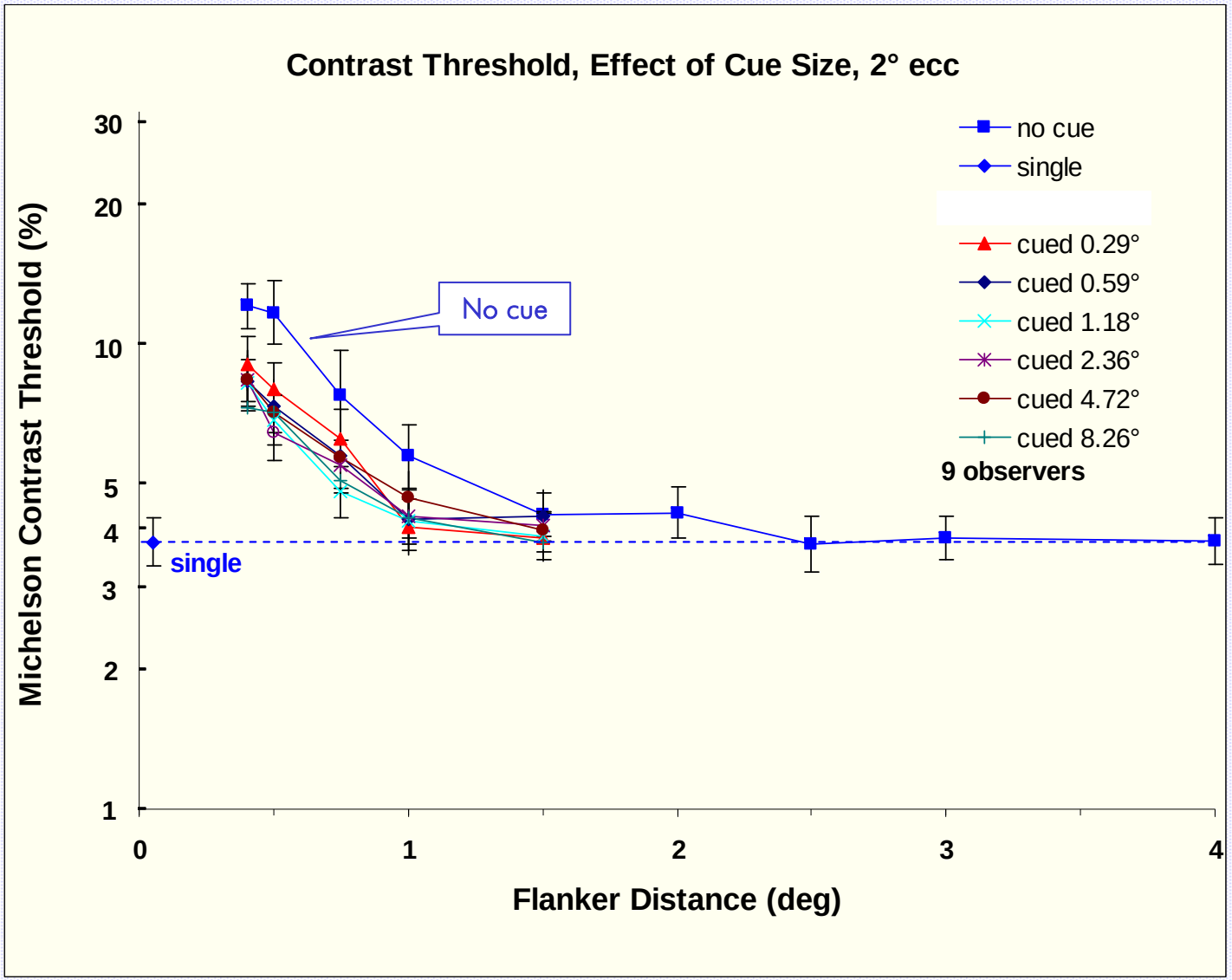
Parametric study: stimulus characteristics

Presentation time 100 ms
SOA between cue and characters 150 ms
Size M-scaled, flanker distance and cue diameter variable

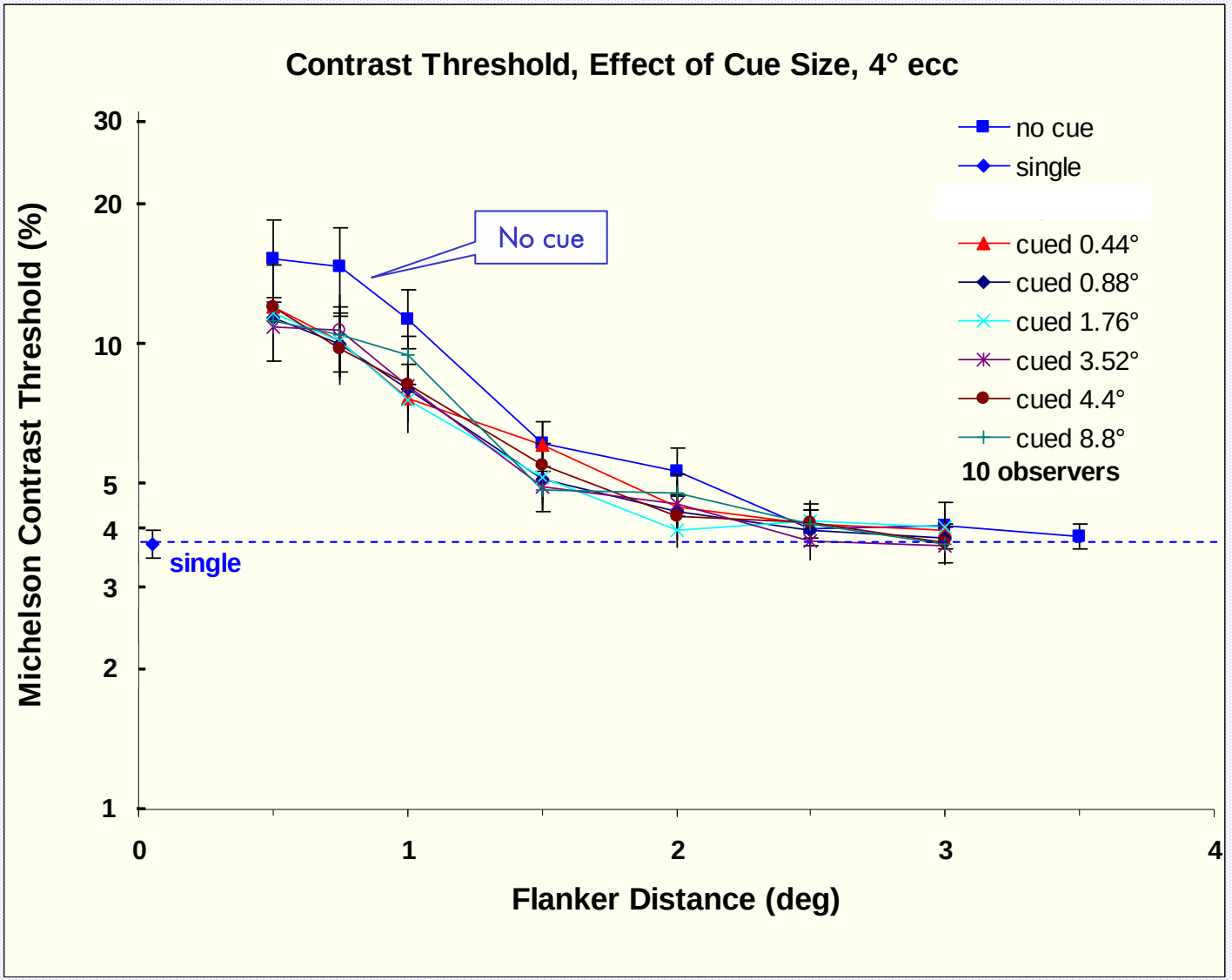
Ecc (deg)	Viewing distance (cm)	Stimulus size (deg)	Spacing between Flankers (deg)									Cue diameter (deg)					
2	**1280**	**0.4**	0.4	0.5	0.75	1.0	1.5	2	2.5	3	4	0.29	0.59	1.18	2.36	4.72	8.26
4	**860**	**0.6**	–	0.5	0.75	1.0	1.5	2	2.5	3.5		0.44	0.88	1.76	3.52	4.4	8.8
6	**640**	**0.8**	–	–	0.75	1.0	1.5	2	2.5	3	4	–	0.52	1.04	2.08	4.16	8.23

Effect of cue size on contrast threshold



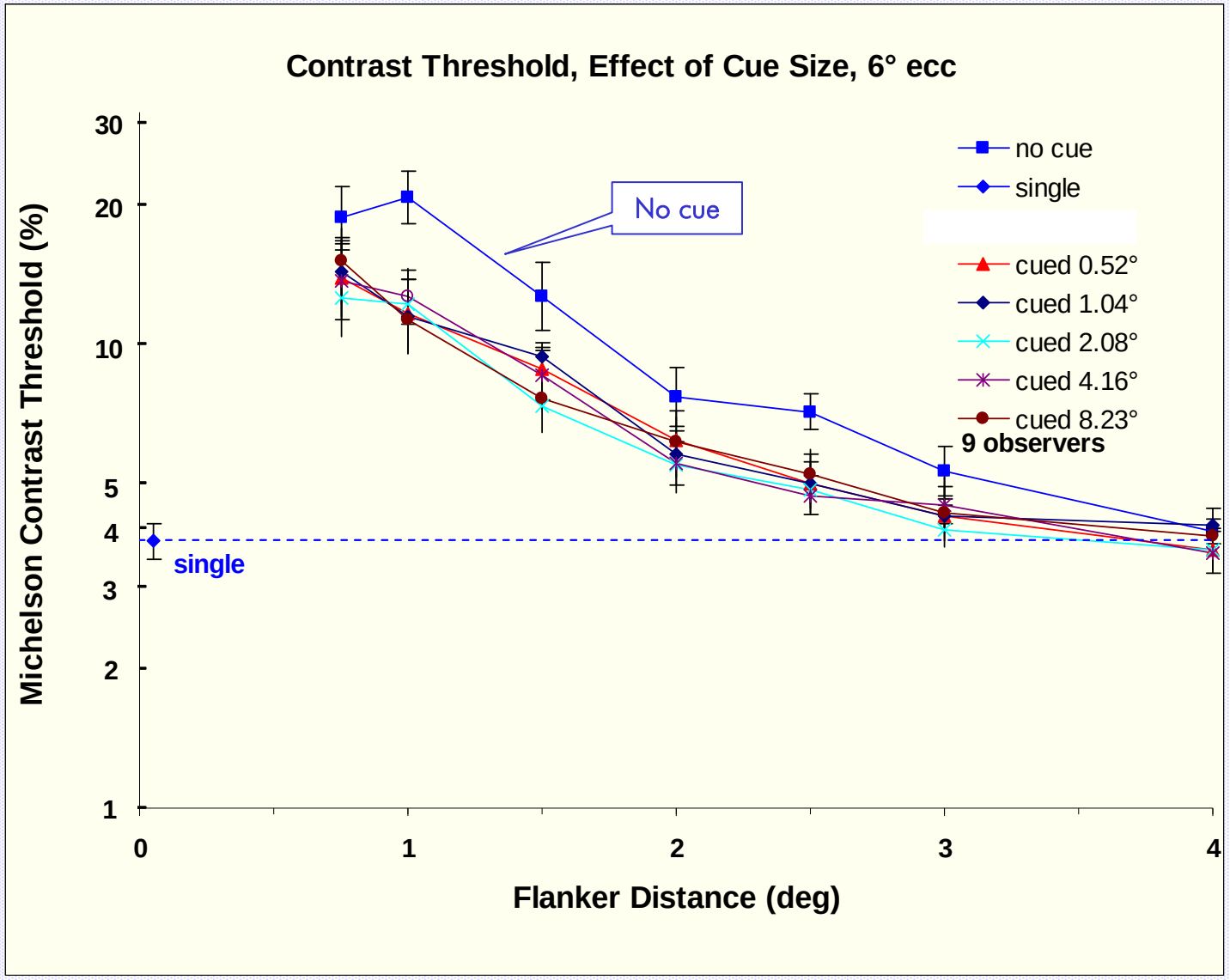
target
2° ecc
0.4° size

Effect of cue size on contrast threshold



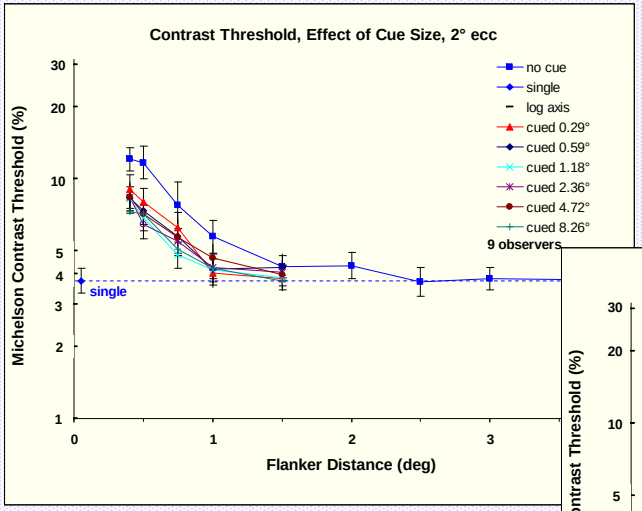
target
4° ecc
0.6° size

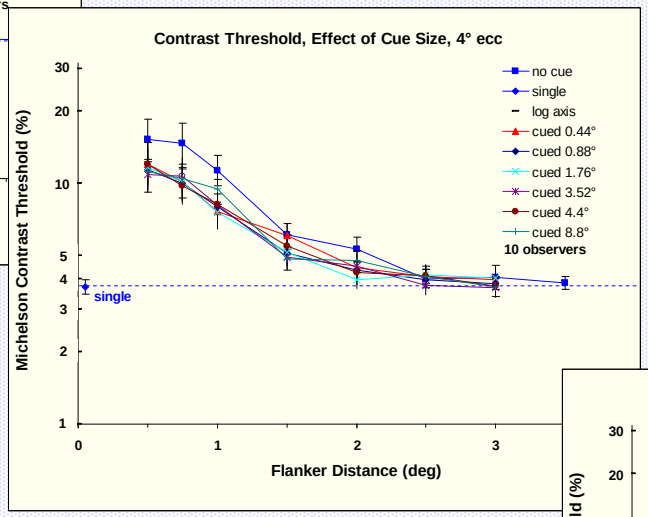
Effect of cue size on contrast threshold

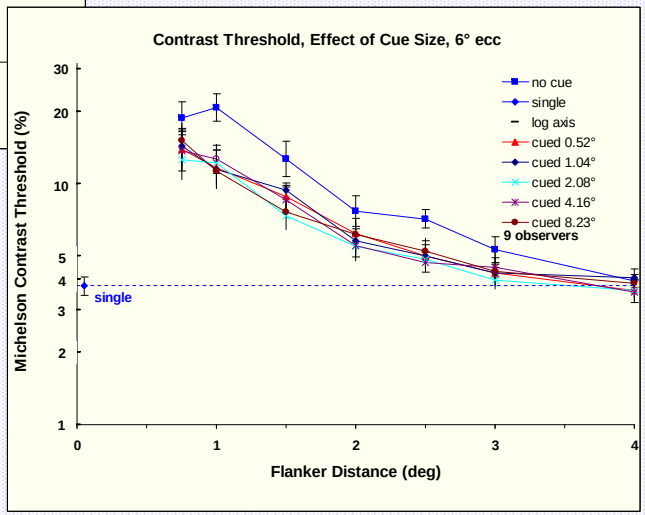


target
6° ecc
0.8° size

Effect of cue size on contrast threshold





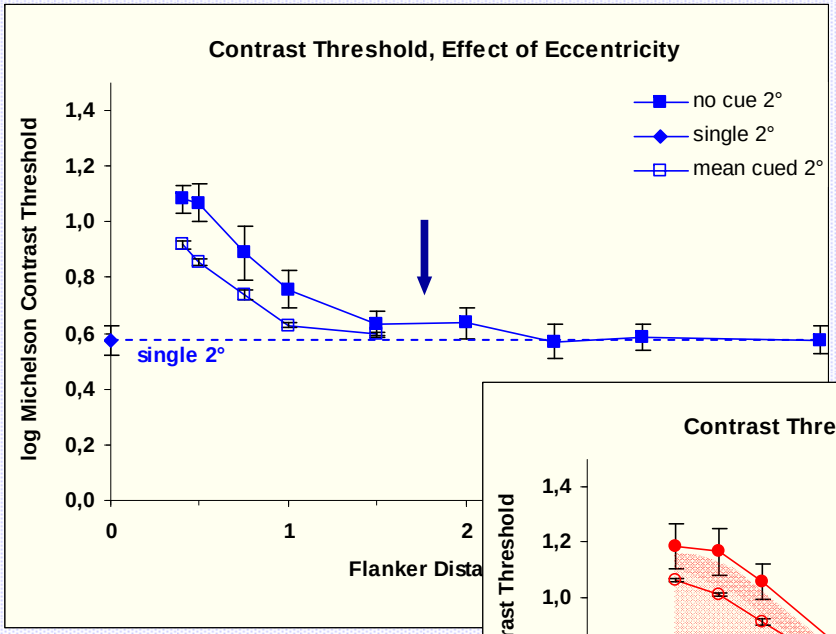


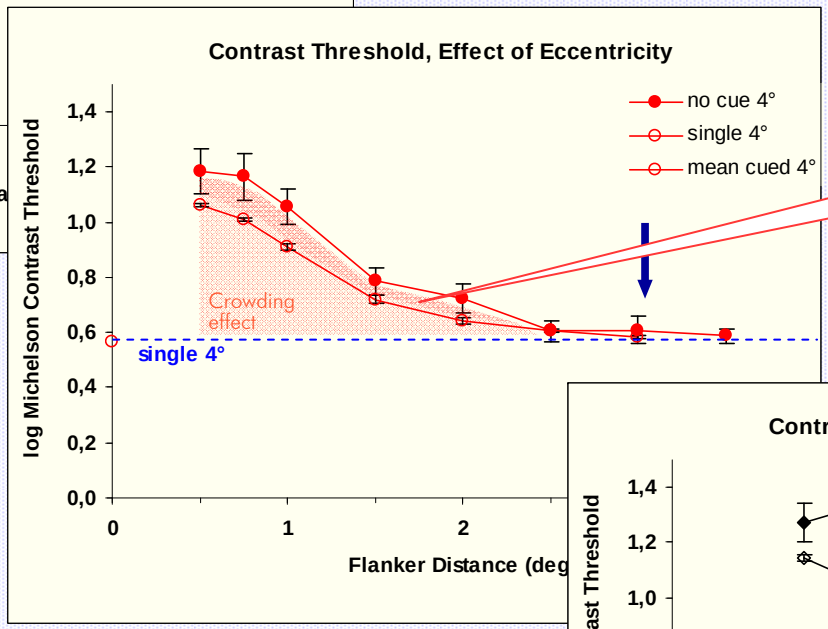
a) Cue has an impact on contrast threshold … but

b) No effect of cue size!

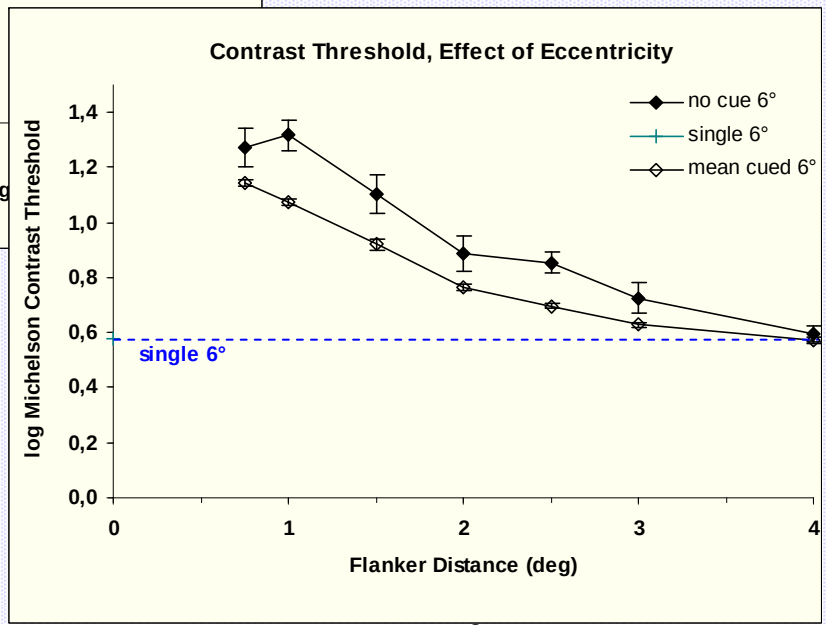
Effect of cue on contrast threshold

Mean over cue sizes





Cue effect

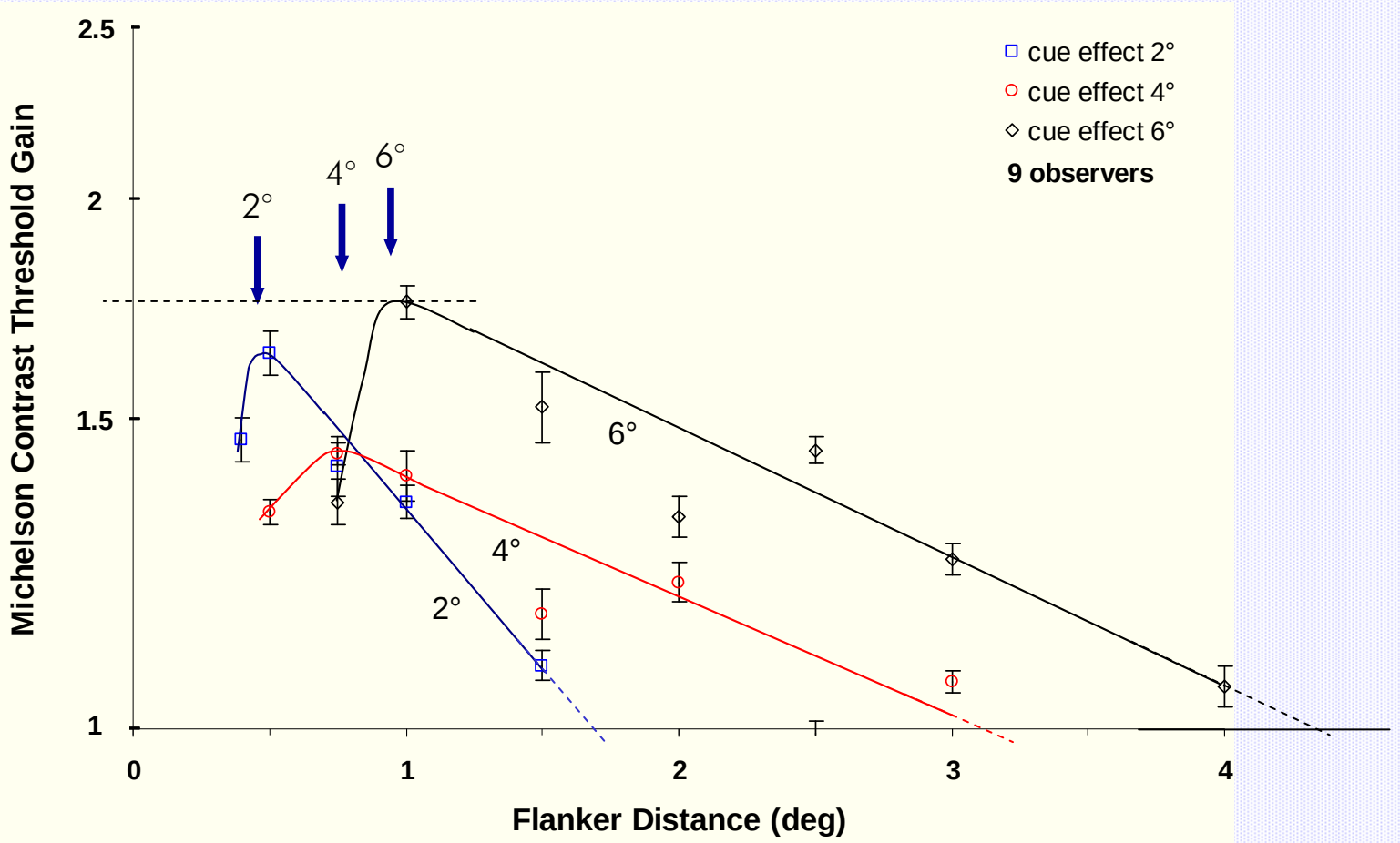


Critical distance: 1,7° / 3,1° / 4,5°

= 80% of eccentricity (constant ratio)

Variation of Bouma's rule (50%)

Cue effect (ratio of contrast threshold with/without cue)



Critical distance = 80% (1,7° / 3,1° / 4,5°)
Maximum gain at 20% of eccentricity (0.5° / 0.75°/ 1°)
Gain up to factor 1.7

"20%/80%-Bouma rule"

Strasburger & Malania. ECVP 2008

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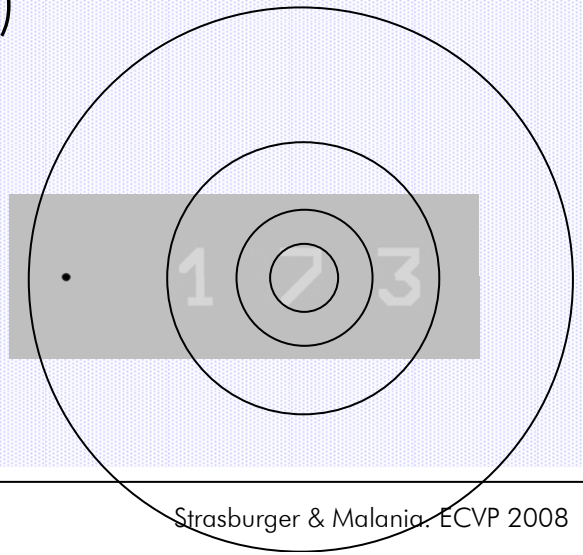
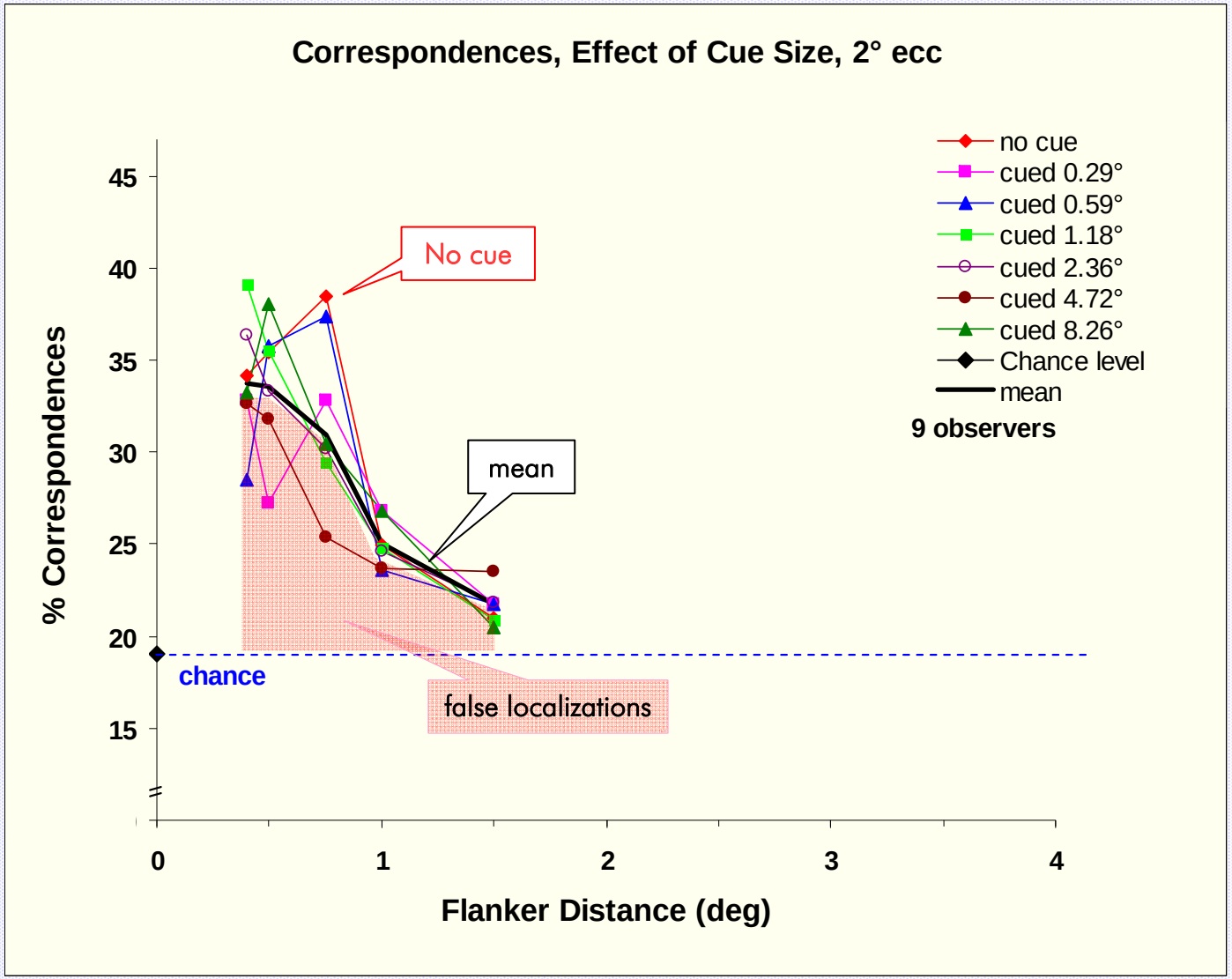
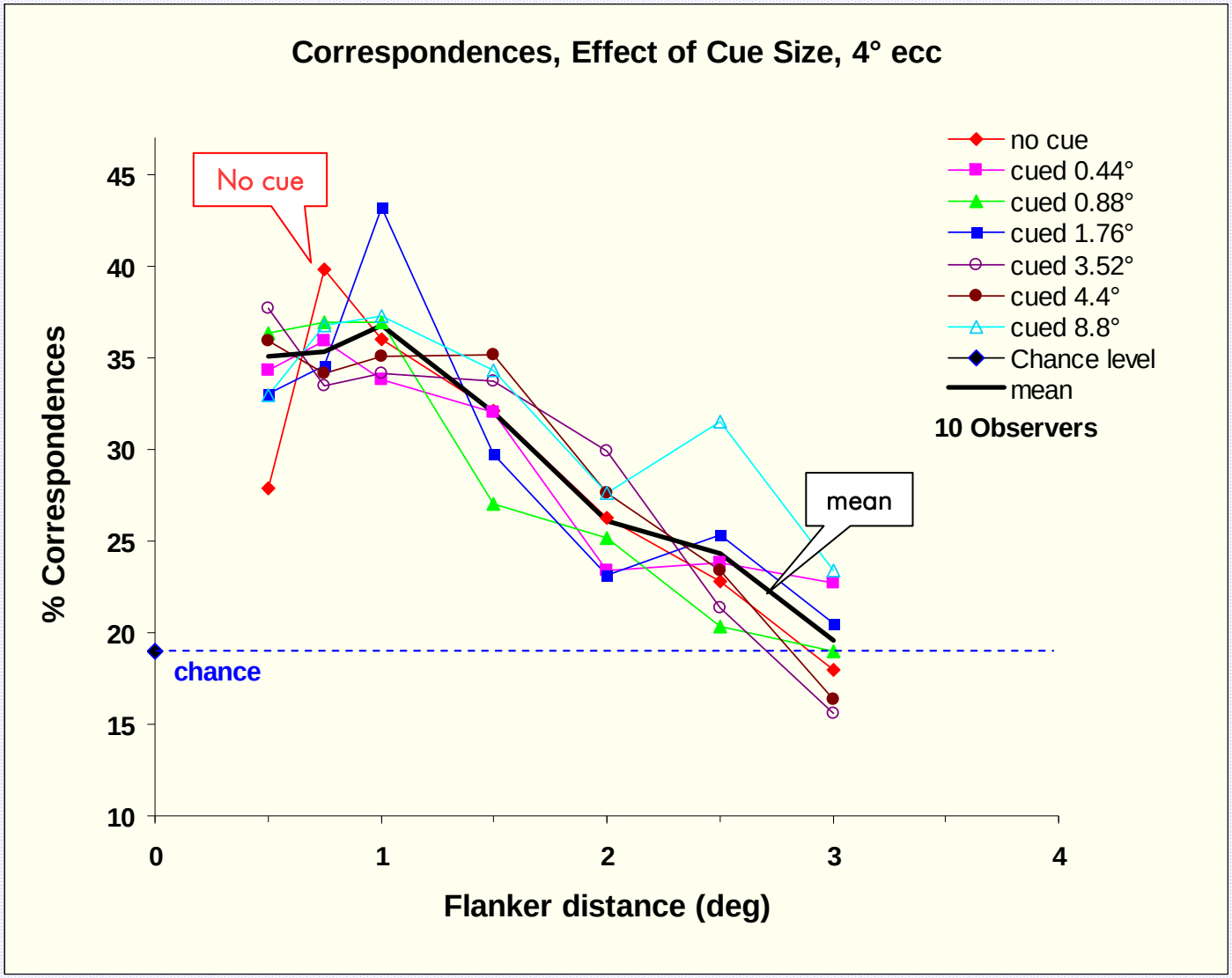


Effect of cue size on false localizations



target
2° ecc
0.4° size

Effect of cue size on false localizations



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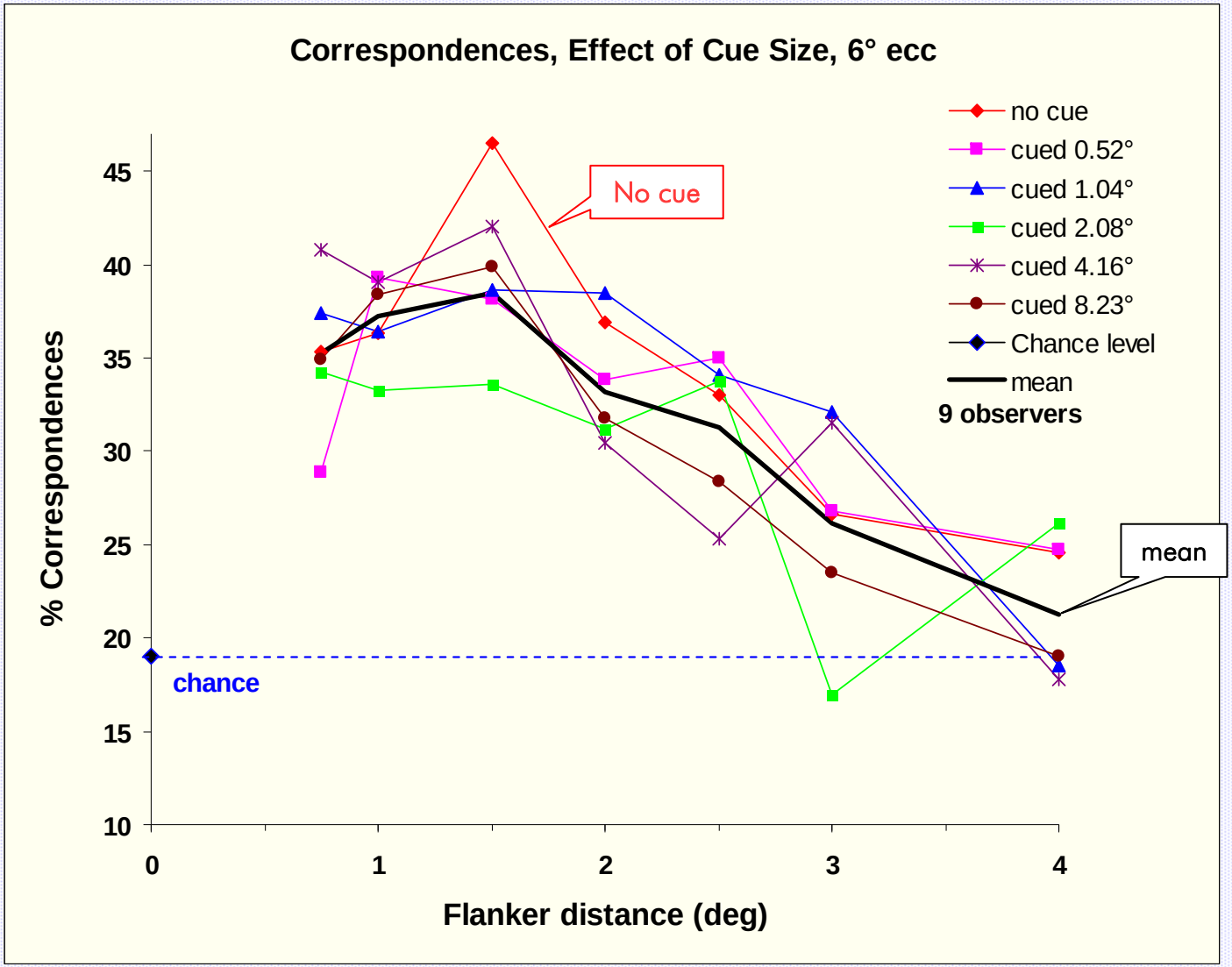

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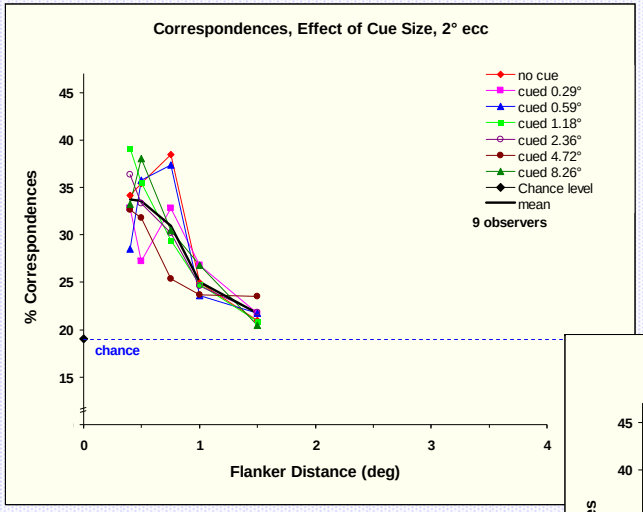
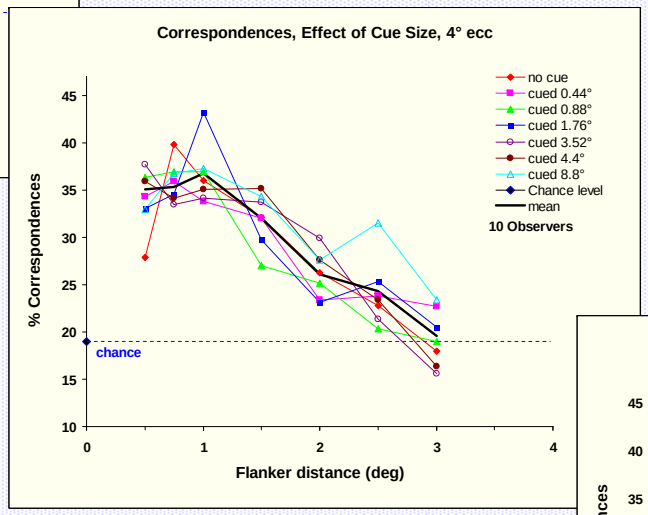
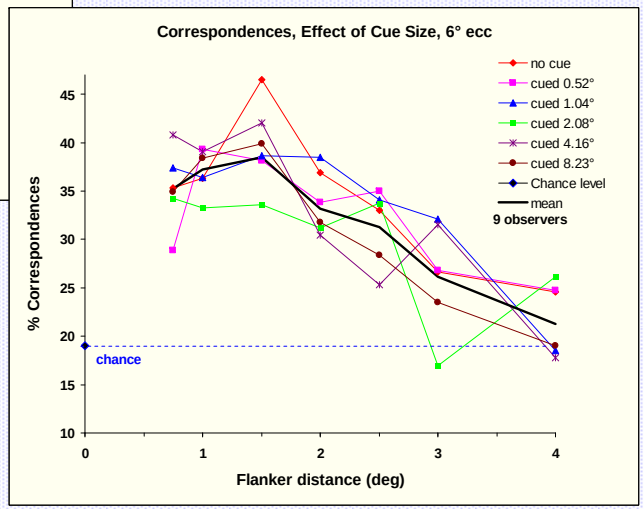
Effect of cue size on false localizations

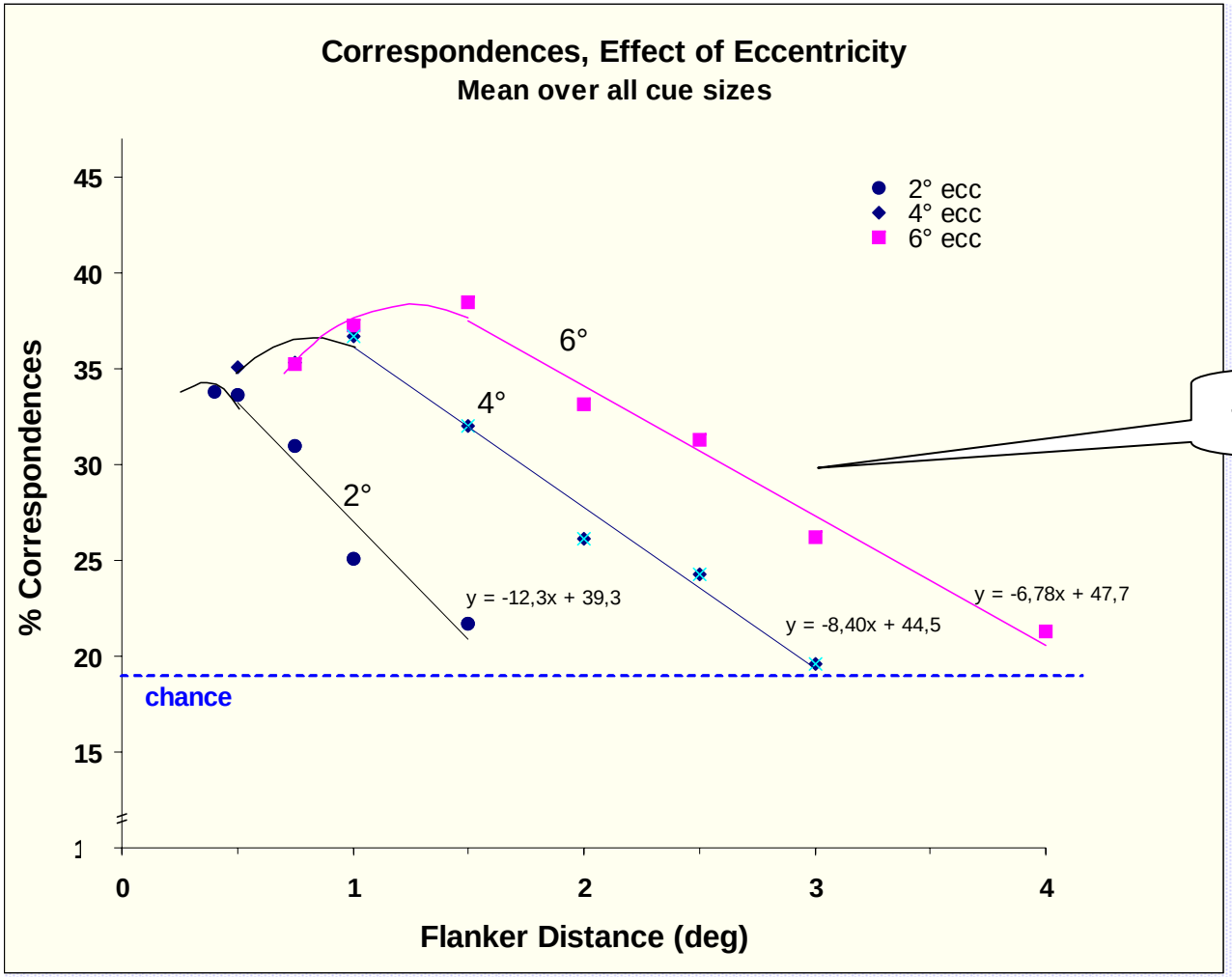






c) Cue has no impact on correspondences (i.e. on source confusion)

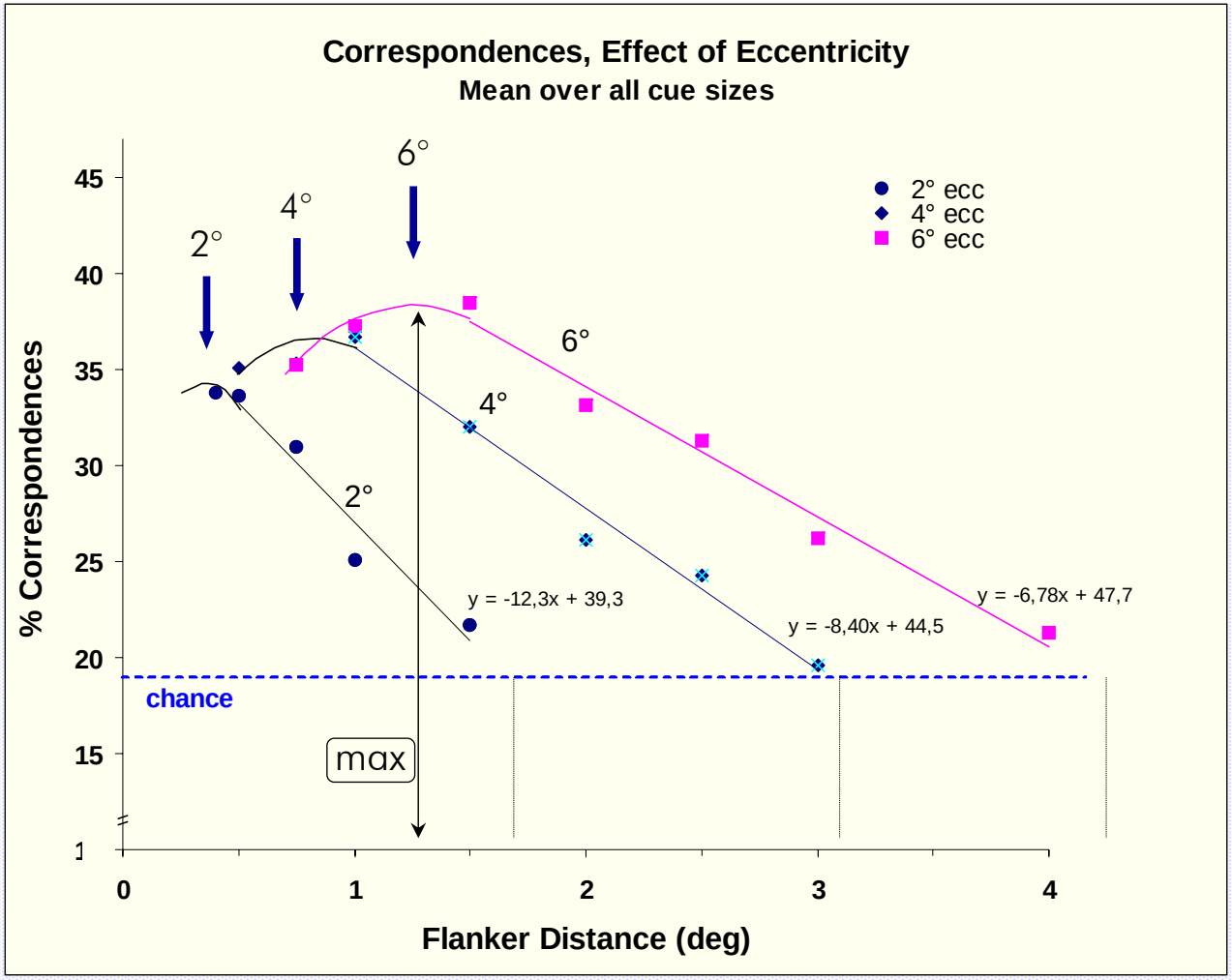
False localizations (with cue, mean over cue sizes)



the 3 means again

a) Source confusion decreases with flanker distance (obvious)
b) Source confusion increases with eccentricity
and occurs at larger flanker distances

False localizations (with cue, mean over cue sizes)



c) Critical distance is 80% of eccentricity (1.7° / 3.05° / 4.2°)

d) Maximum at 20% of eccentricity (0.4° / 0.8°/ 1.3°)

e) Maximum is 38% – 19% = >19% false localizations

Conclusions

Korte (1923)

- 7 Gestalt principles of reading in indirect vision
- False localization applies to both features and whole letters

Effect of cue size

- Cue has an impact on contrast threshold … but
- No effect of cue size!

Cue effect on contrast threshold

- Critical distance is 80% of eccentricity
- Maximum effect at 20% of eccentricity
- Contrast gain up to a factor of 1.7

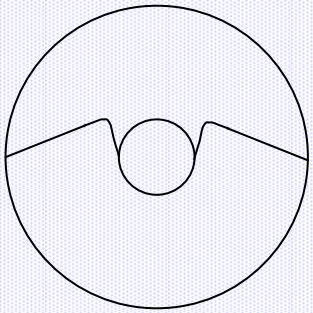
} "20/80% Bouma rule"

Characteristics of false localizations (source confusion)

- Cue has no impact on source confusion!
- Source confusion decreases with flanker distance (obvious)
- Source confusion increases with eccentricity and occur at larger flanker distances.
- Critical distance is 80% of eccentricity, max at 20% ecc.
- Up to ~40% source confusion

Bold conclusions … A doughnut theory

Transient attention improves area V1 gain by 1.7
Spotlight doughnut = 20%–80% ecc
Cue size unimportant



dorsal

Position code weak in the doughnut spotlight,
weakest close around target at 20% ecc
< 40% character jumbling therein
i.e. (60% feature jumbling & other)

Doughnut
by Claus

Bold conclusions … A doughnut theory

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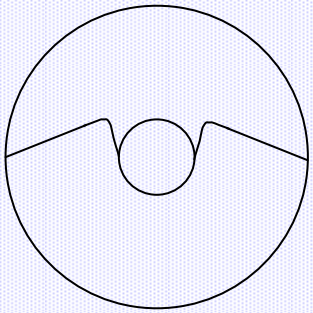

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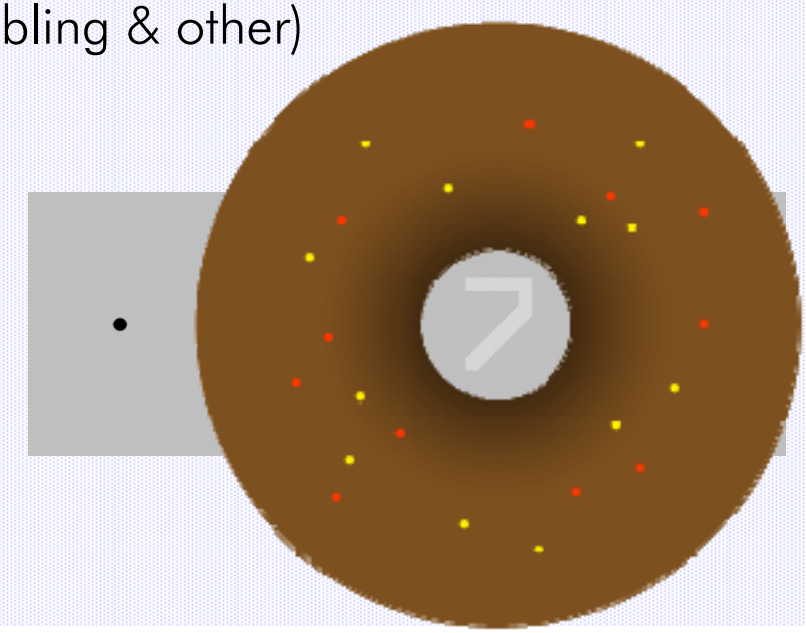

Thank you!

Doughnut
by Claus