Contour Interaction for Foveal Acuity Targets at Different Luminances

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Abstract

Single-letter visual acuity is impaired by nearby flanking stimuli, a phenomenon known as contour interaction. We showed previously that when foveal acuity is degraded by a reduction of letter contrast, both the magnitude and angular spatial extent of foveal contour interaction remain unchanged. In this study, we asked whether contour interaction also remains unchanged when foveal visual acuity is degraded by a reduction of the target"s background luminance.

Percent correct letter identification was measured for isolated, near-threshold black Sloan letters and for letters surrounded by 4 flanking bars in 10 normal observers, 5 at Anglia Ruskin University, UK (ARU) and 5 at Palacky University, Czech Republic (PU). A stepwise reduction in the background luminance over 3 log units resulted in an approximately three-fold increase in the near-threshold letter size. At each background luminance, black flanking bars with a width equal to 1 letter stroke were presented at separations between approximately 0.45 and 4.5 min arc (ARU) or 0.32 and 3.2 min arc (PU).

The results indicate that the angular *extent* of contour interaction remains unchanged at approximately 4 min arc at all background luminances. On the other hand, the *magnitude* of contour interaction decreases systematically as luminance is reduced, from approximately a 50% reduction to a 30% reduction in percent correct. The constant angular extent and decreasing magnitude of contour interaction with a reduction of background luminance suggest foveal contour interaction is mediated by luminance-dependent lateral inhibition within a fixed angular region.

Keywords

Contour interaction, crowding, visual acuity, luminance

1. Introduction

Contour interaction is the reduction of performance on visual spatial tasks, such as letter acuity, that results from the presence of nearby flanking contours. Across observers, the lateral extent of contour interaction generally is scaled in proportion to the observer‟s visual acuity (Flom, Weymouth & Kahneman, 1963; Hess & Jacobs, 1979, Simmers, Gray, McGraw & Winn, 1999, Stuart & Burian, 1962; for exceptions see Hess, Dakin, Tewfik & Brown, 2001). Within observers, the extent of contour interaction increases from the fovea to the peripheral retina, more rapidly than the worsening of non-foveal visual acuity (Bouma, 1970; Hess, Dakin, Kapoor & Tewfik, 2000; Jacobs, 1979; Latham & Whitaker, 1996; Leat, Li & Epp, 1999; Toet & Levi, 1992). However, recent studies demonstrate that the extent of contour interaction measured at a specific retinal location does *not* scale with the size of the target, but remains essentially fixed (Danilova & Bondarko, 2007; Pelli, Palomares & Majaj, 2004; Siderov, Waugh & Bedell, 2013; Tripathy & Cavanagh, 2002). For example, Siderov et al. demonstrated that the lateral extent of foveal contour interaction, expressed in units of min arc, remains the same for targets of high and low contrast, for which foveal acuity differs by up to 2.5 times (0.4 log units). This study showed also that the magnitude of foveal contour interaction, i.e., the maximum reduction in percent correct letter identification compared to the condition with no flanking targets, remains the same for high- and low-contrast acuity targets.

The purpose of the present study was to examine how the magnitude and extent of contour interaction depend on the luminance of a foveal acuity target. Although acuity is highly dependent on target luminance (e.g., Mandelbaum & Sloan, 1947; Shlaer, 1937), the influence of luminance on contour interaction has hardly been addressed. Takahashi (1968) measured foveal contour interaction using a two-line resolution task. Her results for one observer revealed a decrease in the magnitude of contour interaction but no change in its angular extent, as the luminance was reduced from 178 to 1.3 mL (567 to 4.1 cd/m^2). Matteucci, Maraini and Peralta (1963) reported that the magnitude of „separation difficulty‟ in amblyopic eyes, measured as the difference in visual acuity for lines of letters on a chart compared to isolated optotypes, is smaller for acuity charts presented at a mesopic (2 lux) compared to a photopic (120 lux) level of illuminance. Simunovic and Calver (2004) assessed contour interaction for scotopic Landolt C targets that were presented at an eccentricity of 10 deg. They found that contour interaction for different sized targets (range ≈ 1.2 to 1.9 deg) occurs within an approximately fixed spatial extent, on the order of 0.25 deg. Simunovic and Calver noted that this value is smaller than the extent of contour interaction that has been reported using peripheral photopic targets (e.g., Bouma, 1970; Jacobs, 1979; Tripathy & Cavanagh, 2002), but did not present comparison data for their subjects using other target luminances.

Our study examined the extent and magnitude of contour interaction produced by flanking bars on dark Sloan letters, presented at the fovea for a range of background luminances. Similar experiments were conducted concurrently at Anglia Ruskin University, Cambridge, UK (ARU) and at Palacky University, Olomouc, Czech Republic (PU). The results of both experiments indicate that the lateral extent of foveal contour interaction remains unchanged, but the magnitude of contour interaction decreases systematically as the background luminance of the acuity target is reduced.

2. Methods

A total of 10 observers participated in this study, 5 at ARU (3 female and two male, age range = 21 - 64 years old) and 5 at PU (5 women, age range = 22 - 24 years old). All of the observers had normal eye movement control, were free from ocular pathology, and had better than 6/6 corrected visual acuity in each eye. The research was conducted in accordance with the tenets of the Declaration of Helsinki. Appropriate institutional review board approval was obtained at each institution and written informed consent was obtained from each observer before participation. When required, the observers wore appropriate lens correction during testing.

The methods used in both labs were similar to those described previously by Siderov et al. (2013). Dark Sloan letters (C D H K N O R S V Z) with a Weber contrast of -89% were presented one at a time on a bright background, either in isolation or surrounded by 4 flanking bars with the same contrast, length, and stroke width as the surrounded letter. The stimuli were generated using Test Chart 2000Pro software (Thomson Software Solutions, Herts, UK) and displayed on a PC monitor. The display monitor at ARU measured 19 inches diagonally, with 1024 x 768 pixel resolution, a refresh rate of 100 Hz, and an unattenuated luminance of 108 cd/m^2. A 22-inch monitor was used at PU, with 1680 x 1050 pixel resolution, a frame rate of 60 Hz, and an unattenuated luminance of 195 cd/m^2. Ambient illumination in the experimental room at both experimental venues (produced primarily by luminance from the display monitor) remained dim. Testing was performed monocularly and each letter was presented until the observer made a verbal response.

Percent correct letter identification was determined in the absence of flanking bars and for 5 edge-to-edge separations between the letter and the surrounding flanking bars. The same 5 *angular* flanking separations were used for each observer for all background luminances, which spanned a range of 3 log units (see below). These letter-to-flanking-bar separations corresponded to 0.5, 1, 2, 3 and 5 stroke widths of the Sloan letters that were presented in the highest luminance condition, designated 0 ND. In the 0 ND condition, the letter size and viewing distance were selected for each observer to achieve approximately 80% correct when the letters were presented without flanking bars (range of angular letter sizes across observers = 3.2 to 4.75 min arc; range of viewing distances = 10 – 12 m). As the background luminance was reduced, the physical size of the targets on the display screen was increased to maintain approximately 80% correct identification in the no-flank condition. On average, a reduction of the background luminance by 3 log units (3 ND) required an increase in the angular letter size corresponding to 0.56 logMAR for the observers at ARU and 0.53 logMAR for the observers at PU (Table 1). Because of the increase in letter size as the background luminance was reduced, the edge-to-edge separations of the flanking bars at the lowest luminance, when expressed in multiples of the letter stroke width, were approximately 3.5 times smaller than the values listed above for the 0 ND condition (average values listed in Table 1).

For each observer, percent correct letter identification was determined from a total of 100 – 200 presentations per condition, presented in blocks of 25 for each combination of background luminance and flanking-bar separation. For all observers, the data for the 0 ND condition were collected first. The order of the other 3 background luminances varied pseudo-randomly among the observers tested at each site, with the trials for all 5 flanking-bar separations for one background luminance completed before the next luminance condition was begun. Observers were provided at least 10 min to adapt before the start of data collection at the two lowest luminance levels.

To vary the luminance of the acuity and background stimuli, the observers viewed through glass neutral density filters (Thorlabs; http://www.thorlabs.com/) with nominal values of 1, 2 and 3 ND, mounted in a pair of light-tight goggles that also included an opaque shield to occlude the non-viewing eye. The measured luminances of the background field without (0 ND) and with the neutral density filters (1, 2 and 3 ND) were 108, 12.1, 0.82 and 0.09 cd/m^2 at ARU and 195, 19.7, 1.46 and 0.21 cd/m^2 at PU. A difference between the testing conditions at the two institutions is that the observers at PU viewed the acuity targets through a 2.5 mm artificial pupil, whereas the observers at ARU viewed using their natural pupil. All observers were asked to centrally fixate the acuity targets at all luminance levels.

Because of the difference in the testing conditions, the percent correct letter-identification data obtained at ARU and PU were analyzed using separate repeated-measures ANOVAs. Where necessary, the levels of statistical significance reported in section 3, below, include a Huynh-Feldt correction for departures from sphericity.

[Insert Table 1 near here]

3. Results

The two panels of Figure 1 show the average values of percent correct letter identification for the observers at ARU (top) and PU (bottom) as a function of the edge-to-edge flanking-bar separation in min arc. Contour interaction is revealed by the reduced values of percent correct for flank separations less than approximately 3 to 4.5 min arc. A significant main effect of separation exists in both data sets (for the ARU data, $F_{df=5,20} = 17.61$, $p = 0.0021$; for the PU data, $F_{df=5,20} = 47.88$, $p = 1.1 \times 10^{-8}$). Although there is no main effect of background luminance, the interaction between luminance and flank separation is significant for both groups of observers (for the ARU data, $F_{df=15,60} = 3.97$, $p < 0.0001$); for the PU data, ($F_{df=15,60} = 2.89$, $p = 0.0018$). This interaction reflects a systematic reduction in the *magnitude* of contour interaction as the background luminance is reduced. Specifically, in the 0 ND condition, the introduction of flanking bars produced a maximum reduction of percent correct letter identification from 79% to 32% (ARU) and from 91% to 36% (PU). In contrast, the maximum reduction of percent correct in the 3 ND luminance condition was only from 78% to 52% (ARU) and from 90% to 59% (PU).

Recall that the flanking bars were presented at the same angular separations from the acuity target for all background luminances. It is therefore possible that a larger magnitude of contour interaction would be found for low luminance condition if the range of flank-to-target separations were increased. To address this possibility, the 5 observers from ARU were re-tested using acuity targets with a background luminance of 0.09 cd/m^2 and edge-to-edge separations of the flanking bars equal to 0.5, 1, 3 and 5 stroke widths; i.e., between approximately 3.3 and 16.3

min arc, averaged across observers. The resulting variation in percent correct is in close agreement with the data for the 3 ND luminance condition in Figure 1A. As shown in Figure 2, the magnitude of contour interaction for low-luminance foveal targets remains small for the entire range of flanking-bar separations that were tested.

[Insert Figures 1& 2 near here]

Whereas the magnitude of contour interaction decreases when the background luminance of the acuity targets is reduced, Figure 1 illustrates that the lateral *extent* of contour interaction, in min arc, remains essentially unchanged. For example, in the PU data percent correct letter identification for a flanking-bar separation of 3.2 min arc is similar to that obtained using unflanked letters at all 4 background luminances. A comparable result is evident in the data from ARU, except that the percent correct letter identification for a background luminance of 0.09 cd/m^2 is slightly poorer when the average flanking-bar separation is 4.5 min arc than in the unflanked condition. If the data in Figure 1 are replotted with the flanking-bar separations expressed as multiples of the letter-stroke width, it is clear that the extent of contour interaction does *not* scale with the size of the threshold acuity target (Figure 3).

[Insert Figure 3 near here]

Previous reports demonstrated that letter confusions can differ for crowded vs. uncrowded testing conditions (Liu & Arditi, 2001; Wolford & Hollingsworth, 1974). We therefore investigated whether unique letter confusions occurred when the flanking bars were present in our low- and high-luminance background conditions. Specifically, we constructed letter-confusion matrices to compare the observers‟ responses in the 0 and 3 ND conditions for letter presentations without flanking bars and when the letter-to-flanking-bar separation was ~0.8 min arc, i.e., the condition that produced the greatest magnitude of contour interaction. Figure 4 presents confusion matrices based on 1000 letter presentations for these 4 conditions, constructed by averaging the responses of the observers at ARU and PU. In each matrix, the rows specify the letter that was presented and the columns indicate the proportion of the aggregate responses corresponding to each of the 10 possible Sloan letters. As expected, the highest values in each matrix fall principally along the main diagonal, which gives the proportion of trials on which the observers correctly reported each letter. Values off the main diagonal represent letter confusions, which are color coded from light blue to pink to represent low vs. high proportions of confusions. The blank cells in each matrix indicate combinations of presented letters and responses for which no confusions occurred.

It is clear that the confusion matrices for the 0 and 3 ND conditions without flanking bars are similar. On the other hand, when flanking bars are presented at a separation of ~0.8 min arc, the matrix for 0 ND condition includes a number of letter confusions that did not occur in the absence of flanking bars, e.g., responses of “D” for C, “O” for H, “D” for K, “O” for R, “Z” for O, “H” for S, and “V” for D. Some of these unique confusions, such as “D” for C and “H” for S, may be accounted for by the overall increase in the number of response errors that occurs when nearby flanking bars are introduced. However, some of these other confusions, such as “O” for R, “Z” for O, and “V” for D, are not typical miscalls and may result from interactions between the test letter and the flanking bars (Liu & Arditi, 2001). The confusion matrix obtained in the 3 ND condition with flanking bars at a separation of 0.8 min arc appears to be intermediate between the matrix in the 0 ND condition with flanking bars, and the confusion matrices generated in the absence of flanking bars.

[Insert Figure 4 near here]

4. Discussion

The similar extent of contour interaction for foveal acuity targets with different background luminances is consistent with previous reports that the lateral extent of foveal contour interaction occurs within a fixed angular extent, regardless of the size of the acuity target (Danilova & Bondarko, 2007; Siderov et al., 2013). For example, Siderov et al. demonstrated that the extent of contour interaction for high- and low-contrast Sloan letters remains between 3 and 5 min arc, despite a 0.4 logMAR difference in the size of the high- and low-contrast acuity targets. Similarly, for targets presented at a fixed eccentricity from the fovea, the extent of contour interaction or crowding was reported to be essentially independent of the target size (Chung, Levi & Legge, 2001, Hariharan, Levi & Klein, 2005, Pelli et al., 2004, Simunovic & Calver, 2004; Tripathy & Cavanagh, 2002). These results indicate that the lateral extent of contour interaction does not scale with the size of the acuity target and suggest that this extent is a property of the specific retinal location tested. An implication of this result is that the tight relationship between the acuity threshold and the extent of crowding that occurs, for example, when the retinal location of the acuity stimulus is changed (Latham & Whitaker, 1996; Toet & Levi, 1992) breaks down when visual acuity at a single retinal location is altered by varying the parameters of the stimulus.

[Insert Figure 4 near here]

In contrast to the constant lateral extent of foveal contour interaction, the data presented here show clearly that the *magnitude* of contour interaction decreases systematically as the background luminance of the acuity target is reduced. This result is consistent with the limited previous observations about the magnitude of contour interaction at different luminances, made by Takahashi (1968) and Matteucci et al. (1963). The reduced magnitude of contour interaction found at low luminance cannot be attributed to the change in visual acuity when luminance is decreased, as Siderov et al. (2013) showed that a similar reduction of foveal visual acuity, produced by reducing the letter contrast, leaves the magnitude of contour interaction unchanged.

Two competing explanations for contour interaction dominate current research. The first is that the spatial frequency components of the flanking bar stimuli are responsible for contour interaction by reducing the detectability of critical spatial frequency components in the target (Hess, Dakin, Kapoor, 2000; Hess, Dakin, Kapoor & Tewfik, 2000; Levi, Klein & Hariharan, 2002). As pointed out previously (Chung, Levi & Legge, 2001; Danilova & Bondarko, 2007; Simunovic & Calver, 2004), this explanation predicts that the extent of contour interaction should scale with the size of the acuity target. However, both the present and previous results indicate that scaling is *not* observed when the size of the acuity target changes, either in foveal (Danilova & Bondarko, 2007; Siderov et al., 2013) or non-foveal (Pelli et al., 2004; Simunovic & Calver, 2004; Tripathy & Cavanagh, 2002) vision. A second explanation, used to account primarily for the contour interaction at non-foveal retinal locations, is that the features comprising the target and flanks are grouped inappropriately, such that the visual features of the flanking targets are assigned incorrectly to the acuity stimulus (Dakin, Cass, Greenwood & Bex, 2010; Freeman, Chakravarthi & Pelli, 2012; Greenwood, Bex & Dakin, 2009; 2010) and vice versa (Zhang, Zhang, Liu & Yu, 2012). In the current study, changes in the background luminance should have exerted comparable effects on the visibility of the acuity targets and surrounding flanking bars. Although an inappropriate-grouping explanation can account for some aspects of non-foveal crowding, it is difficult to see why an inappropriate grouping of letters and flanking bars should decrease when the background luminance is reduced. The grouping explanation therefore provides no ready explanation for our observation that the magnitude of foveal contour interaction is reduced substantially at low luminance.

A number of investigators favored an explanation for contour interaction based on antagonistic neural interactions between stimuli that are imaged within a common neural receptive field (Flom, Weymouth & Kahneman, 1963; Latham & Whitaker, 1996; Wolford & Chambers, 1984). The observation that contour interaction occurs under dichoptic viewing conditions, i.e., when the acuity target is presented to one eye and flanking bars are presented to the other eye (Flom, Heath & Takahashi, 1963; Kooi, Toet, Tripathy & Levi, 1994; Taylor & Brown, 1972) indicates that these interactions can occur at the level of the visual cortex. It is well known that the contribution of the antagonistic retinal receptive-field surround to the output of a retinal ganglion cell decreases during dark adaptation (Powers & Green, 1990). Although an initial report suggested that the receptive field surround of retinal ganglion cells disappears during dark adaptation, leading to an effective increase in the receptive-field diameter (Barlow, FitzHugh & Kuffler, 1957), subsequent studies concluded that the effect of dark adaptation is to reduce the relative weighting of stimuli imaged within the receptive-field surround compared to the center, without any change in the receptive field dimensions (Cleland & Enroth-Cugell, 1968; Derrington & Lennie, 1982). A reduction in the relative weighting of the receptive-field surround compared to the center has been shown to occur also during dark adaptation in lateral-geniculate (Kaplan, Marcus & So, 1979; Virsu, Lee & Creutzfeldt, 1977) and cortical receptive fields (Ramoa, Freeman & Macy, 1985). Both the reduction in the magnitude of contour interaction and the more-or-less fixed extent of interaction that we observed for dim foveal stimuli appear to be consistent with the changes in receptive-field structure that have been observed to occur at low light levels.

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Table 1. Average letter sizes and minimum and maximum flanker separations (gaps) for each of the luminance conditions for the two groups of observers.

	ARU				PU			
	0 ND	1 ND	2 ND	3 ND	0 ND	1 ND	2 ND	3 ND
Average Letter Size (min arc)	4.5	5.4	9.1	14.5	3.2	3.2	4.6	11.0
Min Gap Size (% letter size)	10%	8%	5%	3%	10%	10%	7%	3%
Max Gap Size (% letter size)	100%	83%	50%	31%	100%	100%	69%	29%

Figure Legends.

Figure 1. Percentage correct responses averaged across the observers at Anglia Ruskin University (ARU, top) and Palacky University (PU, bottom) and plotted as a function of flanker separation in min arc for the 4 luminance conditions. Error bars represent ±1 SE. Data at „INF" on the abscissa represent the unflanked condition.

Figure 2. Percentage correct responses averaged across observers at Anglia Ruskin University and plotted as a function of flanker separation for the 3 ND luminance condition. Filled symbols replot the data for this luminance condition from the top panel of Figure 1. Unfilled symbols show the results for flanker separations equal to 10, 20, 40, 60 and 100% of the letter size. As in Figure 1, the error bars represent ±1 SE and „INF" on the abscissa indicates the unflanked condition.

Figure 3. Percentage correct responses averaged across the observers at Anglia Ruskin University (ARU, top) and Palacky University (PU, bottom) for the 4 luminance conditions re-plotted from Figure 1, with flanker separation expressed as a percentage of the letter size. Error bars represent ±1 SE. Data at „INF" on the abscissa represent the unflanked condition.

Figure 4. Letter confusion matrices for the 0 and 3 ND luminance conditions (top and bottom, respectively), without flanking bars (left) and with flanking bars at a separation of ~0.8 min arc (right). Each matrix was constructed by averaging the proportions of responses made by the observers at ARU and PU for each of the 10 presented Sloan letters. Blank cells indicate that the specified letter-response combination did not occur. Color coding of the values in the off-diagonal cells indicates relatively low (blue) to high (pink) proportions of the individual letter confusions.

Figure 1

ARU
Average Contour Interaction
No filter condition
1 ND filter
2 ND filter
3 ND filter
Percentage Correct
Flanker Separation (min arc)
0
20
40
60
80
100
0
2
4
6
8
INF
PU
Percentage Correct
Flanker Separation (min arc)
0
20
40
60
80
100
0
2
4
6
8
INF

Figure 2
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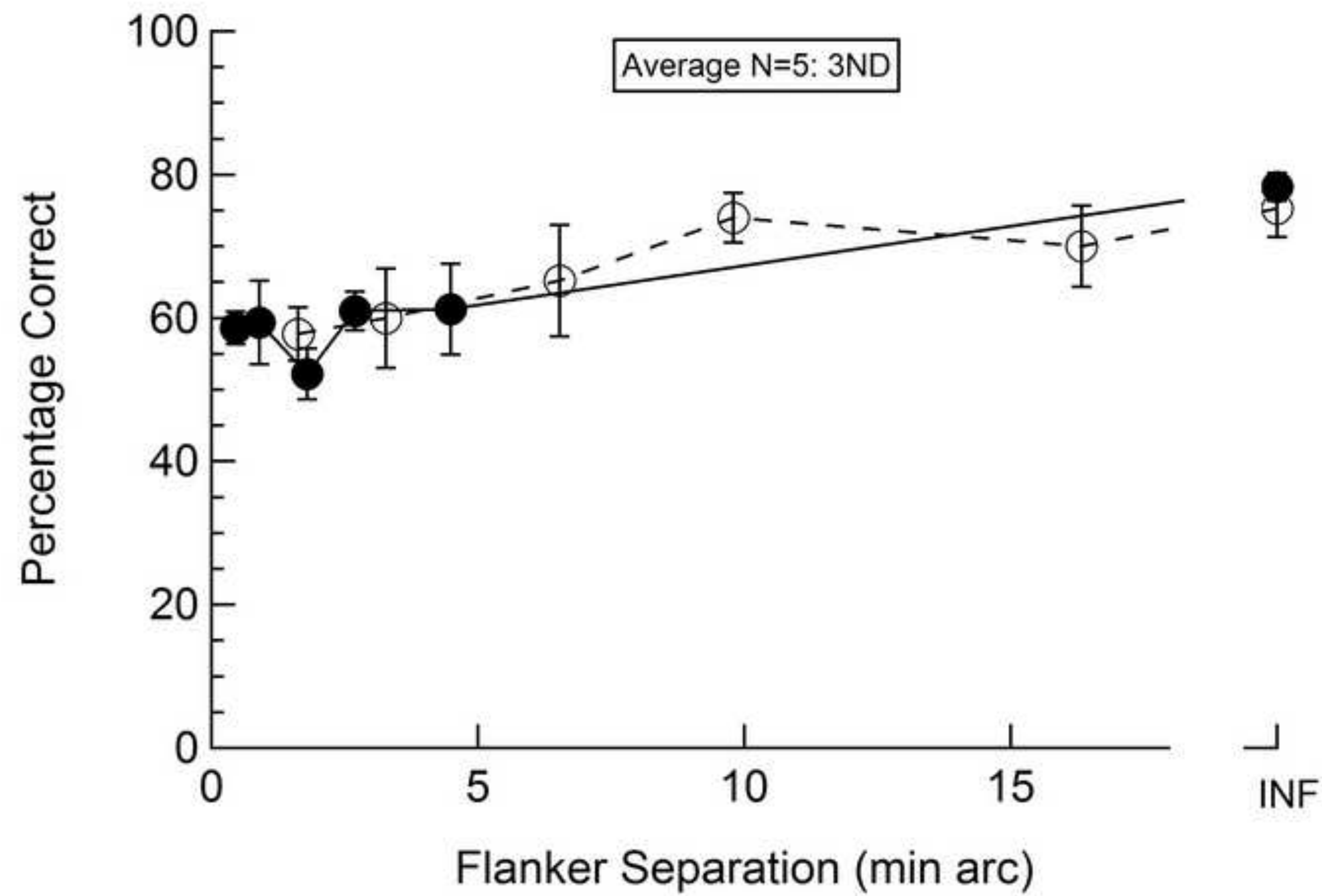

Figure 3

100
80
60
40
20
0
Percentage Correct
ARU
Average Contour Interaction
No filter condition
1 ND filter
2 ND filter
3 ND filter
0
50
100
150
INF
Flanker Separation (percentage letter size)
100
80
60
40
20
0
Percentage Correct
PU
0
50
100
150
INF
Flanker Separation (percentage letter size)

Figure 4

0 ND, No Flanks

Response

Letter Presented	C	D	H	K	N	O	R	S	V	Z
C	0.92			0.01		0.04		0.03		
D	0.02	0.81		0.01		0.12	0.02	0.02		
H			0.87	0.01	0.09		0.02			
K			0.01	0.89	0.01	0.01	0.01	0.01	0.05	
N			0.11	0.03	0.85				0.01	
O	0.08	0.08			0.01	0.80	0.01	0.02		
R			0.02	0.02	0.15		0.76	0.05		
S	0.02	0.10				0.05	0.04	0.69		0.09
V									1.00	
Z				0.01	0.01	0.01	0.01		0.01	0.95

0 ND, 0.8 min Gap

Response

Letter Presented	C	D	H	K	N	O	R	S	V	Z
C	0.41	0.19	0.03	0.06	0.02	0.09	0.05	0.06	0.02	0.09
D	0.30	0.06	0.04	0.07	0.04	0.34	0.05	0.02	0.02	0.05
H	0.03	0.04	0.52		0.12	0.12	0.06	0.02	0.03	0.05
K	0.07	0.10	0.05	0.45	0.04	0.02	0.13	0.08	0.01	0.05
N	0.02	0.09	0.29	0.04	0.19	0.12	0.08	0.10	0.06	0.02
O	0.16	0.12	0.05	0.08	0.03	0.15	0.14	0.08	0.06	0.12
R	0.05	0.03	0.22	0.07	0.13	0.05	0.21	0.17	0.05	0.01
S	0.05	0.08	0.11	0.05	0.02	0.08	0.16	0.29	0.09	0.05
V	0.02	0.10	0.03	0.09	0.08		0.08	0.01	0.51	0.07
Z	0.01	0.06	0.04	0.03	0.04	0.03	0.02	0.09	0.03	0.63

Color Key

Color Key
0.001 - 0.049
0.05 - 0.099
0.10 - 0.199
0.20 - 0.299
0.30 - 0.399

3 ND, No Flanks

Letter Presented	C	D	H	K	N	O	R	S	V	Z
C	0.82			0.04		0.07	0.02	0.03		0.02
D	0.04	0.73	0.01		0.02	0.17		0.03		
H			0.83	0.03	0.13					
K	0.01			0.88	0.04		0.02	0.01	0.02	0.02
N			0.01	0.02	0.92		0.02	0.01	0.02	
O	0.12	0.15				0.69		0.03		
R			0.06	0.04	0.12		0.71	0.05	0.01	0.02
S	0.01	0.03		0.01	0.07	0.02	0.05	0.79	0.01	0.01
V							0.01		0.99	
Z				0.01			0.03		0.01	0.95

3 ND, 0.8 min Gap

Letter Presented	C	D	H	K	N	O	R	S	V	Z
C	0.51	0.10	0.01	0.04	0.05	0.19	0.01	0.05	0.01	0.03
D	0.17	0.40	0.01	0.02		0.28	0.04		0.02	0.05
H			0.76	0.04	0.11		0.03	0.03	0.01	0.03
K	0.08	0.01		0.71	0.08	0.01		0.06	0.02	0.03
N			0.07	0.05	0.74	0.01	0.05	0.03	0.02	0.03
O	0.22	0.16	0.02	0.02	0.03	0.38		0.03	0.05	0.08
R		0.02	0.14	0.11	0.17	0.01	0.36	0.13	0.04	0.02
S	0.11	0.09	0.03	0.04	0.06	0.08	0.07	0.46	0.02	0.04
V			0.02	0.06	0.06		0.03	0.06	0.71	0.04
Z	0.01	0.01	0.01	0.01	0.01		0.02	0.02	0.01	0.90