# Attention modulates neuronal correlates of interhemispheric integration and global motion perception

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In early retinotopic areas of the human visual system, information from the left and right visual hemifields (VHFs) is processed contralaterally in two hemispheres. Despite this segregation, we have the perceptual experience of a unified, coherent, and uninterrupted single visual field. How exactly the visual system integrates information from the two VHFs and achieves this perceptual experience still remains largely unknown. In this study using fMRI, we explored candidate areas that are involved in interhemispheric integration and the perceptual experience of a unified, global motion across VHFs. Stimuli were two-dimensional, computer-generated objects with parts in both VHFs. The retinal image in the left VHF always remained stationary, but in the experimental condition, it appeared to have local motion because of the perceived global motion of the object. This perceptual effect could be weakened by directing the attention away from the global motion through a demanding fixation task. Results show that lateral occipital areas, including the medial temporal complex, play an important role in the process of perceptual experience of a unified global motion across VHFs. In early areas, including the lateral geniculate nucleus and V1, we observed correlates of this perceptual experience only when attention is not directed away from the object. These findings reveal effects of attention on interhemispheric integration in motion perception and imply that both the bilateral activity of higher-tier visual areas and feedback mechanisms leading to bilateral activity of early areas

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play roles in the perceptual experience of a unified visual field.

## Introduction

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(G , 2000;
T , S , S , & H , 1988). Y

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(VHF) (A. T. S ,
W , & S , 2004; T , M , H -
, L , & D , 1998; L & W ,
2004). H ,

Pacman

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P - . I
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P - ,
(F 1, ). B
P -
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VHF
P - .
W
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M ). I “ ”
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# Methods

## Participants

B U ,
DTK, SE, CO,
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C B U . P
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E “ ;
“ ”
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, DTK, SE, CO. A
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HB KD.

## MR data acquisition

M 3
T (M T , S AG, E
G ) 12- - . A
- T1- - -
-
( -
; $= 1 \times 1 \times 1$ $^3$;
[TR] = 2600 ; [TE] = 3.02 ; = 8°;
[FOV] = 256 × 224 $^2$; :
; : – ;
: 176; [GRAPPA]: 2).
F MR -
(TE: 40 ; TR: 2000 ;
FOV: 192 × 192 $^2$; : 64 × 64; -
: 3 × 3 $^2$; : 71°; : 3
; ; : 26;
: ). E -
( “ ”
, “ ” )
-
( AA “
” ). T -
; (ROI)
, ,
MT+;
.

## MR display system

T -
(NEC NP125, : 1024 × 768,
: 60 H ) - (N V
489MCZ900, N , R , NY, USA). P -
- . T –
72.5 ,

30° × 22° . T
1832 / [2]
CIE $x = 0.357$, $y = 0.351$.

## Stimuli

A
J ( :// . . .
/~ /P W J / . ). A
- . T

(
G
377.25 / [2],
6 × 6
, F 1). I -
“P - ”
“ ” . B
503 / [2]. T P -
. B
. I ,
,
“ ” P - .
T F 2. A
. T
. D
,
480 . F ,

. T

. I P - ,

. W , ,
;
(F 1).

## Experimental procedure and fixation task

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MRI . E
12 ,
12 . T
10
(F 2

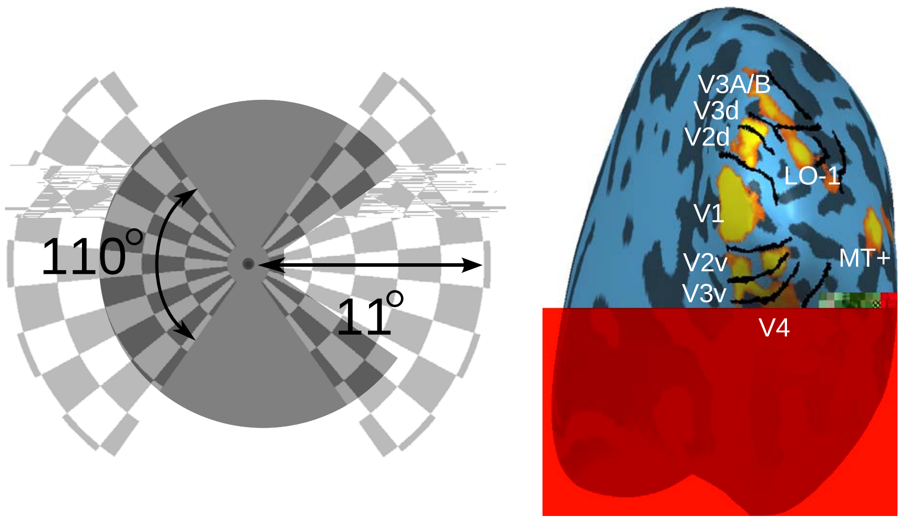


Figure 3. ROIs were identified using wedges texture-mapped with counter-phase contrast reversing checkerboard patterns in early visual areas (the Pac-man figure in the background is shown here for visualization purposes; it was not present in the actual experiment). For MT+, moving random dots were used as a localizer. Boundaries between early visual areas were drawn using the results of a separate retinotopic mapping session for each participant. The image on the right shows ROIs and visual area boundaries on an inflated brain of one participant.

, MT (H ., 2002; M ., 2000). H , . T , MT+.

## Retinotopic mapping stimuli

A . R . T - - - - . T 30° 30° 10 , 360° 12 . T . T 2° 1° 14°. E 10 . T 10 . F , V3A/B, LO-1, LO-2 , L H (2006) ( T ., 1997). T 3-D . B - MR (E , G , & W , 1997; S ., 1995).

## MR data processing and analysis

F B - V QX (B I , M , T N ). P , 3-D , , - ( 0.015 H ) (A. M. S ., 1999). N MRI . A , - , . F ROI - B V QX. V ($p <$ $10^{-4}$, ) . F - , , J . T - . A , - (F 5), - ( 12 ) . A , P -

(F 6).

F ,

*t* ( . .,

P -

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## Behavioral experiment

– 64 . T ’
- . T

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(250
, ) ,
. T

. S -
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(P - – , –
, – ),
(MANOVA) (ANOVA ).

## Results

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VHF ,
VHF . T ,
(RF)
VHF
’
. O , RF
VHF,
. C -
, ,
330.6( )]TJ0-1.1122TD[( 331.6(8 .)-33423( )W 332.9(

. U “ ”-
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U - , “ -
“ ”
.” T “ ”
. I ,

Passive View

Average % MR signal difference

# Discussion

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V3A/B, LO-1, MT+
P -

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, LGN,
P -
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. T
, VHF
. T

(T .,
1997). M ,
-
L , MT+, .
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L
(A. T. S ., 2004; T
., 1998)
. L
. (2009)
V1 LOT ,
MT+, LOT
V1 ( V ., 2004). T
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MRI,

. MT+
(B & B , 2005; C & M ,
1990)
V1 (B & B , 2005;
L & R , 2000). T
MT+ M
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, LGN (L & R , 2000;
S , P , W , & H , 2004). G

V1 (B &
B , 2005), MT+
(V .,
2004) ,
V1.
S , LGN

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LGN–MT+ K (B
& B , 2005; S ., 2004),
. I
, LGN
(SC),
SC MT (B ,
2004). M , , -
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SC
MT (B , 2004;
C , 2004). I MT+
SC , ,
LGN . T

V1, V2, V3
MT .
C

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(G , 2000; N & C ,
1996). I , G ç, B , S ,
K (2011), MRI DTI,

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MT
V1 . T MT

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S -
MT (C & M , 1990; G ç .,
2011) V3–V3A/B (C &
M , 1990) V1, V2, V3

(C & M -
, 1990). T

VHF . MT
V1,
V2 V3 (B & B , 2005;
B , 2004). H
,
V1, V2, V3, -
MT
. T , MT+

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E
, MT+
(B & B , 2005; C
., 2011; C , H , D , & V , 2001;
O'C , R , K , T , & S , 1997;
S ., 2002). M ,
-
(G ., 1999) LGN
(O'C , F , P , & K , 2002). W

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. T ,

VHF

. T

(L & R , 2000; Z & F , 1998).

P RF MT

70°

(B , 2013; B , M , & V , 1998; M , B , & V , 1995). M , MT RF

, RF

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(B ., 2009; C ., 2011; W ., 2006; H ., 2007). M , - (O'C , D , & K , 1999; R , L , & S , 1998),

(M M & S , 2004, 2005) - (S ., 2002; T & T , 1999)

VHF MT.

O

B . (2006),

-

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, V2 V3

. T

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R ,

- , P -

. I

MRI

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- , P -

, MRI

P -

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W -

P - ,

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. H , ,

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RF , V1/2,

B . (2006) . N

P - (85% -

, 76% ) . T

P -

- (

P -

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LOT V3A/B, MT+, LO1). H ,

LOT

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# Conclusions

T ,

. O

V3A/B, LO-1, MT+

(

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*Keywords: global motion perception, interhemispheric integration, fMRI, visual brain, perceptual experience of unified visual field*

# Acknowledgments

S S T

R C T "1001" (108K398),

E C "M C I

R " (PIRG-GA-2008-239467),

T A S "D Y

I " . A

U M ,

C M R R

NIH N B I C

C G (P30 NS057091). HB KD

F

U C , S D

.

C :

C : H B .

E : @ . . .

A : D P & N

M R R C , B U -

, A , T .

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