Spatial Attention in a Classroom is Influenced by Egocentric Thinking

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ABSTRACT. This study examined the effects of egocentric thinking on spatial attention within a classroom setting. Seventy-four undergraduates (52 women) of traditional college age were recruited through a research participation pool at a large university in Los Angeles, CA. Participants were randomly assigned to write for 3 min about the location of objects in the front of a classroom from either an egocentric (object-self relations) or an allocentric (object-object relations) perspective. Although more left-located objects were described overall, $F(1, 59) = 5.92$, $p = .018$, $\eta_p^2 = .09$, participants who wrote from an egocentric perspective described significantly more objects located to their left than right, $t(23) = 3.26$, $p = .003$, $d = 0.66$; whereas, those who wrote from an allocentric perspective described a statistically equal number of objects to both sides, $t(36) = 0.10$, $p = .922$. Our findings are consistent with previous work showing right-hemisphere dominance under the egocentric frame of reference and are the first to show that priming an egocentric perspective increases leftward attention in a naturalistic context of a classroom setting. Future research could examine the effects of frame of reference on spatial attention in other everyday contexts, such as driving or viewing internet content.

Whether we are parking a car, sitting in a classroom, or designing our bedroom, we are constantly analyzing and making sense of the position of objects—a process called spatial attention. There are two frames of reference that underlie spatial processing (Galati, Pelle, Berthoz, & Committeri, 2010; Zaehle et al., 2007). An egocentric frame of reference is viewer centered, whereby we judge the spatial position of objects in relation to ourselves; by contrast, an allocentric frame of reference is viewer independent, whereby we judge the spatial position of objects in relation to other objects (Galati et al., 2010; Zaehle et al., 2007). For example, a person using an egocentric frame of reference might describe the location of a tree in the park as "the tree is 12 feet away from *me* and to *my* left at about 10 o'clock," whereas from an allocentric frame of reference, another might say, "the tree is 10 feet south of a redwood tree and 5 feet east of a street lamp." Although both descriptions are made from the viewer's perspective, the egocentric description is self-referential.

Neuroscientific studies indicate that the egocentric and allocentric frames may be lateralized to more heavily involve either the left or right hemisphere (Abrahams, Pickering, Polkey, & Morris, 1997; Feigenbaum & Morris, 2004; Galati et al., 2000; Iachini, Ruggiero, Conson, & Trojano, 2009; Northoff et al., 2006; Vallar et al., 1999). The present study was the first to examine whether frame of reference would lead to greater lateralized spatial attention toward objects in an everyday context—in this case, while seated in a classroom.

Hemispheric Dominance and Spatial Attention

Due to the contralateral organization of the human visual system, the right hemisphere first processes objects and stimuli that appear to the left of our

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central viewpoint. Similarly, the left hemisphere first processes objects and stimuli located to the right of our central viewpoint (Hemond, Kanwisher, & Op de Beeck, 2007). The right hemisphere is more specialized for spatial attention, and thus, when its functionality is altered, spatial attention deficits are commonly seen (Silveri, Ciccarelli, & Cappa, 2011). One example is a condition known as visuospatial neglect that occurs in patients that have had cerebral lesions. For instance, Weintraub and Mesulam (1987) discovered that right, not left, hemisphere lesions disrupt spatial attention to the left. In a more recent study, Silveri et al. (2011) tested spatial attention in patients with various forms of degenerative brain pathologies and found that right parietal lesions were associated with neglect of stimuli located to their left.

Because of the specialization of the right hemisphere for spatial attention, when the right hemisphere is activated in a person with normal brain function, that person's attention will be directed towards the left visual field (Manly, Dobler, Dodds, & George, 2005). Smith and Trope (2006) conducted seven experiments in which a primed, powerful state increased global processing compared to a powerless state. In Experiments 1 to 6, they found that when individuals were made to feel powerful, they detected patterns, extracted the gist, rather than focusing on details, and categorized stimuli at a broader level. In Experiment 7, the researchers showed that the high power-priming task led to a leftward bias in spatial attention, as measured by a line bisection task, suggesting right hemisphere activation. Additionally, Nicholls, Loftus, Mayer, and Mattingley (2007) found that movement in the left (contralateral) hand activated the right hemisphere, shifting spatial attention to the left, and increasing collisions into the right side of a narrow doorframe that participants walked through. Furthermore, Manly et al. (2005) concluded that sleep deprivation counteracts the normal leftward spatial attention bias, shifting it rightward, as the activity of the right hemisphere is more connected to the arousal network (sympathetic nervous system). These three studies indicate that when the right hemisphere is activated, regardless of the stimulus, attention is directed to the left, and when it is less activated (i.e., sleep deprivation), attention shifts back towards the right.

Frame of Reference and Hemispheric Dominance

The majority of studies to date have found that egocentric processing results in right hemisphere activation, specifically activation in the right parietal cortex, shifting the viewer's attention to the left (Northoff et al., 2006). Iachini et al. (2009) found that patients with right parietal lesions have an impaired ability to judge the distance of objects in relation to themselves (egocentrically). Furthermore, in persons with normal brain functioning, Galati et al. (2000) used fMRI to map frame of reference in the brain. Their participants were asked to describe the location of a visual stimulus in relation to either themselves, or in relation to another object. They found significant activation of the right parietal lobe when participants egocentrically judged the location of objects, but no significant lateralized brain activation occurred when participants allocentrically judged the location of objects.

Similarly, in another one of their studies using fMRI, Vallar et al. (1999) tested the effect of egocentric processing in seven healthy individuals who were instructed to press a button every time they perceived that a horizontally moving vertical bar passed the midsagittal plane of their body. Compared to the control group participants, who were told to press the button when the direction of the moving bar changed, and the allocentric participants, who were instructed to press the button when the moving bar passed the subjective midpoint of a horizontal line, the researchers detected more activation in the right hemisphere than the left under egocentric conditions. These studies suggest that the right hemisphere plays a critical role in egocentric processing, and therefore under egocentric conditions, a person's attention will likely be directed more towards the left. Further, there are clinical implications of these findings. Similar to the behavioral deficit of visuospatial neglect (Vallar et al., 1999), a lack of egocentric processing may be a symptom of right hemisphere damage.

However, not all studies have found an association between egocentric processing and right hemisphere activation. Previous studies have found an association, specifically, between the right parietal cortex and egocentric processing; however, it should be noted that some studies indicate that the right temporal lobe may be involved in allocentric processing, particularly with spatial memory (Abrahams et al., 1997; Feigenbaum & Morris, 2004).

Previous work on egocentric and allocentric frames of reference has focused on the extent to which these perspectives are lateralized to one

hemisphere. In general, judgments about the distance of objects in relation to self (egocentric) have been associated with the right parietal cortex. These studies have not examined the link between right hemisphere activation due to egocentric thinking and spatial attention in the environment. Given that awareness likely shifts between egocentric and allocentric frame of references in everyday life, it is important to determine whether or not frame of reference directly influences the side to which we direct our spatial attention. Therefore, in the present study, we examined the effect of egocentric versus allocentric frames of reference on spatial attention in an everyday context.

In the present study, participants wrote about the location of objects within a classroom setting for 3 min under egocentric or allocentric instructions. Based on the studies presented above, showing right hemisphere activation during egocentric judgments about object location, we hypothesized that an interaction would occur between writing prompt and object location, with participants in the egocentric condition describing more objects located in the left than right sides of the classroom, and with participants in the allocentric condition not differing in the number of objects described in the left and right sides of the classroom.

Method

Participants

Seventy-four undergraduates (52 women) of traditional college age were recruited through a psychology research participation pool at a large university in Los Angeles, CA. This sample size was based on a target of at least 36 per group (72 total) as shown by Smith and Trope (2006) to yield statistically significant results on line bisection after a brief writing task. All participants were undergraduates who volunteered for extra course credit. The participants were randomly assigned to receive the egocentric or allocentric instruction. All provided informed consent prior to their participation.

Design

The present study used a 2 x 2 mixed design with the writing prompt (egocentric vs. allocentric framing) as a between-subjects variable and the side of the classroom in which described objects were located as a within-subjects variable.

Materials

The objects that the participants described were located in an on-campus classroom. The classroom contained regular features including a projector screen and chalkboard in the center, long tables, a light switch, and a wall-mounted media panel. To increase the number of distinctive objects that participants could write about, we placed six objects in the front of the room prior to each session: lecture podium, a small green gift bag, a remote control, a small stool, a set of two textbooks, and a three-ring binder.

The six objects were clustered into two groupings of three, each placed on a table located at the left and right side of the front of the classroom. On one table, the podium rested with the gift bag on top of it and the remote control beside it. On the other table the stool was placed upside-down with two textbooks resting inside the legs and the three-ring binder leaning against the stool.

The writing task was administered on paper. The instructions intended to induce an egocentric versus allocentric frame of reference were printed at the top of an otherwise blank sheet of paper. The instructions for the egocentric condition were as follows:

> Describe all of the objects in the room in terms of how they are positioned in relation to you. For each object you see, describe what it appears to be. Describe where it is in relation to where you are. Use words like left/right, above/below, closer/farther, and estimate actual distances as best you can. Be as specific as possible, so that if someone reads this, they could sketch out the things in the room you describe. The most important thing is that you think of yourself as the focal point in the room, so be sure to refer to your own location in relation to each object even if it feels repetitive.

The instructions for the allocentric condition were:

> Describe all of the objects in the room in terms of how they are positioned in relation to each other. For each object you see, describe what it appears to be. Describe where it is in relation to the next thing you see. Use words like left/right, above/below, closer/farther, and estimate actual distances as best you can. Be as specific as possible, so that if someone reads this, they could sketch out the things in the room you describe. The most important thing is that you focus on the objects in

> the room and ignore the people, including yourself, and your own location. Pretend you are viewing the room on tape and are not in it at all.

Both prompts concluded with an additional sentence: "Once the researcher says 'Go' you have 3 min, and try to keep writing the entire time." This writing task was novel in studying the effects of frame of reference; however, similar writing tasks have been found to induce states associated with lateralized activation (Smith & Trope, 2006).

Measures

Allocentric and egocentric writing prompts. We first scored the writing samples for adherence to the prompt, as this was critical for the manipulation to be effective. The first two authors independently read each writing sample, blind to experimental condition by removing the prompt from the top. The procedure was to count how many references to objects were egocentric versus allocentric, and compute the percentage of references that adhered to the instruction based on usage of the words *I*, *me*, and *myself* (all egocentric mentions associated with the self). Participants who did not adhere to the writing prompt on at least 20% of their references to objects were excluded from the analyses. This selection criterion of 20% was used in order to maximize the effect of writing prompt on frame of reference as well as to maximize the amount of participants that could be kept in the study. As such, if participants were assigned to the egocentric frame of reference, but described more than 80% of the objects in relation to other objects (allocentric) or if participants were assigned to the allocentric frame of reference, but described more than 80% of the objects in relation to themselves (egocentric), they did not follow the directions and were excluded from the study. This resulted in 13 participants in the egocentric and no participants in the allocentric group being excluded, reducing the sample size to 24 in the egocentric group and maintaining 37 in the allocentric group. The selection criterion of 20% was lower than optimal but higher adherence rates dramatically lowered the sample size in the egocentric group.

Side. In reviewing the writing samples, references to the regular features of the classroom (e.g., eraser, projector screen, desks, chalkboard, walls) were often ambiguous. For example, if a participant mentioned a desk or chalkboard, it was impossible to know the side of the room to which they were referring. Therefore, the selected dependent variable was the number of the six, placed objects referred to in the writing sample that were located on the left versus right side of the room. The first two authors counted the object references independently and blind to the participant's experimental condition. Participants used different terms to refer to objects (e.g., the green gift bag was referred to as a present or bag) but the six target objects were distinct from the classroom objects, and very few discrepancies in scores occurred, all of which were easily resolved through discussion.

Each participant had a score from 0 to 3 for the number of objects coded as *right* or *left*, permitting a within subjects comparison. For example, if two objects were mentioned that were on the right side of the room, and one object was mentioned that was on the left side of the room, the scoring would be: *right* = 2, *left* = 1.

Procedure

Participants were tested in group sessions ranging from five to eight, depending on the number who signed up for a session. A maximum of eight participants was determined by space limitations, namely, up to eight seats could be staggered in the central lane of the classroom with clear views of the entire front. The six objects were positioned within the classroom. Consistency was assured by referring to a photograph taken of the target layout. The location of the object groupings was switched between sessions so that they appeared in the left and right sides of the classroom for an equal number of participants. The two groupings were used to eliminate the need to run enough sessions to counterbalance the position of each object, for example, pairing the gift bag with every combination of two objects on each side of the room.

Upon arrival, participants were asked to sit in one of the centrally located chairs and then were given, face down, the prompt for the writing task. The prompts for the writing task were shuffled by hand prior to the session and distributed with a cover sheet so that the researcher did not know which task was distributed to a given participant. Upon the researcher's instruction, participants turned over the sheet of paper and were asked to read the instructions for the writing task. Any questions were answered privately at the participant's desk. They were encouraged to keep writing the entire 3 min as timed by the researcher. The entire study through debriefing lasted less than 10 min.

Results

To test the hypothesis that an egocentric frame of reference would lead to right hemisphere activation, and therefore more references to objects located to the participants' left, a 2 x 2 mixed factorial Analysis of Variance (ANOVA) was conducted with the writing prompt (egocentric vs. allocentric condition) as a between-subjects variable and left- versus right-side object location as a within-subjects variable. The analysis indicated a main effect of side with more objects described on the left ($M = 1.11$, $SD = 1.23$) than on the right ($M = 0.70$, $SD = 0.96$), $F(1, 59) = 5.92$, $p = .018$, $\eta_p^2 = .09$ and an interaction of side and writing prompt, $F(1, 59) = 5.32$, $p = .025$, $\eta_p^2 = .08$ (see Figure 1).

Independent samples t tests were used to examine simple effects of the writing prompt within each side of the room. Left-side objects were more often described by the egocentric ($M = 1.54$, $SD = 1.29$) than the allocentric ($M = 0.84$, $SD = 1.12$) group, $t(59) = 2.26$, $p = .027$, $d = 0.58$. However, the number of right-side objects did not differ between the egocentric ($M = 0.54$, $SD = 0.78$) and allocentric ($M = 0.81$, $SD = 1.05$) group, $t(59) = -1.08$, $p = .286$). A paired sample t test indicated that in the egocentric group, more objects were described to the left, than to the right side of the room, $t(23) = 3.26$, $p = .003$, $d = 0.66$. In the allocentric group, the number of objects described on the left and right sides of the room did not differ, $t(36) = 0.10$, $p = .922$. The test for the main effect of the writing prompt was not statistically significant, $F(1, 59) = 1.35$, $p = .25$, indicating the prompts did not elicit a difference in the total number of objects described.

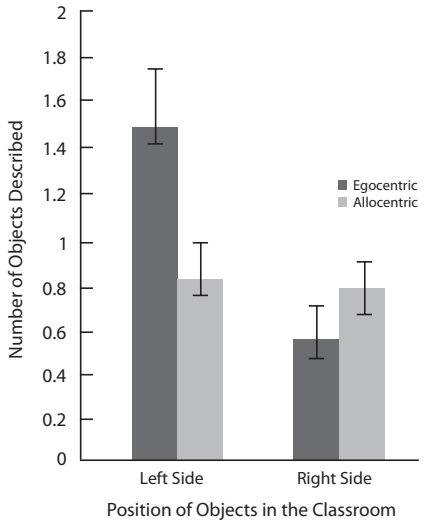
Discussion

The purpose of this study was to determine how egocentric and allocentric frames of reference would affect spatial attention in the everyday context of a university classroom. Our hypothesis was that under egocentric conditions the right hemisphere would be more activated relative to the left hemisphere, and thus, a left spatial bias would be observed in egocentric but not allocentric conditions. This study provides support for our hypothesis in that the egocentric group wrote about significantly more left-located objects, whereas, in the allocentric group, the difference in the means was not significant, indicating that left- and right-located objects were described equally often. Our finding that more left-located objects were described overall (combining the two writing prompts) is consistent with the large body of research showing a generally left spatial bias in people with normal brain function (Galati et al., 2000; Vallar et al., 1999). However, our finding that allocentric processing did not seem to significantly lateralize brain activation is consistent with some, but not all, research. Consistent with our results, previous fMRI studies show no significant activation of one hemisphere relative to the other in an allocentric frame of reference (Galati et al., 2000); however, in studies involving spatial memory, the right temporal lobe does show increased activity relative to the left hemisphere (Abrahams et al., 1997; Feigenbaum & Morris, 2004) suggesting that lateralization of the brain may occur to an extent during both egocentric and allocentric processing.

As the first known study to use an egocentric/allocentric writing task in an everyday context, we encountered a few limitations. First, we discovered that participants had trouble adhering to the egocentric writing prompt. Most in this group made a combination of egocentric and allocentric references, leading us to use fairly liberal selection criteria of at least 20% of object references being egocentric. Future studies using this type of writing prompt might benefit from placing greater emphasis in the instructions that each object should be described in relation to oneself. In addition, many references to objects were excluded from analyses

FIGURE 1

Mean Number of Objects Mentioned on Left and Right Sides of Room in Egocentric and Allocentric Conditions



due to the ambiguity of whether the reference was to a right- or left-sided object (e.g., wall, table). Our analysis involved only the six, conspicuous objects that we placed in the room. Because the side to which these objects were placed was counterbalanced, we do not expect that the particular objects influenced our findings between-groups, however, their oddity (e.g., upside down stool on a table) may detract from the everyday context of the classroom. We felt it was important to place an assortment of objects on tables to ensure visibility, but future studies could design a setting that features more naturalistic objects. In addition, although our sample size was not large, we had adequate power to test the hypothesis regarding writing prompt and side interaction. Lastly, the participants were fairly homogenous with regards to age (all were young adults), which may be a limitation to this study. Spatial attention may differ between older and younger individuals as the lateralization of spatial attention decreases with age, such that the elderly may not show right hemispheric dominance on spatial processing (Loibl, Beutling, Kaza, & Lotze, 2011). Therefore, in the elderly, it is possible that egocentric thinking would not increase leftward spatial attention, which remains a topic for future research.

Despite these limitations, the results of this study do have implications for spatial attention in various real-world contexts. This study is unique in that it focused on spatial attention within a learning environment, the everyday classroom. The results of this study indicate that students, when sitting in a classroom (an egocentric frame of reference), may focus more attention to material presented in their left visual field. Thus, future studies could explore if greater memory retention and/or enhanced learning occur when material is presented on the left side of the chalkboard, for instance, or left walls of the classroom. Understanding the correlation between spatial processing and learning could have a drastic effect on classroom dynamics and the methodologies and strategies employed by teachers to relate key information to their students. Presumably, individuals experience frequent variations in frame of reference, whether visually exploring the room they are in or moving through an environment. Our effect sizes indicated that 8% of the variance in object descriptions was accounted for by the interaction of side and writing prompt. This is a modest effect size (Kiess & Green, 2010) representing a step towards understanding the effect of frame of reference on spatial attention in a real-world context.

In addition, future studies could explore the state and situational factors that trigger shifts in frame of reference in everyday situations. Our findings suggest that if a person's awareness focuses on the position of that individual in relation to surrounding objects then greater spatial attention is directed toward the left. One situation where someone might judge distance from an object to the self is while maneuvering a car. In this situation, the person is most likely in an egocentric reference frame because he or she is looking at the objects in relation to his or her own position. It is possible then that, while thinking egocentrically, drivers would attend more to objects in their left visual field and pay less attention to those in their right. Such a finding would have implications for the placement of road signs to where they would be most noticeable by drivers. Finally, while viewing an advertisement, one may be in an egocentric reference frame as one thinks of how the advertisement, and therefore the product, could be useful for oneself. In this case it would be interesting to test whether or not a person attends more to the left side of the advertisement as the right hemisphere would be more activated.

In summary, egocentric thinking increased spatial attention toward the left in a classroom setting. This was the first study to demonstrate that cognitive priming of frame of reference can influence spatial attention in a real world setting. Future studies could make use of this brief, object-self relations writing task to manipulate frame of reference.

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