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评 述

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摘要 ,
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关键词

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,
, . Parkes [5]
(crowding)[1]. , Gabor ,
. , Gabor
, [2,3]; Gabor . Greenwood [6]
, [4]. ,
1923 , Korte : “ ,
, , .
, ‘ ’
”[2]. .
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[7,8], . , , [9~16]. . , , , . 2007 , (*Journal of vision*) , ; , . , .

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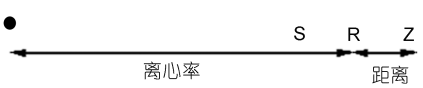
1.1

1 . , R (target), S Z (flanker), (eccentricity), . (critical spacing) . : ( ) , ; ( ) , , , .

1.2

[17], , [3] [18~21] [22] [6] [23,24]



1

[25] [26]. , [17] [27,28] . , , , (ordinary masking) (lateral interaction) (surround suppression) . , . . Pelli [29] , , . , [21,29], [30]. Kooi [31] , , . Levi [32] , . Petrov [33] , , (inner-outer anisotropy). , Whitney Levi[1] 6 , : ( ) ; ( ) , ; ( ) . , , . Bouma[34,35] , 0.4~0.5 , Bouma . Bouma [17,25]; ( ) (anisotropy). , [36], , , . , [20]. , , [37]. 2 ; ( ) (inner-outer asymmetry),

2

;

,

[24,34,38]. 2 ,

;

( ) (temporal tuning).

, [39,40],

. ,

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Whitney Levi[1] 6

(diagnostic criteria), 6

. , ,

[41,42]. Petrov [33] ,

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2

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,

[10,14,18,20,43~45]; ( )

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[19,46~49].

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[5,50]. [51]

(event-related potentials, ERPs) (functional magnetic resonance imaging, fMRI) ,

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2.1

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. Flom [52] ,

(Landolt C) ,

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“ ”[3].

[4,53]. Motter Simoni[54]

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[55]. , ,

(V1: (*Cebus albifrons*), 1.5 1[56];

, 3 1[57] ; V2: , 1.5 1[58]; V4:

, 2 1[59]),

.

(long-range horizontal connections).

[60,61]. (*Catus*)

6~8 mm[62~65] .

, [66].
,
[31],
[63,67~69].
Orbach Wilson[70], Wilkinson [71] Parkes
[5] ,
(texture),
,
[29,36].
. ,
( ) (
) [4,31,52,72].
,
, [69].
, ,
[73],
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. Blake [18] Ho
Cheung[20]
, ,
V1 .
, Millin [74] fMRI
. ,
(blood oxygen level dependent, BOLD)
, ,
,
. , V1
, , V1
; , (lateral
occipital complex, LOC), .
, ,
,
. V1
, Arman [75] Bi
[76] fMRI V1 ,
, V2.
, V4 ,

, V4
2 1[59],
[36]; V4
0.5 , Bouma .
V4
[77,78], Chung [10]
,
. Liu [21] ,
1/4 ,
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,
.
V2 V3,
, , V2 V3
.
, V1
. V1, V2 V3 ,
V4 LOC.
, ,
V1.
,
. Chakravarthi Cavanagh[79]
,
. , metacontrast
.
, metacontrast
,
[80~86];
(object substitution mask) ,
,
,
[87,88].
, metacontrast
,
, ,
LOC[89],
LOC .
Ho Cheung[20] (contin-
uous flash suppression technique)

, , . Ho
. Wallis Bex[90] “ Cheung[20]
”(adaptation-induced blindness) .
, ,
. . .
, , ,
. Chakravarthi Cavanagh[40]
, , ,
,
, Shin Tjan[91] Gabor 2 6~8 Hz , 6~8 Hz
, “ ”2 ,
. , . Petrov Meleshkevich[38] ,
Gabor , , ,
, ,
, . , Tripathy
; Gabor , Cavanagh[49] ,
“ ” , ,
, , ,
. , [93], .
, . ,
“ ” . , ,
. Nador
2.2 [94] (steady state visually
, evoked potential, SSVEP)
; . 2 Gabor 36 Gabor
. , ,
1996 , He [19] , ,
( ) ( );
, , Gabor,
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[92]. 2 22 , ,
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, , .
. He [19] ,
Blake [18] , Blake [18] , He , ,
[19] . Fischer [95] ,
, , Gabor Gabor , Gabor

(drift),

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. Yeh [96] ,

. Faivre [97]

Faivre Kouider[98] ,

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, .
(lateral interaction) , Maniglia [123] ,
, Gabor Gabor ,
. Gabor . ,
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[9,119~124].
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Chung[9] 8 3
, 6000 .
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34% 64%,
(3),
. , Hussain
[121] ,
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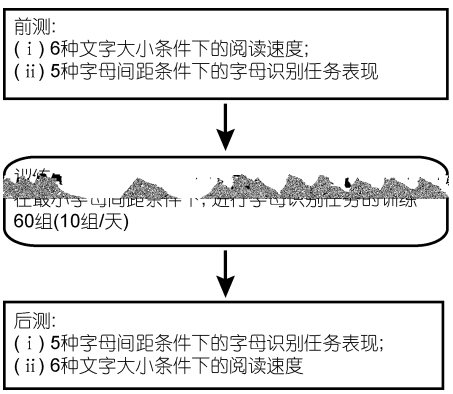
Huckauf Nazir[120] ,



3 Chung[9]

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Huang Watanabe[119]
10° . 6
, ,
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, ,
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, ,
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Sun [124] (ideal observer
analysis) ,
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6
, 2 , 1 Ž(, ,
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(perceptual window)

. , ,
, ,
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[51]
. ,
. (vision-for-perception)
(vision-for-action)

5 [128]. Chen [129]
,
, ;
,
[23,24]
, , ,
[26] [25] [97] . ,
[97,98] . ,

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, . , ,
, , : ( )
. , [51] (,),
, V1 , ? ( )
, ?
, . ? ( )
, . , ,
, ? ( ) ,
, ?
. ( ) ,
Harrison [125~127] ?
, , ,
, (ERPs)
[126]. , (fMRI) ,
( ) (transcranial magnetic stimulation, TMS)
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Neural Mechanisms of Visual Crowding Effect

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When a target is presented with nearby flankers in the peripheral visual field, it becomes difficult to be identified, which is a phenomenon termed crowding. Studying crowding not only facilitates understanding of object recognition, but also benefits the remedy of macular degeneration, amblyopia and dyslexia. Since the concept of crowding was put forward, researchers have studied it extensively and gained much knowledge. Here, we provide an overview of the advances in this research field, including the properties of crowding, the existing theories and computational models that were proposed to explain the underlying neural mechanisms of crowding and how to alleviate crowding with perceptual learning. Although there has been tremendous growth of this topic, controversies remain. Further studies with elaborate designs and advanced technologies are required to address these controversies.

visual crowding, neural mechanisms, computational models, perceptual learning

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