

Pseudoneglect in native readers of Georgian and Arabic

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Abstract

Introduction: We aimed to compare the pseudoneglect in left-to-right vs right-to-left readers. Our study was encouraged for several reasons: 1. Only a few studies report on pseudoneglect in Star cancellation task performance and extended use of this task is desirable. 2. At the same time, we used a new test for pseudoneglect – Cancel the Rabbit task, which has not been used in earlier studies. 3. This is the first study of pseudoneglect in representatives of human cultures (namely Georgians), that have not been studied earlier.

Observation: Georgian and Arab participants performed the Star cancellation task. Another group of Georgian participants performed the Cancel the Rabbit task. The number of first cancellations was significantly higher on the left side in Georgian participants. More than half of young adult Arabs display pseudoneglect in the Star cancellation task. However, no significant difference in the number of left-sided and right-sided first cancellations was found in Arab participants. Female Arab participants made more left-sided cancellations, compared to males.

Conclusion: Most young adult Georgians display pseudoneglect on a group level. The phenomenon is consistent across the tasks on star cancellation and rabbit cancellation. More than half of young adult Arabs display pseudoneglect in the Star cancellation task performance.

Bias toward the right visual hemispace, displayed by some individuals, Georgians, and Arabs, is due to the activation of their left brain hemisphere in tasks on visual target cancellation.

Habitual reading right-to-left promotes the participation of the left hemisphere in cancellation task performance.

Keywords: Pseudoneglect; Reading direction; Arabic; Georgian; Cancellation task

1. Introduction

Healthy individuals prefer directing attention to either the right or left visual hemispace. In most cases, the bias toward the left hemispace is reported. This phenomenon is known as “Pseudoneglect” [1].

Pseudoneglect mimics the clinical phenomenon of unilateral spatial neglect (UN). Clinical observations of UN patients with damage to the left vs. right brain hemisphere and studies using visualization techniques suggest the predomination of the fronto-parietal regions of the right hemisphere in spatial attention [2,3,4,5,6]. The “Interhemispheric rivalry model” proposes that the allocation of spatial attention is balanced by transcallosal inhibition. Both hemispheres

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compete to direct attention to the contralateral hemispace with the domination of the right hemisphere in the organization of visual-spatial attention [7]. Functional magnetic resonance imaging in healthy adults confirms the association of the right-dominant network of brain regions (intra-occipital and intra-parietal sulci, eye fields, and right ventral cortex) with perceptual pseudoneglect [8]. In the fMRI study, the right intra-parietal sulcus and lateral peristriate cortex were shown to activate attention allocation in healthy participants [9]. In healthy young adults, pseudoneglect was associated with greater right middle frontal resting activation across theta, beta, and gamma bands [10].

Pseudoneglect deserves attention for many reasons. Pseudoneglect may prevent a balanced distribution of visual attention to the left and right visual hemispace during visual navigation in the environment [11]. Bias to the left visual hemispace is increased in the stressogenic situation [12] and is altered in individuals with certain neurodevelopmental disorders [13,14]. At the same time, attentional bias to the hemispace in humans is subject to cultural influence [15,16]. Here, we concentrate on the association between pseudoneglect and reading direction by comparing pseudoneglect in native speakers of Georgian and Arabic.

Visual field asymmetries have long been suggested to reflect a tendency to scan information in the direction of reading in the native language [17]. The difference in the attentional bias between left-to-right and right-to-left readers is shown by comparing Israeli and French participants [18,19] and Italian and Israeli participants [20,21]. In sum, the inversion of spatial bias in right-to-left readers compared to Western samples has been demonstrated. As for native readers of Arabic, the authors [22] studied the line bisection and symbol cancellation task performance in healthy adult Arab participants. The authors compared the results to the data on the Western population, which existed in the literature. Line bisection error biases in Arabs were found to be the opposite of Western biases. Symbol cancellation demonstrated leftward bias, however, it was smaller than that seen in Western reports. Other authors [23] used a letter cancellation task and did not find spatially biased errors in native readers of Arabic.

Our study was encouraged for several reasons: 1. Only a few studies [20 for example] used the Star cancellation task (SCT) to find the relationship between reading habit and pseudoneglect. SCT is successfully used in the study of visual attention, and extended use of SCT in the research of pseudoneglect seems desirable. At the same time, we introduced the new test for pseudoneglect – Cancel the Rabbit Task (CRT) which has not been used in other studies; 2. Since the issue refers to the interrelation between cultural phenomenon and pseudoneglect, it is desirable to study representatives of human cultures, different from those, who have already been involved; 3. Pseudoneglect is evident at the population level. However, some individuals, display a rightward bias to the visual hemispace. We tried to give some theoretical explanations for this fact.

2. Method

Volunteer healthy participants, with normal or corrected to normal vision, of both sexes, aged 19-25, right-handers (self-reported), were recruited by snowball sampling. All participants were university students and spoke their native language and English.

They were divided into 3 study groups. Group 1 (G1): Georgian participants, 258 in total, of both sexes, mean age 23.5. Group 2 (G2): Georgian participants, 258 in total, of both sexes, mean age 24. All study participants in G1 and G2 spoke native Georgian and English. Group 3 (G3): Arab participants, of both sexes, 79 in total, mean age of 22.3. All of them spoke native Arabic and English. The reading direction in Georgian is left-to-right, and the reading direction in Arabic is right-to-left.

All participants were informed, that we were testing the speed of test performance and that the obtained information would be used for scientific publication with guaranteed confidentiality and anonymity.

Instructors: Graduating psychology and medicine students were trained in the conduct of SCT and CSR and data collection. Among them, were 5 psychology students, Georgians, and 3 guest medicine Arab students. Guest students conducted the SCT with G3 in their homeland, during winter vacations. Instructors were selected based on their academic excellence.

Tests on cancellation: Paper and pencil versions of the SCT and CSR were used. Letters, and words, included in classical SCT as distractors [20], may provoke attention bias to the left visual hemispace [24]. For this reason, we removed the letters and words from SCT to observe the pseudoneglect without the influence of verbal stimuli; SCT was delivered to G1 and G3, and CSR was delivered to G2. Study participants were seated at the table, opposite their instructor. The page was placed on the table, alongside the midline of the participant's body, with a clean side up. The instruction was as

follows: when I turn this paper upside down, you will see large and small stars. You have only 60 seconds and your job is to cancel small stars with a pencil, as much as possible. Take a pencil, please. Ready? The instructor turned the paper upside down with his (her) right hand and let the participant cancel the targets. After 60 seconds the task performance was stopped. The same instruction was given in the case of CSR, and instead of canceling stars, the participant was instructed to cancel small rabbits, dispersed among larger ones. There was no instructional demand to fix eyes somewhere on the paper, neither on its center nor the periphery. The sidedness of the first cancellation, left or right, was registered in G1, G2, and G3.

The present research work does not contain any studies performed on human subjects by any of the authors. Informed consent was obtained from all individual participants included in the study.

SPSS software was used for data statistical analysis. A chi-square test of independence was conducted to compare the data within Groups G1, G2, and G3 and to examine the relationship between the direction of reading (left-to-right vs right-to-left) and first cancellation side preference (Right vs Left).

3. Results

The results obtained and data analysis are represented in Tables 1, 2, and 3.

Table 1 The number of left - and right-sided cancellations in SCT and CSR

Number/percentage of the first cancellation	Georgians		Arabs
	SCT	CSR	SCT
On the left side	186/72.09%	191/74.03%	44/55.7%
On the right side	72/27.91%	67/25.97%	35/44.3%
Total	258 (Group 1)	258 (Group 2)	79 (Group 3)

The number of left-sided cancellations was 114 and 124 more than right-sided cancellations in G1 and G2 respectively, and 9 more in Group 3.

Table 2 Data statistical analysis

Direction of reading		Side of the first cancellation		Total
		Right	Left	
Left to right	Count	72	186	258
	Expected Count	81.9	176.1	258.0
	% within the direction of reading	27.9%	72.1%	100.0%
	Adjusted Residual	-2.7	2.7	
Right-to-left	Count	35	44	79
	Expected Count	25.1	53.9	79.0
	% within the direction of reading	44.3%	55.7%	100.0%
	Adjusted Residual	2.7	-2.7	
Total	Count	107	230	337
	Expected Count	107.0	230.0	337.0
	% within the reading direction	31.8%	68.2%	100.0%

Chi-Square Tests	Value	df	Asymptotic Sign. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7.504 ^a	1	0.006		
Continuity Corrections ^b	6.766	1	0.009		
Likelihood Ratio	7.235	1	0.007		
Fisher's Exact Test				0.008	0.005
Linear-by-Linear Association	7.482	1	0.006		
N of Valid Cases	337				

0 cells (0.0%) have an expected count of less than 5. b. Computed only for a 2x2 table

The minimum expected count is 25.08. There was no significant association $P < .05$ between the SCT and CSR figures (stars and rabbits) and first cancellation side preferences in G1 and G2. The result indicates that the test (SCT and CSR) has no significant effect on the side preference. The analysis revealed a significant association between the direction of reading in the native language and the side of the first cancellation, as indicated by the Pearson chi-square test, $\chi^2(1, N=337) = 7.504, p = .006$. The continuity correction chi-square was also significant, $\chi^2(1, N=337) = 6.766, p = .009$, further confirming the association. The likelihood ratio chi-square test also supported these findings, $\chi^2(1, N=337) = 7.235, p = .007$. Specifically, the adjusted residuals indicate that Georgian participants were significantly more likely to choose the left side (Adjusted Residual = 2.7) and less likely to choose the right side (Adjusted Residual = -2.7) than expected. Conversely, Arab participants were significantly more likely to choose the right side (Adjusted Residual = 2.7) and less likely to choose the left side (Adjusted Residual = -2.7) than expected.

The number of left-sided cancellations was 5 and 1 more than right-sided cancellations in Female and male Arab participants respectively (Table 3).

Table 3 Results of SCT performance concerning the gender in Arab participants

Number of first cancellations	Arab Participants	
	Male	Female
On the left side	29 (51.8%)	14 (60.87%)
On the right side	27 (48.2%)	9 (39.13%)
Total	56	23

As shown in Table 3, female participants made more left-sided cancellations, while in the group of males, the number of left and right-sided cancellations was nearly equal.

4. Discussion

Data obtained confirms that most Georgian participants display pseudoneglect. With this respect, the data obtained follow the results of the studies of pseudoneglect in representatives of European populations [1,11,13,14,18-21]. At the same time, the leftward bias to the visual hemispace was expressed in both SCT and CRT. Thus, pseudoneglect in Georgian participants is a stable phenomenon on a group level across the tests on cancellation. Arab participants (55.7%) displayed pseudoneglect in SCT. In the authors' study [22], 63% of Arab participants were shown to start cancellation from the left side. As suggested, pseudoneglect is present in humans regardless of reading habits, and its evolutionary origin is demonstrated in several reports [see 20 for review]. However, compared to Georgians, there was no significant predomination of either the leftward, or rightward shift on a group level in Arab participants. The higher number of rightward cancellations in the group of Arab participants (44.3%), compared to Georgians, (27.91% in SCT and 25.97% in CSR) suggests the influence of reading direction on the pseudoneglect, as it is demonstrated in readers of Hebrew and Arabic [18-22] and in contrast to the study [23] that was not able to reveal the spatially biased errors in letter cancellation task performance in native readers of Arabic. Data obtained confirm the suggestion, that visual-

spatial processing involves scanning to the left side of space in left-to-right readers and to the right hemisphere in right-to-left readers [17].

Existing data concerning the leading role of the right hemisphere in pseudoneglect may explain the dominance of the leftward cancellations on the group level among study participants. However, rightward bias toward visual hemisphere, registered in some study participants, needs explanation.

Although there is a consensus concerning the dominance of the right cerebral hemisphere in visual-spatial processing, a certain role of the left hemisphere has long been suggested [25]. Some clinical data argue for a bilateral representation of spatial orientation in the right and left hemispheres. The authors [26] found left-sided visual neglect in patients with lesions to the left hemisphere. At the same time, all study participants, except one, displayed aphasia, and, therefore, neglect in these clinical cases could not stem from reversed lateralization of language and spatial functions in the brain hemispheres. The authors suggested bilateral representation of a spatial function in patients examined. Other authors provided arguments for bilateral representation of spatial orientation [27]. UVN was found in approximately 30% [6] and 43.5% [28] of patients with left-sided stroke with consequent neglect of the right visual hemisphere. Authors reported neglect severity not to differ between left and right UVN [29]. According to clinical observation [30], lesions to the left hemisphere result in allocentric visual spatial neglect. Participation of the left hemisphere in the organization of spatial orientation is suggested as a phylogenetic relict in humans, inferior to the right-hemispheric dominance in most individuals [26]. fMRI study of healthy adults suggests the left hemisphere to participate in certain visuospatial tasks [31]. Thus, participation of the left hemisphere in visuospatial processing should be considered in the case of visual attentional bias in healthy individuals. Some data speak in favor of this suggestion. For example, declining and even reversion of pseudoneglect in older adults is attributed to decreased right-hemispheric activity and more symmetric visual field processing [32]. According to the Activation orientation model [33] the level of activation of the brain hemisphere (right vs. left) determines the direction of attention to the contralateral hemisphere (left vs. right respectively). We suggest, that the bias of attention toward the right visual hemisphere, displayed by some participants, Georgians and Arabs, stems from individual characteristics of brain functional asymmetry and consequent activation of the left hemisphere during cancellation task performance. At the same time, reading from right to left, acquired in early childhood, promotes activation of the left hemisphere, a consequent reduction of the leftward attentional bias, and a shift of attention to the right hemisphere in right-to-left readers. A comparison of the results of male and female Arab participants in SCT might suggest, that male participants are more sensitive to the cultural influence of reading direction. However, the small number of participants in the gender subgroups does not allow us to make conclusions.

5. Conclusions

Most young adult Georgians display pseudoneglect on a group level. The phenomenon is consistent across the tasks on star cancellation and rabbit cancellation. More than half of young adult Arabs display pseudoneglect in the star cancellation task performance.

Bias toward the right visual hemisphere, displayed by some individuals, Georgians, and Arabs, is due to the activation of their left brain hemisphere in tasks on visual target cancellation.

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Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest to be declared

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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