Title
Reading and writing direction causes spatial biases in mental model construction in language understanding

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 36(36)

ISSN
1069-7977

Authors
Roman, Antonio
Flumini, Andrea
Escobar, Marysol
et al.

Publication Date
2014

Peer reviewed

Reading and writing direction causes spatial biases in mental model construction in language understanding

Antonio Román (reche@ugr.es)
Dept. of Experimental Psychology, University of Granada, Spain

Andrea Flumini (andrea.flumini2@unibo.it)
Dept. of Psychology, University of Bologna, Italy

Marysol Escobar (marysol_puig13@hotmail.com)
Autonomous University of Baja California, Mexico

Julio Santiago (santiago@ugr.es)
Dept. of Experimental Psychology, University of Granada, Spain

Abstract

Is the direction of the script able to cause spatial biases in the mental models that understanders build when listening to language? In order to answer this question, we manipulated experimentally the experience of reading a script with different directionalities. Spanish monolinguals read either normal (left-to-right), mirror reversed (right-to-left), rotated downward (up-down), or rotated upward (down-up) text, and then drew the contents of auditory descriptions such as “the square is between the cross and the triangle”. The directionality of the drawings showed that a brief reading experience is enough to cause congruent and very specific spatial biases in mental model construction. However, there were limits to this flexibility: there was a strong overall preference to arrange the models along the horizontal dimension.

Keywords: Reading and writing direction; Spatial bias; Mental model; Cognitive flexibility; Working memory; Language comprehension.

Can arbitrary and irrelevant aspects of the code that conveys a message, such as its directionality, modulate the mental representation of the contents of the message? In this paper we show that they do.

It is now a standard assumption in the psychology of language comprehension that the final representation achieved by comprehenders is a mental model of the described situation (Johnson-Laird, 1983; Van Dijk, & Kintsch, 1983; Zwaan & Radvansky, 1998, for a review). Mental models are working memory representations about the world. They are analogical, spatial, and populated by concrete content, although they can also represent abstract content (Goodwin & Johnson-Laird, 2005; Santiago, Román, & Ouellet, 2011). Once set up, mental models can be “run” in working memory, allowing us to anticipate consequences, reason, solve problems, and plan actions. Language provides instructions that guide mental model construction in the comprehender (Johnson-Laird, 1983). From a description such as “the table is between the lamp and the TV,” the listener can construct a mental model that represents the spatial position of those three objects. However, the input leaves unspecified many aspects of the situation, which the comprehender must infer. For example, two different spatial arrangements of the three objects are consistent with the sentence above: the lamp may be located to the left of the table or to its right (the TV would be at the opposite side). Jahn, Knauff, and Johnson-Laird (2007) observed that the preferred initial model for such a description aligns the three mentioned objects horizontally in left-to-right (L–R) order. They suggested that this preference for L–R models was a bias induced by the habitual reading and writing direction (RWD) of their German participants. As Jahn et al (2007) showed, such biases are not inconsequential: the spatial arrangement of the objects in the model helps solving some kinds of problems and hinders others.

Román, El Fathi, and Santiago (2013) confirmed the suggestion by Jahn et al (2007) that such spatial biases correlate with habitual RWD. They tested Spanish and Moroccan participants on a task that consisted in drawing auditorily presented sentences describing static scenes such as "the table is between the lamp and the TV”. Spanish participants preferred to draw the lamp on the left and the TV on the right, whereas Moroccan participants (who read and write in Arabic, a R-L script) tended to draw the lamp on the right and the TV on the left. These results add to a wide, though dispersed, literature that shows that habitual RWD correlates with lateral biases in a variety of mental processes and representations, including low level perceptual and attentional skills (Andrews, Aisenberg, d'Avossa, & Sapir, 2013; Maass, Pagani, & Berta, 2007; Mishkin & Forgays, 1952; Pollatsek, Bolozky, Well, & Rayner, 1981; Smith & Elias, 2013; Spalek & Hammad, 2005), visual exploration (Chokron & Imbert, 1993; Kugelmass & Lieblich, 1970), motion preferences in drawing (Kebbe & Vinter, 2012; Nachshon, 1985; Shanon, 1979) and kissing (Shaki, 2012), item choice from a list (Ariel, Al-Harthy, Was, & Dunlosky, 2011), aesthetic preferences (Chokron & De

Agostini, 2000; Nachshon, Argaman, & Luria, 1999; Pérez González, 2011), and product attitudes in advertising (Chae & Hoegg, 2013). RWD also induces lateral biases in the mental representation of abstract concepts, such as number magnitude (the SNARC effect; Dehaene, Bossini, & Giraux, 1993; Zebian, 2005), time (Fuhrman & Boroditsky, 2010; Ouellet, Santiago, Israeli, & Gabay, 2010; Tversky, Kugelmass, & Winter, 1991), events (Dobel, Diesendruck, & Bölte, 2007; Maass & Russo, 2003), letter sequences (Shaki & Gevers, 2011), and social groups differing in agentivity (Maass, Suitner, Favaretto, & Cignacchi, 2009).

How flexible are lateral biases induced by RWD? Many studies in the literature show that preliterate children show either no lateral biases (Dobel et al, 2007), or L-R biases not linked to RWD (Kugelmass & Lieblich, 1970; Opfer, Thompson, & Furlong, 2010; Shaki, Fischer, & Göbel, 2012). As children learn to read, RWD-linked biases develop slowly and progressively (Fagard & Dahmen, 2003; Kebbe & Vinter, 2012; Kugelmass & Lieblich, 1970; Dobel et al, 2007; Shaki et al, 2012; Tversky et al, 1991). Teaching children to read another language with opposite directionality reduces those biases (Kugelmass & Lieblich, 1970; Nachshon, 1983), although they can be quite resistant to change when the new script is introduced at the adult age (de Sousa, 2012). This pattern of results suggests that RWD induces spatial habits with a limited degree of flexibility, which need important amounts of time and practice to develop and change. In contrast, other studies show that these biases are very flexible, and that the mere exposition to a script can make its associated lateral biases to appear instantly in bilinguals (Fischer, Shaki, & Cruise, 2009; Shaki & Gevers, 2011). Román et al (2013) also tested a group of Moroccan bilinguals in either Standard Arabic or their second L-R language (either French or Spanish). The input language had a clear effect on drawing direction, supporting a flexible deployment of spatial habits depending on the language in use. However, there was also a smaller influence of long-term habits linked to the participants' higher practice in reading Arabic (favouring R-L biases). Thus, both short-term and long-term influences can be observed in the manifestation of lateral spatial biases, and it is still unclear what factors are responsible for the preponderance of one or another kind in a given situation (see discussion in Román et al, 2013).

Unfortunately, most previous studies use basically correlational designs, comparing participants who read different scripts, which precludes random assignment of participants to groups. Therefore, extant studies do not allow us to establish a causal link between RWD and spatial biases, nor to isolate its time course during learning. The observed findings could be accounted for by a myriad other factors that covary with script direction. For example, many cultural graphic manifestations, such as comic strips, calendars, and charts, covary in directionality with the script, and could account for the observed biases. The most solid conclusions can be drawn from studies that compare bidirectional bilinguals using each of their languages, but this kind of participants might actually constitute a special case, and the potential effects of modulating factors such as degree of bilingualism or starting age are still far from clear.

More suited to reveal and explore causal effects are training studies. In them, monolingual participants are randomly assigned to use scripts of different directionality. This fully experimental design allows the inference of causal relations between directional experience and spatial biases in target tasks, while all other factors are kept constant. It also allows measuring the amount of training necessary for the development of the biases. To our knowledge, only two studies so far have followed this approach. Fischer, Mills, and Shaki (2010) showed that manipulating the associations of small and large numbers with the left and right sides of lines within a set of 20 cooking recipes (without changing script direction) was enough to change and even revert the SNARC effect. This study shows that some factors other than script direction may actually be able to induce spatial biases, and that their effects may develop quite fast. The only study which has directly manipulated script direction is Casasanto and Bottini (2013). Dutch participants were presented with phrases like "one day later" and judged whether they referred to the past or the future by pressing either a left or right key, or an up or down key. Text could be presented either in L-R direction, mirror reversed (R-L), or 90º rotated downwards (up-down, U-D) or upwards (down-up, D-U). After a short practice, mirror reading was able to reverse the standard association between left and past, and right and future, showing faster latencies for right-past and left-future responses than the opposite mapping. When both text and response keys were rotated onto the vertical axis, U-D text induced an up-past down-future congruency effect, and D-U text induced the reversed effect. Their results support a causal role for script direction on the directionality of the mental representation of time, and again suggest that these directional habits can be established after a very short practice.

One central aim of the present study was to extend Casasanto and Bottini's (2013) results to a task that taps onto the processes of mental model construction from linguistic input. This task is a variant of the drawing task used by Román et al (2013). Descriptions of static scenes composed by geometrical shapes such as "the square is between the cross and the triangle" were presented auditorily and participants drew the three objects on a sheet of paper. We assessed how the directionality of their drawings was influenced by the prior reading of a short Spanish text in either standard (L-R), mirror reversed (R-L), or 90º rotated print, either upwards (D-U) or downwards (U-D). The drawing task used geometrical shapes instead of real world objects so that the participants would not feel compelled to arrange them necessarily along the horizontal axis.

Experiment

Method

Participants Eighty Spanish psychology students at the University of Granada (mean age 21.9 years; 10 males; 5 left-handed). All of them were Spanish native speakers and did not know any language with a different RWD.

Materials For the reading task, we prepared a 1195 words fiction narrative in Spanish. Words were printed in 15 points Arial font. The text occupied four pages, each one containing five to six paragraphs of four to six lines each one.

For the drawing task we selected nine common geometrical shapes which could be drawn easily (square, rectangle, cross, rhombus, triangle, circle, trapezium, oval, pentagon). As a result of combining the names of those geometrical shapes, 441 sentences describing a between relation among three different shapes were constructed. For example, “The circle is between the cross and the rectangle” or “The oval is between the triangle and the rhombus.” All sentences referred to completely static scenes without any agentive structure.

From this set of 441 sentences, 40 sentences were randomly selected to be used in the task. They were randomly divided into two lists of 20 sentences each one. Each participant was presented with only one list. The sentences were read aloud by a female experimenter and recorded in independent sound files.

Procedure The participant sat in front of a computer screen at a desk with a pen and a stack of 20 empty square sheets. Stimulus presentation was controlled by Eprime 2.0. Participants were instructed that they should read aloud a 4-pages text presented on the screen at their own pace. Reading aloud secured that the text was read. Each group read the text with a different directionality (see fig. 1): L-R (standard), R-L (mirror reversed), U-D (rotated 90º clockwise), and D-U (rotated 90º counterclockwise).

Instructions warned them to pay attention to the text because at the end of the experiment there would be five questions about the content of the story. After finishing reading, they moved on to draw a set of auditorily presented sentences, each one on a different sheet. This task was presented as a filler task before the final comprehension questions. Care was exercised not to mention any particular spatial arrangement (e.g., horizontal). The program presented the sentences through loudspeakers. Participants controlled the rate of presentation by pressing a button to advance to the next one.

During the drawing task, the experimenter stood behind the participant and coded in situ and out of the participant's sight the order in which each of the three mentioned objects was drawn (object order) and the order in which participants completed the different spaces in the sheet: right, left, center, up, down or any other (spatial order). Finally, model order was coded a posteriori from the drawings themselves, depending on the locations where the two side objects were placed with respect to the central object (for more detail, see the Data Coding section in Roman et al, 2013.) As the analyses in Román et al (2013) showed, analyzing spatial order and object order independently did not qualify the results obtained in the measure of model order, so in the present study we analyzed only the latter.

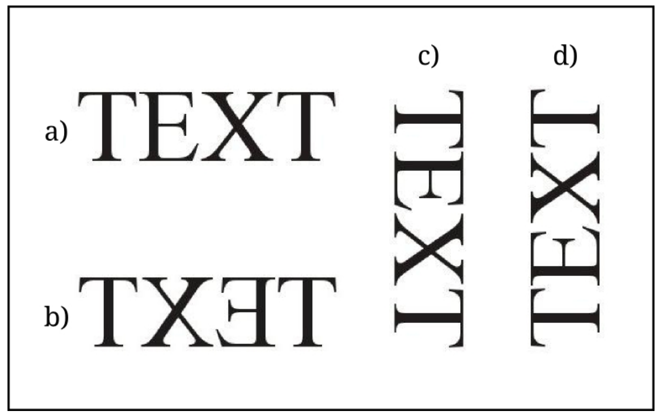

Figure 1: a) Standard L-R text; b) Mirror-reversed text;c) Up-down text; d) Down-up text.

Design and Data Analysis There were four groups of 20 participants, depending on the type of directional training: L-R (standard), R-L (mirror reversed), U-D (rotated 90º clockwise), and D-U (rotated 90º counterclockwise). In each condition, the number of drawings with a L-R, R-L, U-D, and D-U directionality was counted. Because the four conditions are not independent, it was not possible to use ANOVA. Therefore, we turned to 95% confidence intervals and t-tests in order to estimate whether the number of drawings of a given type was significantly different from zero and the other conditions.

Results

If the central object (e.g., the circle in the sentence “The circle is between the cross and the rectangle”) was drawn anywhere else than at the center, the trial was considered invalid and was not included in the final analysis. Trials where it was not possible to ascertain the axis along which the objects were drawn (i.e., diagonal arrangements) were also discarded. The number of items rejected was less than 1%. No participant had more than one item rejected. Left-handers were few (5) and unequally distributed between groups, so the effect of handedness could not be assessed. The results did not change in any relevant way if left-handers were removed from the data.

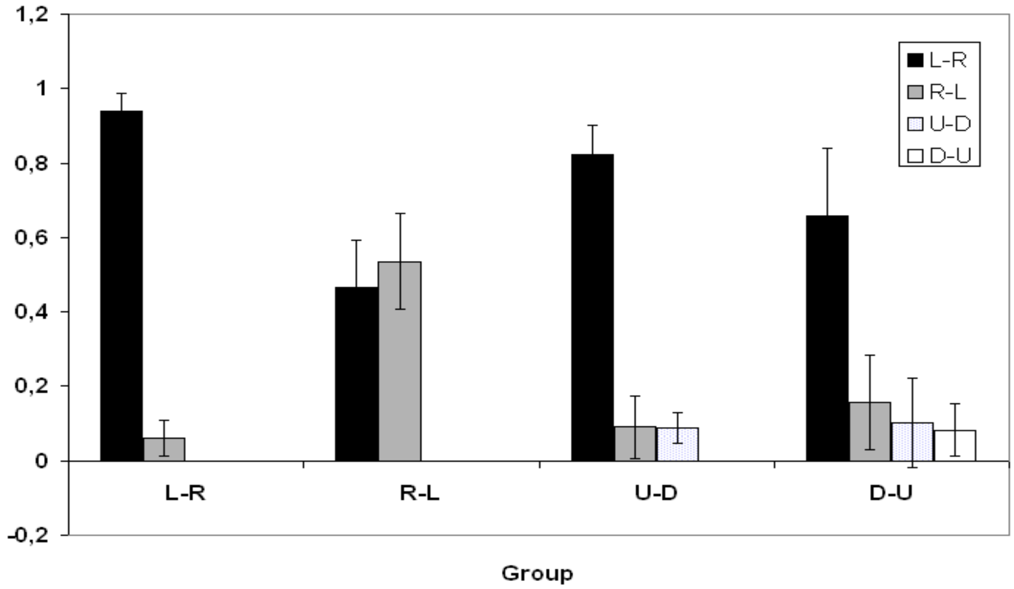

Figure 2: Proportion of drawn models of each directionality (L-R, R-L, U-D, and D-U) in each training group. Error bars show 95% confidence intervals.

The results revealed clear effects of prior practice with scripts of different directionality (see fig. 2). All conclusions that can be drawn from visual inspection of confidence intervals in fig. 2 were supported by t-tests.

In the group who read standard L-R Spanish, the great majority of drawings (93.9%) were arranged along the horizontal axis from left to right. The remaining drawings (6.1%) were horizontal from right to left. Although not frequent, their amount differed from zero (see fig. 2; $t(19)=2.68$, $p=0.01$). There were no vertically oriented drawings.

In the group who read mirror reversed R-L text, the pattern of results contrasted sharply with the L-R group: the percentage of R-L drawings increased to 53.5%, and L-R drawings decreased to 46.5%. Again, there were no drawings with vertical directionality. Contrasts between both groups in the proportions of L-R and R-L drawings were significant (L-R models: $t(38)=7.24$, $p< 0.0001$; R-L models: $t(38)=-7.24$, $p<0.0001$). Having a brief experience of reading in the opposite direction was able to change the direction of the contents of the mental model of auditorily presented sentences, almost halving a nearly absolute preference for L-R models.

The two groups with previous exposure to horizontal reading (L-R and R-L) revealed a very strong preference to locate the drawn models on the horizontal axis, as not a single vertical drawing was produced. Would previous experience with vertical script change this preference? As shown in fig. 2, the U-D group also showed a predominance of L-R models (82.2%), but it was weaker than in the L-R group ($t(38)=2.65$, $p=0.01$). Previous experience reading U-D text was able to increase U-D models from 0% to 9%, a numerically small but significant change as assessed by a t-test against zero (see fig. 2; $t(19)=4.55$, $p=0.0002$). No D-U models were produced in this group. The percentage of R-L models (9%) was not different from that in the L-R group ($t(38)=-0.63$, $p=0.53$) and it was also different from zero ($t(19)=2.27$, $p=0.04$). Therefore, reading U-D script decreased L-R models and increased U-D models, leaving the amount of R-L models unaffected.

Prior experience reading D-U text also reduced L-R drawings (65.7%) in comparison to the L-R group ($t(38)=3.15$, $p=0.003$), bringing it down to a level comparable to that in the group who read U-D text ($t(38)=1.75$, $p=0.09$). The amount of R-L models was again different from zero ($t(19)=2.59$, $p=0.02$) but similar to that in the L-R group ($t(38)=-1.48$, $p=0.15$). Reading D-U text did increase D-U models significantly above zero ($t(19)=2.49$, $p=0.02$). U-D models, in contrast, were not produced reliably more often than zero ($t(19)=1.80$, $p=0.09$). Therefore, reading D-U text also decreased L-R models and increased D-U models, without affecting R-L models.

Discussion

Summing up, a short prior training reading in different directions produced quite specific spatial biases on the mental models constructed from subsequent auditory descriptions. Reading standard L-R text produced a nearly absolute preference for horizontal L-R models. Reading mirror reversed R-L text increased considerably the amount of R-L models. Reading U-D and D-U text was able to significantly increase above zero the amount of U-D and D-U models, respectively, although the size of the increase was small. Given the absolute absence of vertical models in the two horizontal reading training conditions, this small increase is no doubt of theoretical importance. There also was a small but significant tendency to produce some R-L models in all non-mirror-reading groups, but this tendency remained impervious to prior directional practice. Finally, the overall pattern reveals a strong preference to construct models along the horizontal versus the vertical axis.

Can pre-established, life-long L-R tendencies be made even stronger by immediate practice? The current study did not have a no-practice control group, but present data can be compared to published data by Román et al. (2013). In an analogous scene description drawing task using real world objects such as table, chair and TV, but without a prior reading phase, they observed 70.7% of L-R models in the Spanish group. Interestingly, this is located between the 93.9% attested in the L-R group and the 46.5% observed in the R-L group in the present study. With respect to Román et al (2013) participants, L-R practice increased ($t(37)=3.40$, $p<0.05$) and R-L practice decreased ($t(37)=2.72$, $p<0.05$) the amount of L-R models.

Present findings therefore provide clear support for a causal influence of RWD on the spatial inferences that are made during mental model construction from auditory linguistic input. What is the specific causal factor remains to be isolated. RWD provides a systematic directional training which can also be obtained from experiences with comic strips, book pages, number lines, charts, and so on. The present study establishes that exposure to text is able by itself to change spatial biases, but does not discard other potential causes.

The present study also suggests that the amount of practice needed to substantially change previously established tendencies is very small: a few minutes of reading a text with a different directionality sufficed to affect a subsequent language comprehension task. This is in sharp contrast with many studies that document a slow and progressive development of spatial biases during the process of learning to read (e.g., Kugelmass & Lieblich, 1970; see review in the Introduction section) and motivates the need of further research on the factors that may explain this contrast. One interesting possibility is the duration of short-term biases. It is possible that a short directional experience has a clear effect on spatial biases, but that those biases are short-lived and vanish after a period of minutes. Perhaps in order to induce more permanent spatial biases a much greater amount of consistent practice is needed. Future studies using training designs such as the present one will be able to answer this question.

The present study also reveals a very strong overall preference to arrange mental models along the horizontal axis, even though the drawing task made use of geometrical figures such as a square, a triangle, and a circle, that could be just as well drawn along the vertical axis. This horizontal preference may have two different origins. On one side, it might be the result of long-term experience with a horizontal script. On the other side, it might originate from universal preferences of mental model construction. It is possible that people have a strong tendency to place the objects in mentally simulated scenes as if they were standing on the ground instead of piled up in a stack, even when the objects are geometrical figures which have no real world constraints. Future studies using readers of vertical scripts, such as Taiwanese Chinese, will provide a definitive answer to this question.

Acknowledgments

This research was supported by Grants P09-SEJ-4772, Junta de Andalucía and European Regional Development Fund (ERDF), and PSI2012-32464, Spanish Ministry of Economy and Competitivity, both to Julio Santiago (PI).

References

Andrews, B., Aisenberg, D., D'Avossa, G., & Sapir, A. (2013). Cross-cultural effects on the assumed light source direction: Evidence from English and Hebrew readers. *Journal of Vision, 13*(2), 1–7.

Ariel, R., Al-Harthy, I. S., Was, C. A, & Dunlosky, J. (2011). Habitual reading biases in the allocation of study time. *Psychonomic Bulletin & Review, 18*(5), 1015–21.

Casasanto, D., & Bottini, R. (2013). Mirror reading can reverse the flow of time. *Journal of Experimental Psychology: General.* doi:10.1037/a0033297

Chae, B. (Grace), & Hoegg, J. (2013). The future looks "right": Effects of the horizontal location of advertising images on product attitude. *Journal of Consumer Research, 40*(2), 223–238.

Chokron, S., & De Agostini, M. (2000). Reading habits influence aesthetic preference. *Cognitive Brain Research, 10*(1-2), 45-49.

Chokron, S., & Imbert, M. (1993). Influence of reading habits on line bisection. *Cognitive Brain Research, 1*(4), 219-22.

De Sousa, H. (2012). Generational differences in the orientation of time in Cantonese speakers as a function of changes in the direction of Chinese writing. *Frontiers in Psychology, 3*(255), 1–8.

Dehaene, S., Bossini, S., & Giraux, P. (1993). The mental representation of parity and number magnitude. *Journal of Experimental Psychology: General, 122*(3), 371-396.

Dobel, C., Diesendruck, G., & Bölte, J. (2007). How writing system and age influence spatial representations of actions: A developmental, cross-linguistic study. *Psychological Science, 18*(6), 487-491.

Fagard, J., & Dahmen, R. (2003). The effects of reading-writing direction on the asymmetry of space perception and directional tendencies: A comparison between French and Tunisian children. *Laterality, 8*(1), 39–52.

Fischer, M. H., Mills, R., & Shaki, S. (2010). How to cook a SNARC: Number placement in text rapidly changes spatial-numerical associations. *Brain and Cognition, 72*(3), 333–336.
Fischer, M. H., Shaki, S., & Cruise, A. (2009). It takes just one word to quash a SNARC. *Experimental psychology, 56*(5), 361–6.
Fuhrman, O., & Boroditsky, L. (2010). Cross-cultural differences in mental representations of time: Evidence from an implicit nonlinguistic task. *Cognitive Science, 34*(8), 1430-1451.
Goodwin, G. P., & Johnson-Laird, P. N. (2005). Reasoning about relations. *Psychological Review, 112*(2), 468-493.
Jahn, G., Knauff, M., & Johnson-Laird, P. N. (2007). Preferred mental models in reasoning about spatial relations. *Memory & cognition, 35*(8), 2075-87.
Johnson-Laird, Philip N. (1983). *Mental models*. Cambridge, MA: Cambridge University Press.
Kebbe, H., & Vinter, A. (2012). How culture, age, and manual dominance affect directionality in drawing side view objects. *Journal of Cross-Cultural Psychology, 44*(1), 160–172.
Kugelmass, S., & Lieblich, A. (1970). Perceptual exploration in Israeli children. *Child Development, 41*(4), 1125-1131.
Maass, A., & Russo, A. (2003). Directional bias in the mental representation of spatial events: Nature or culture? *Psychological Science, 14*(4), 296-301.
Maass, A., Pagani, D., & Berta, E. (2007). How beautiful is the goal and how violent is the fistfight? Spatial bias in the interpretation of human behavior. *Social Cognition, 25*(6), 833-852.
Maass, A., Suitner, C., Favaretto, X., & Cignacchi, M. (2009). Groups in space: Stereotypes and the spatial agency bias. *Journal of Experimental Social Psychology, 45*(3), 496-504.
Mishkin, M., & Forgays, D. G. (1952). Word recognition as a function of retinal locus. Journal of Experimental *Psychology, 43*(1), 43-48.
Nachshon, I. (1985). Directional preferences in perception of visual stimuli. *The International Journal of Neuroscience, 25*(3-4), 161-174.
Nachshon, I., Argaman, E., & Luria, A. (1999). Effects of directional habits and handedness on aesthetic preference for left and right profiles. *Journal of Cross-Cultural Psychology, 30*(1), 106-114.
Opfer, J. E., Thompson, C. a, & Furlong, E. E. (2010). Early development of spatial-numeric associations: Evidence from spatial and quantitative performance of preschoolers. *Developmental Science, 13*(5), 761–771.
Ouellet, M., Santiago, J., Israeli, Z., & Gabay, S. (2010). Is the future the right time? *Experimental psychology, 57*(4), 308-14.
Pérez González, C. (2011). Lateral organisation in nineteenth-century studio photographs is influenced by the direction of writing: A comparison of Iranian and Spanish photographs.*Laterality*. doi:10.1080/1357650X.2011.586701
Pollatsek, A., Bolozky, S., Well, A. D., & Rayner, K. (1981). Asymmetries in the perceptual span for Israeli readers. *Brain and Language, 14*(1), 174-180.
Román, A., El Fathi, A., & Santiago, J. (2013). Spatial biases in understanding descriptions of static scenes: the role of reading and writing direction. *Memory & Cognition, 41*, 588–599.
Santiago, J., Román, A., & Ouellet, M. (2011). Flexible foundations of abstract thought: A review and a theory. In A. Maass & T. W. Schubert (Eds.*), Spatial dimensions of social thought* (pp. 41-110). Berlin: Mouton de Gruyter.
Shaki, S. (2012). What's in a kiss? Spatial experience shapes directional bias during kissing. *Journal of Nonverbal Behavior, 37*(1), 43–50.
Shaki, S., & Gevers, W. (2011). Cultural characteristics dissociate magnitude and ordinal information processing. *Journal of Cross-Cultural Psychology, 42*(4), 639-650.
Shaki, S., Fischer, M. H., & Göbel, S. M. (2012). Direction counts: A comparative study of spatially directional counting biases in cultures with different reading directions. *Journal of Experimental Child Psychology, 112*(2), 275–81.
Shanon, B. (1979). Graphological patterns as a function of handedness and culture. *Neuropsychologia, 17*(5), 457-465.
Smith, A. K., & Elias, L. J. (2013). Native reading direction and corresponding preferences for left- or right-lit images. Perceptual & Motor Skills: *Learning & Memory, 116*(2), 1–13.
Spalek, T. M., & Hammad, S. (2005). The left-to-right bias in inhibition of return is due to the direction of reading. *Psychological Science, 16*(1), 15-18.
Tversky, B., Kugelmass, S., & Winter, A. (1991). Cross-cultural and developmental trends in graphic productions. *Cognitive Psychology, 23*, 515-557.
Van Dijk, T. A., & Kintsch, W. (1983). *Strategies in discourse comprehension.* New York: Academic Press.
Zebian, S. (2005). Linkages between number concepts, spatial thinking, and directionality of writing: The SNARC effect and the reverse SNARC effect in English and Arabic monoliterates, biliterates, and illiterate Arabic speakers. *Journal of Cognition and Culture, 1*(2), 165–190.
Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin, 123*(2), 162-185.