Interaction between Emotion and Pseudoneglect

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"Pseudoneglect" refers to a spatial processing asymmetry consisting of a slight but systematic bias toward the left shown by healthy participants across tasks. It has been attributed to spatial information being processed more accurately in the left than in the right visual field. Importantly, evidence indicates that this basic spatial phenomenon is modulated by emotional processing, although the presence and direction of the effect are unclear.

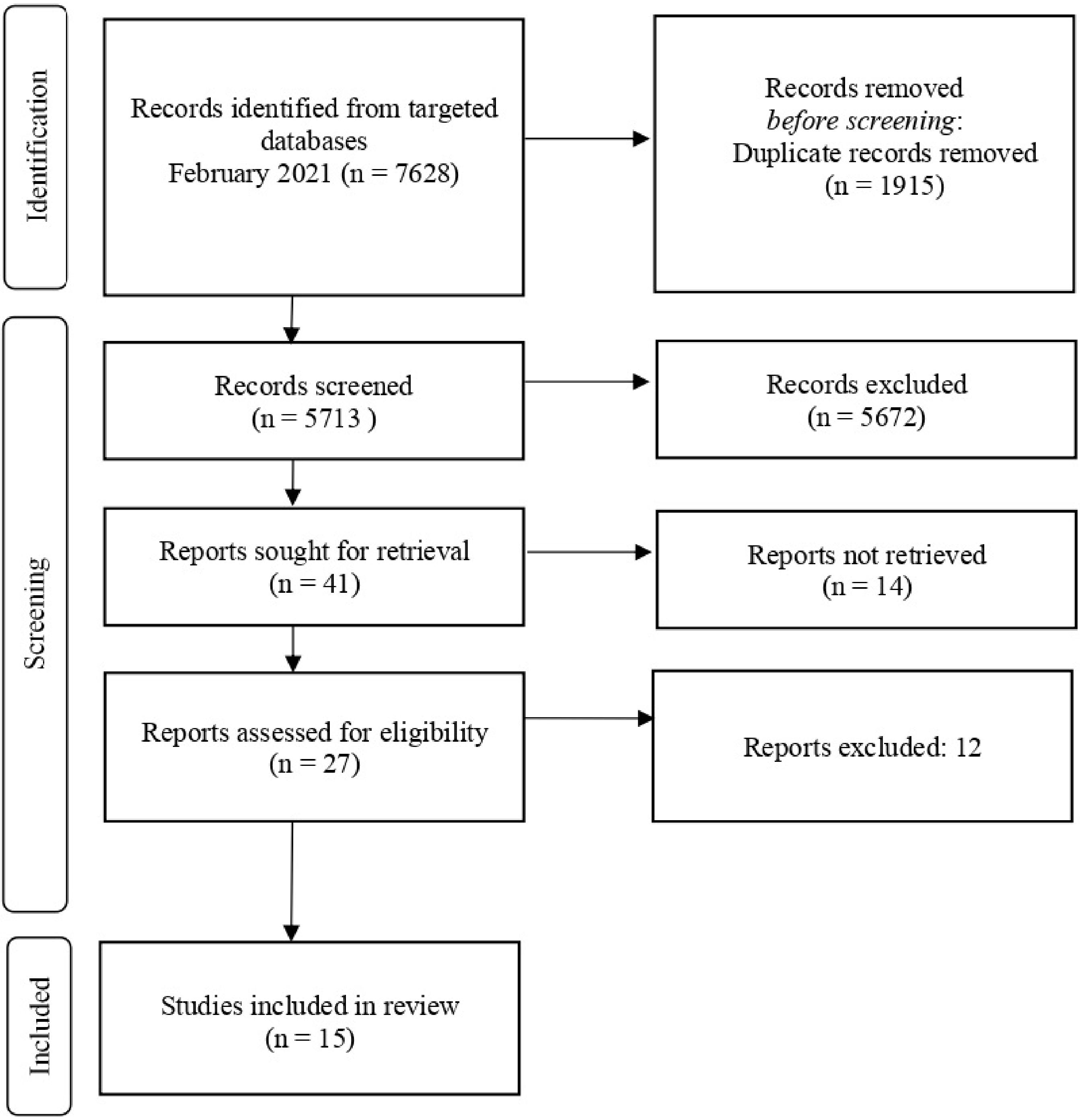
emotion perceptual asymmetries lateralization visual neglect attention bias

1. Introduction

Over the last two decades, much research has focused on the influence of emotion on spatial biases in both patients and neurologically intact individuals, based on the strong influence that emotion has on attention in everyday life, on the tight interconnection between the neural mechanisms that mediate these two phenomena, and on the brain lateralization of emotion processing. In this context, spatial attention tasks such as the line bisection have been used in an attempt to disentangle the issue of emotion and attention lateralization. The rationale is that if attention is right-lateralized and emotion is also right-lateralized (i.e., "right-hemisphere hypothesis" [1]), then both functions concur in shifting the activation balance in favor of the right hemisphere, enhancing the pseudoneglect in the left hemifield. An alternative account sees positive emotion lateralized to the left and negative emotion to the right (i.e., the "valence-specific hypothesis" [2]) predicts that negative emotion should increase the relative activation of the right hemisphere and enhance pseudoneglect. In contrast, positive emotion should increase the relative activation of the left hemisphere and attenuate pseudoneglect.

The association between emotion and the right hemisphere goes back to the very early neurology literature when Mills [3] observed that patients with a lesion in the right side of the brain had an impairment in emotional expression. For the right-hemisphere hypothesis, the perception of emotional stimuli is related to the activity of the right hemisphere, regardless of affective valence [4]. Conversely, the valence-specific hypothesis is based on evidence that lesions in the left frontal lobe were related to negative emotional states while lesions in the right hemisphere were more associated with positive or maniac emotional states [5]. For the valence-specific hypothesis, the left hemisphere processes positive emotions, whereas the right hemisphere processes negative emotions [6]. An alternative, the "approach–withdrawal" hypothesis, proposes that brain asymmetries observed for positive and negative emotions are related to the underlying motivational system linked to positive and negative emotions [7]. Accordingly, the left prefrontal cortex is involved in processing approach-related emotions, such as happiness and anger, whereas the right prefrontal cortex processes withdrawal-related emotions, such as sadness and fear.

Despite a large body of research, evidence on the interaction between emotion and spatial attention is still not well understood. A systematic review on the relation between pseudoneglect and emotion conducted according to the PRISMA guidelines (see **Figure 1**), [8] yielded 15 studies published by February 2021 that measured the relationship between emotional processing and spatial attention pseudoneglect.



Inclusion criteria were: (1) original, peer-reviewed articles; (2) written in English; (3) conducted on adults; (4) included at least one task to measure pseudoneglect (line bisection task, landmark task, greyscales task, grating scales task, tactile rod bisection task, lateralized visual detection, cancellation task; and (5) included at least one task with emotional stimuli or employed a measure of emotional state/trait as they relate to pseudoneglect. Articles from all publication years were accepted (see **Table 1**).

Authors	Sample Size	Gender	Age (years)	Emotional Stimuli	Emotional Measures	Attentional task	Results	Bisection bias - Baseline	Bisection bias - Emotional modulation
Hausman, 2005	38	24 F and 14 M	females M = 26.96, SD = 6.19, males M = 33.93, SD = 10.02		State-Trait-Cheerfulness-Inventory	Females were asked to bisect lines during the menstrual phase and during the midluteal phase. Males were tested only once.	Mood did not affect the results	Leftward bias	No effect
Mohr et al., 2005	24	20 F and 4 M	M = 20.9, SD = 4.71 years	Lines composed of strings of letters with emotional and neutral words		Bisection task of strings of letters	Exp. 4 The rightward bisection bias is stronger with emotional as compared to neutral words	Rightward bias	Emotional words shift to the right
Drake et al., 2006	27	11 F and 16 M	unknown		The Positive and Negative Affect Schedule (PANAS)	Paper an-pencil line bisection task	Rightward errors in visual line bisecting correlated positively with the Positive Affect subscale.	-	Positive emotions as a trait shift to the right
Drago et al. 2008	17	8 F and 9 M	M = 66, SD = 9.55	5 abstract and 5 impressionistic paintings	Likert scale about the evocative impact of the painting	Paper and-pencil line bisection task after painting viewing	Negative correlation between the evocative impact of the painting and line bisection bias	Rightward bias	Stronger emotional evocation goes with less bias to the right
Tamagni et al., 2009	48	24 F and 24 M	M = 24.5, SD = 1.5	Valenced positive and negative words		Word detection task and line bisection task	A recognition advantage for negatively emotional words is evident only for participants with a leftward bisection bias	15 leftward bias and 18 rightward bias	Better detection of negative emotional words correlates with a leftward bias
Lourenco et al., 2011	35	21 F and 14 M	M = 21.2		CLQ claustrophobia questionnaire filled after the experiment	Line bisection using a laser pointer at nine distances. Lines were centered on legal-sized paper and attached horizontally to a wall.	Participants with greater claustrophobic fear showed more gradual rightward shifts in attentional bias over distance (i.e., larger for near spaces) than those with less claustrophobic fear.	Rightward bias	Claustrofobic fear shifts to the right
Cattaneo et al., 2013	26	13 F and 13 M	M = 21.7, SD = 2.13	Exp.1 Female and male faces happy, sad, and neutral Exp. 2 Female and male vocal sounds happy, sad, and neutral		Exp. 1 Computerized perceptual line bisection task with emotional faces with the same valence as flankers Exp. 2 Haptic bisection rods while listening emotional vocal sounds	Prolonged (but not transient) exposition to concurrent happy stimuli significantly shifts the bisection bias to the right compared to both sad and neutral stimuli	Leftward bias	Positive emotional faces shift to the right relative to negative and neutral faces Positive vocal sounds shift to the right relative to neutral and negative ones
Armaghani et al., 2014	20	10 F and 10 M	M = 21.61	1 Female face happy, sad, and neutral		Paper and-pencil perceptual line bisection task with emotional faces with the same or different valence as flankers	Presentation of emotional faces induce a greater leftward deviation compared to neutral faces, independent of where these faces are presented (left or right hemifield). However, faces portraying negative emotions tend to induce a greater leftward bias than positive emotions	Leftward bias	Emotional positive and negative faces shift to the left relative to neutral faces
Leggett et al., 2015	25 23 22 19 23	21 F and 4 M 11 F and 12 M 16 F and 6 M 9 F and 10 M 18 F and 5 M	M = 22.48, SD = 3.60 M = 26.13, SD = 9.44 M = 24.50, SD = 7.41 M = 22.74, SD = 3.68 M = 24.26, SD = 5.93	Exp.1 5 Female and 5 male faces happy, angry and neutral Exp. 2 Photographs of animals, scenes, etc. 10 approach, 10 avoidance, and 10 neutral Exp.3 Female and 5 male faces happy, angry and neutral Exp.4 Emotional faces	Exp. 1 NaN Exp. 2 Different valence and same arousal Exp. 3 NaN Exp. 4 Exp. 5	Exp. 1 Landmark task (which side is longer) with a central face as emotional prime Exp. 2 Landmark task with a central photograph as emotional prime Exp. 3 Same as exp.1 but with mixed trials Exp. 4 Landmark task (the transector is closer to the left or right end) with a central face as emotional prime Exp. 5 Replication of Exp. 1	Exp. 1 Negative faces shift to the left Exp. 2 No emotional effect Exp. 3 No emotional effect Exp. 4 No emotional effect Exp. 5 happy faces shift to the left (opposite to the exp. 1) - failed to replicate	-	Opposite trends between experiments
Failla et al., 2016a	50	37 F and 13 M	M = 4.41, SD = 0.52	Faces and words with positive, negative, and neutral valence		Pen-and-paper line bisection and computerized line bisection with the line composed of words or faces, and the bisection with either the right or left hand	Positive and negative valenced words produce a shift to the left more than do valenced faces Positive and negative valenced faces produce a shift to the right relative to baseline	Leftward bias	Positive emotional words shift to the left Positive and negative emotional faces shift to the right
Failla et al., 2016b	62	49 F and 13 M	M = 19.81, SD = 1.90	8 paintings from Drago et al. (2008), original and mirrored version	TAS-20	Paper and-pencil line bisection task after painting viewing	no relationship between line bisection accuracy and painting ratings	Leftward and rightward bias	-
Milhau et al., 2016	49 22	unknown	unknown	Words with positive, negative, and neutral valence		Exp 1 Landmark task for estimate the baseline and then preceeded by a central valenced word as a prime (task to report if the transector is on the left or right side) Exp. 2 Landmark task for estimate the baseline and preceeded by a central valenced word as a prime (task to report which side is longer))	Exp. 1 Right-handers less "right" responses after negative words, compared to the positive ones, left-handers less "right" responses after positive words compared to the negative ones Exp. 2 similar pattern to exp. 1	Exp. 1 Rightward bias Exp. 2 No bias	Negative emotional words shift to the left (for the right-handers)
Hausman et al., 2016	47	21 F and 26 M	M = 20.64, SD = 0.74	2 pieces of classic music with positive (happy) and negative (sad) valence	State-Trait Cheerfulness Inventory (before and after music)	Exp 2 Listening to valenced music and paper-and-pen line bisection task	no differences in bisection accuracies across groups and music conditions	No bias	Positive emotional music shifts to the right
Somma et al., 2021	47	41 F and 6 M	M = 20, SD = 1.33		COVID-19 Pandemic Lockdown Student Stress Scale, Coping Orientation to Problem Experienced-New Italian Version	Cancellation task	The degree of pseudoneglect increment positively correlated with perceived stress, and negatively correlated with Positive Attitude and Problem Solving COPE-NIV subscales	Leftward bias	Stress shifts to the left, and active coping strategies shift to the right
Ostrugno et al., 2020	160	82 F and 78 M	M = 23.33, SD = 3.65	36 figurative paintings and 36 photographs of natural scenes		Bisection task superimposed on a gray background, painting or photograph	More pseudoneglect when the background was a painting	Leftward bias	Neutral paintings shift to the left

2. Current Findings and Conclusions

Of the 15 studies meeting the inclusion criteria, 11 studies used visual stimuli, such as faces, words, and pictures with emotional connotations. The main finding is that the majority of the studies found that pseudoneglect was modulated by emotional stimuli or by participants' self-reported emotional state or trait. However, the direction of these effects is less clear-cut. Of the studies with emotional faces or words, three reported that emotion induces a rightward bias (or attenuates the leftward bias): one study used emotional words [9], one used angry and happy faces [10], and one used happy and sad faces [11]. Four studies reported that emotion induces a leftward bias (or attenuates the rightward bias): one study used happy and sad faces [11] and three studies used negative words [9][12][13][14]. One study with faces and words reported mixed results [15]. The two studies using auditory stimuli [11][16] report a rightward bias when listening to sad and happy music. Moreover, studies on the effects of self-reported affect and traits on pseudoneglect show that positive affect [17] and positive attitude [18] are correlated with a rightward bias. Finally, greater self-reported claustrophobic fear is related to a rightward bias when the line bisection is performed at a short distance [19].

The entry conclude that there are substantial methodological differences across studies that could account for the heterogeneity in the observed findings. Firstly, the time between presenting the emotional stimuli and spatial attention tasks varies, with some employing simultaneous and others sequential presentation. This difference does not rule out low-level variables (such as surround suppression) due to simultaneous versus sequential stimulus presentation that might contribute to the attention bias [20]. Secondly, some studies present the line flanked by two emotional stimuli and some others flanked by just one stimulus on the left or right side of the line. However, contextual stimuli may influence the localization of the subjective midpoint, biasing the bisection away from the location of the flanker [21]. Indeed, using one flanker seems to increase the attentional load for extracting the segment from the background and reduce the salience of the flanked-line segment [22]. Thirdly, there are individual differences in the attention bias at baseline and this variability does not seem to predict the direction of changes driven by the emotional modulation of the bisection bias. Finally, an additional neural factor may contribute to the complex picture that emerges from the literature. This is related to which hemisphere is preferentially involved in processing the specific category (e.g., faces, words, sounds, etc.) of the stimuli used and their relative position in the visual field (i.e., central vs. peripheral presentation). For instance, visual stimuli such as faces and words likely activate networks of non-parietal visual category-selective regions that include the right fusiform face area [23] and the left visual word form area [24].

Future studies should consider comparing brain activation asymmetries during the baseline and during the task while taking into account the brain hemisphere that is preferentially involved in processing the category of stimuli used.

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