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Sex differences in the processing of flankers

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The study of sex differences in cognition has often focused on differences in spatial processing. Recently, sex differences in selective attention have been observed by Bayliss, di Pellegrino, and Tipper (2005), showing that women are more influenced than men by irrelevant spatial cues. The current study elaborates on this finding and tests whether sex differences in the processing of irrelevant information also occur in a simpler task, in which there is no need to redirect visual attention and no need to remember multiple spatial stimulus–response associations. Here, attention is studied using a novel combination of a go/no-go task and a flanker task. A total of 80 neurotypical participants were studied, and it was found that responses in women were more strongly affected by flanker information than were responses in men. This suggests that these sex differences were not due to difficulties with spatial reorientation, or remembering spatial stimulus–response relationships. The findings are discussed in the context of the hunter–gatherer theory of sex differences.

Keywords: Attention; Sex differences; Hunter–gatherer; Flanker task; Go/no-go task

It is well established that women and men differ in performance on a number of cognitive tasks (Halpern, 1992; Weiss, Kemmler, Deisenhammer, Fleischhacker, & Delazer, 2003), most strongly in mental rotation tasks (Collins & Kimura, 1997). The aim to understand these individual differences is driven by more than just academic curiosity. Studying sex differences is important for educational research (Halpern, 1997) and might ultimately help to explain why some mental disorders, such as autism (Baron-Cohen, 2002), attention deficit hyperactivity disorder (Biederman et al., 2002), and depression (Piccinelli & Wilkinson, 2000) are expressed so differently in the two sexes.

This article is about sex differences in selective attention and distraction in the neurotypical population. Distraction and selective attention are two sides of the same coin. Selective attention is the mechanism supporting the processing of a portion of relevant sensory input, whilst distraction is what happens if selective attention works suboptimally. Distraction occurs in varying degrees, varying from a normal degree of distraction (occurring in practically all people) to extreme levels of distraction making normal functioning difficult. Even though there are many studies on sex differences in dysfunctional attention in disorders such as autism (Baron-Cohen,

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2002) and attention deficit hyperactivity disorder (Biederman et al., 2002), there are only a few studies addressing this in the neurotypical population. It seems that there is still much to learn.

A recent study of sex differences in the processing of irrelevant information (Bayliss, di Pellegrino, & Tipper, 2005) used a sophisticated adaptation of the Posner cueing paradigm (Posner, 1980). Participants were instructed to respond to a letter placed left or right of an image of a face (looking to either the left or right) or an arrow (pointing either to the left or to the right). On half the trials, the direction of the eye gaze or the arrow was invalid in respect to the location of the letter that people had to respond to. Women were more distracted by the uninformative eye gaze or arrow than were men. In another recent study of selective attention and distraction, using an auditory–visual distraction paradigm, it was found that women are more distracted than men by irrelevant novel stimuli in a negative emotional context (Garcia-Garcia, Domínguez-Borràs, SanMiguel, & Escera, 2008).

One unresolved question about the study of Bayliss et al. (2005) is whether the prominence of spatial elements that have an orientation feature plays an essential role in the sex differences found. After all, the relevant stimuli in their study involved attentional redirection and processing arrow direction. It is frequently argued that women may be at a disadvantage in tasks that involve "spatial orientation, mechanical abilities and mathematics" (Weiss et al., 2003, p. 871), and it could thus easily be argued that this caused (at least part of) the sex differences observed in the Bayliss et al. (2005) study.[1] A specific aim of the current study was to find out whether women would still be more distracted when spatial features are minimized.

The experimental approach of the current study is a newly developed combination of a go/no-go task and a flanker task. Flanker tasks can measure levels of distraction (Eriksen & Eriksen, 1974). In flanker tasks, participants often need to make a choice between multiple response keys and might thus need to process the spatial location of response layout (e.g., left vs. right key). To minimize the use of spatial features in the response alternatives, the current experiment uses just one response button.

Further, the paradigm differentiates between flankers that are response compatible, response incompatible, or response neutral. The different types of flankers can help to disassociate the types of distraction that might occur.

It was expected that flankers influence all participants irrespective of sex, but that this influence is stronger in women than in men, even when the role of spatial reorientation and remembering spatial stimulus–response relationships is minimized. This was confirmed in the experiment reported below, suggesting that problems with spatial processing are unlikely to be the (only) underlying cause of sex differences in selective attention.

Method

Participants

A total of 80 neurotypical young adults (18–23 years, all university students, equal numbers of both sexes) participated in this study and were rewarded with a snack bar. All participants had normal or corrected-to-normal vision.

Apparatus

Stimuli were presented on a 17-inch CRT colour monitor. The space bar of a regular PC keyboard functioned as response button. The experiment was controlled by custom software on standard PC hardware.

A 3×3 grid (10×10 cm) of white lines (1 mm in width) was presented at the centre of a black screen. Go and no-go stimuli were green and red circles (15 mm in diameter), respectively, presented in the centre square of the grid. Flankers were green, red, and blue circles.

[1]Nonetheless, it is certainly not the case that women are at a disadvantage in all tasks involving spatial features. In fact, women are known to outperform men in certain tasks requiring memory for object location (Eals & Silverman, 1994; Postma, Izendoorn, & De Haan, 1998) and in an embedded figure task (Weiss et al., 2003).

Procedure and design

Participants received verbal and written instructions to perform trials organized as follows. The grid was visible for the duration of the experiment (Figure 1). On each trial, a flanker (red, green, or blue) appeared in one of the eight squares surrounding the centre square (colour and position were randomly chosen on each trial). After 200 ms, a red or green circle was presented in the central grid position (while the flanker stayed on the screen). People were instructed to respond to this latter central stimulus if it was green (go trials) and to withhold a response if it was red (no-go trials). The circles would disappear after the response was given (or if no response was given within 500 ms since the onset of the central stimulus). The maximum response time (RT) was 500 ms. Lack of a response in a go trial as well as a response in a no-go trial was immediately followed by an error message ("too slow" or "error", respectively). Error messages were presented for 2 seconds. Each intertrial interval lasted 500 ms.

The experiment started with at least 10 training trials. The training would continue until a participant was able to perform 10 correct trials in a row. Once training was finished, participants performed 240 trials in two blocks. Between the two blocks was an opportunity for a short rest.

The study used a mixed design with one between-subject factor (sex: female and male) and two within-subject factors. The within-subject factors were response mode (with the levels go and no-go), and flanker type (with the levels compatible, incompatible, and neutral). Compatibility of flankers is here defined as a correspondence between the required response and the response associated with the flanker. Thus, a green flanker in a go trial was compatible, but incompatible in a no-go trial. A red flanker in a go trial was incompatible, but compatible in a no-go trial. Blue flankers were always neutral, because blue was never associated with any response.

Data analysis

Of the training data, only the number of trials it would take a participant to be able to perform 10 consecutive trials correctly was considered for data analysis. For the rest of the data, the median RT (of correct go trials) and error rates (of go and no-go trials) of each participant in each within-participant condition were calculated for further analysis in a mixed-design repeated measures analysis of variance (ANOVA).

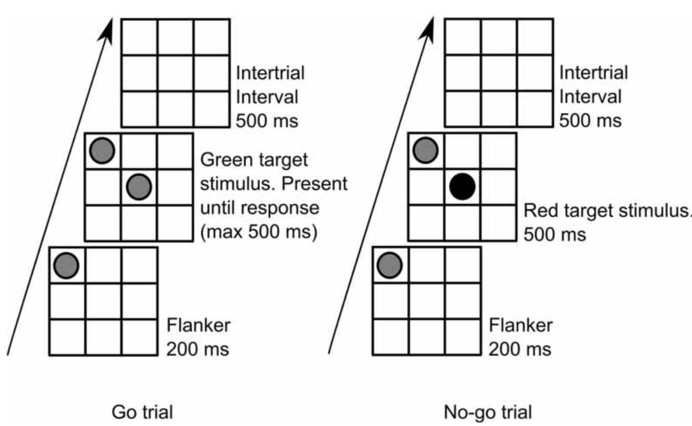

Figure 1. *Examples of the main events in go trials (left) and no-go trials (right). A 3 × 3 grid (10 cm × 10 cm) with white lines (1 mm in width) was presented on a black screen for the duration of the experiment. On each trial, a red, green, or blue circle was presented in one of the eight squares surrounding the central grid square. A period of 200 ms after the onset of the flanker stimulus, a red or green circle was presented in the central grid position. People needed to respond to this latter central stimulus if it was green (go trial), but to withhold a response if it was red (no-go trial). Once the participants responded (maximum allowed response time was 500 ms), both circles would disappear, and 500 ms later the next trial would start.*

Results

First of all, the number of training trials performed was analysed. All participants performed at least 10 training trials, but people performed on average 3.9 ± 0.9 (group mean ± 1 standard error of the mean, *SEM*) trials more (because the experimental control computer would not stop the training until people could perform 10 trials without making an error). Group comparison showed that women performed significantly more additional training trials (5.8 ± 1.6) than men (2.0 ± 0.7), $t(78) = 2.2$, $p = .03$. For the remaining analyses reported below, training trials were discarded.

RT data (correct responses in go-trials only, Figure 2) were analysed using a mixed-design ANOVA with one between-subject factor (sex, with the levels female and male) and one within-subject factor (flanker type, with the levels compatible, incompatible, and neutral). A significant main effect of the factor flanker type, $F(2, 156) = 72.9$, $MSE = 9{,}070.9$, $p < .01$, as well as a significant interaction between flanker type and sex, $F(2, 156) = 4.4$, $MSE = 543.7$, $p = .01$, were found.

Further RT analyses were carried out to identify where exactly the interaction between flanker type and sex comes from in terms of the cost/benefit analysis of attention. The 2×2 ANOVA of the factors sex and flanker type (incompatible vs. neutral) revealed a significant interaction, $F(1, 78) = 5.1$, $MSE = 358.5$, $p = .03$. The 2×2 ANOVA of the factors sex and flanker type (compatible vs. neutral) did not show a significant interaction. Altogether, these separate ANOVAs indicate that incompatible flankers caused more distraction in women than in men.

Error percentages (Figure 3) were also analysed with a mixed-design ANOVA. An important difference between this error analysis and the RT analysis is that no-go trial data can be analysed as well. For easiest comparison with the RT data, the go trials and the no-go trials were analysed separately.

The ANOVA of error rates in the go trials (Figure 3, left) revealed that women made significantly more errors (5.4 ± 0.8) than men (2.6 ± 0.5), $F(1, 78) = 9.1$, $MSE = 467.5$, $p < .01$. There was a main effect of flanker type, $F(2, 156) = 23.0$, $MSE = 312.8$, $p < .01$, but no interaction between flanker type and sex, $F(2, 156) = 3.9$, $MSE = 29.2$, $p = .12$. ANOVA of the error rates in no-go trials (Figure 3, right) showed again that women made more errors (4.1 ± 0.5) than men (2.5 ± 0.3), $F(1, 78) = 7.0$, $MSE = 160.3$, $p < .01$. There was a main effect of flanker type, $F(2, 156) = 71.2$, $MSE = 900.0$, $p < .01$, and a significant interaction between flanker type and sex, $F(1, 78) = 6.0$, $MSE = 76.4$, $p < .01$.

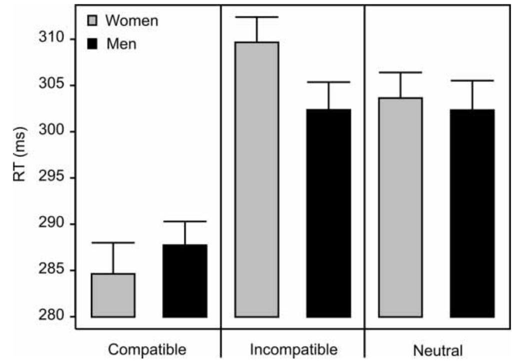

Figure 2. *Average response times (RT) for women (*n = 40*, grey) and men (*n = 40*, black) in the three flanker conditions (compatible, incompatible, and neutral). Error bars indicate one standard error of the mean (*SEM*).*

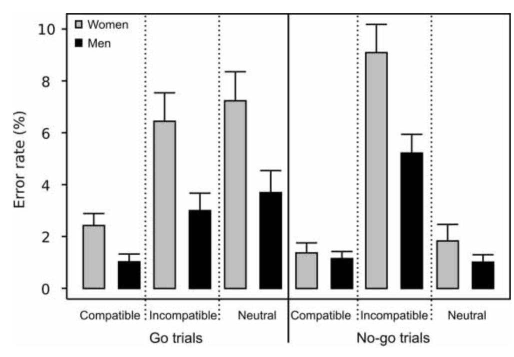

Figure 3. *Average error rates for women (*n = 40*, grey) and men (*n = 40*, black) as a function of response mode (go, no-go) and flanker type (compatible, incompatible, and neutral). Error bars represent 1* SEM*. In the go trials, least errors were made in the compatible flanker condition. In the no-go trials, most errors were made in the incompatible flanker condition. This effect was strongest in women.*

Analogous to the RT analyses, further analyses of error rates in the no-go trials were carried out to identify where exactly the interaction between sex and flanker type comes from. The 2×2 ANOVA of the factors sex and flanker type (incompatible vs. neutral) showed a significant interaction, $F(1, 78) = 5.5$, $MSE = 92.9$, $p = .02$. Finally, the 2×2 ANOVA of the factors sex and flanker type (compatible vs. neutral) did not reveal a significant interaction. As in the analysis of the RT data, these separate ANOVAs indicate that incompatible flankers caused more distraction in the female group than in the male group.

Discussion

The aim of this study was to explore sex differences in distraction and selective attention. A novel task with minimal requirements for spatial operations was used. It was expected that all participants would be affected by irrelevant stimulus information, but that this effect would be more pronounced in women. The findings confirmed these expectations: Across participants, incompatible flankers impaired performance, and this impairment was more pronounced in women than in men. Further, women needed more training to reach criterion level in the task, and the female group made more errors across conditions.

In the remainder of the discussion, these findings are put in the context of other research of cognitive sex differences. There is much research on sex differences, but the ultimate causes of these differences are still difficult to determine. Differences between the sexes can be the result of socialization, the result of inborn differences, or a combination of the two. Support for a socialization explanation of sex differences comes from a narrowing of previously observed sex differences (Feingold, 1988) and the lack of a consistent pattern in some cross-cultural samples (Feingold, 1994; Spelke, 2005). Support for a biological explanation of sex differences comes from observed sex differences in infants (Alexander, Wilcox, & Woods, 2009), consistent patterns in some cross-cultural samples (Geary & DeSoto, 2001), and findings related to purely biological variables, such as variation in sex hormones (Kimura, 1996). Arguments for both versions have been discussed elsewhere (Baron-Cohen, 2002; Spelke, 2005). Even though the two positions seem to be contradictory, there are models that help us to explain how small inborn sex differences at birth can lead to larger differences at a later age through socialization (Geary, 1989).

In order to understand the ultimate causes of sex differences, such as the ones observed in this study, there is a need for a precise description of sex differences in behaviour in the first place. The current study was designed to corroborate and describe such behavioural differences in a task measuring distraction. Now that these sex differences have been described, and now that these sex differences found here show an interesting similarity to the findings of Bayliss et al. (2005), we can propose an underlying mechanism that would explain these findings, hopefully to be tested by future studies.

The hunter–gatherer theory of sex differences (Eals & Silverman, 1994) offers an explanation of the findings of this study. This theory states that sex differences are the result of an evolutionary adaptation process, in which women and men have acquired skills most useful to their respective gender roles in hunter–gatherer societies. According to this theory, women excel in gathering tasks, and men in hunting tasks. Arguably, in order to excel in gathering, and thus not to miss any potential target, one should be "open" to all response alternatives. In contrast, in order to excel in hunting, one needs to restrict oneself to focusing on a small area and ignore similar but irrelevant targets; for example, in order to catch a prey animal, it is better to focus on one sensitive spot of one prey animal, rather than focusing on the whole herd. Accordingly, in the flanker go/no-go paradigm, men might be better at ignoring flankers because flankers are not in the target area of the grid.

An exciting extension of the current study and a further opportunity to test the hunter–gatherer model of sex differences would be to explore whether women indeed excel in tasks in which participants' gathering skills are tested. Indeed, one should expect that women are at an advantage in a task in which responses need to be made to stimuli that can appear at any location in the visual field and stimuli that have only been defined broadly (e.g., anything eatable), rather than specifically defined stimuli (e.g., one specific visible stimulus).

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REFERENCES

Alexander, G. M., Wilcox, T., & Woods, R. (2009). Sex differences in infants' visual interest in toys. *Archives of Sexual Behavior*, *38,* 427–433.

Baron-Cohen, S. (2002). The extreme male brain theory of autism. *Trends in Cognitive Sciences*, *6*(6), 248–254.

Bayliss, A. P., di Pellegrino, G., & Tipper, S. P. (2005). Sex differences in eye gaze and symbolic cueing of attention. *The Quarterly Journal of Experimental Psychology A*, *58*(4), 631–650.

Biederman, J., Mick, E., Faraone, S. V., Braaten, E., Doyle, A., Spencer, T., et al. (2002). Influence of gender on attention deficit hyperactivity disorder in children referred to a psychiatric clinic. *American Journal of Psychiatry*, *159,* 36–42.

Collins, D. W., & Kimura, D. (1997). A large sex difference on a two-dimensional mental rotation task. *Behavioral Neuroscience*, *111*(4), 845–849.

Eals, M., & Silverman, I. (1994). The hunter-gatherer theory of spatial sex differences: Proximate factors mediating the female advantage in recall of object arrays. *Ethology and Sociobiology*, *15*(2), 95–105.

Eriksen, B. A., & Eriksen, C. W. (1974). Effects of noise letters upon the identification of a target letter in a nonsearch task. *Perception and Psychophysics*, *16*(1), 143–149.

Feingold, A. (1988). Cognitive gender differences are disappearing. *American Psychologist*, *43*(2), 95–103.

Feingold, A. (1994). Sex differences in variability in intellectual abilities: A cross-cultural perspective. *Sex Roles*, *30,* 81–92.

Garcia-Garcia, M., Domínguez-Borràs, J., SanMiguel, I., & Escera, C. (2008). Electrophysiological and behavioral evidence of gender differences in the modulation of distraction by the emotional context. *Biological Psychology*, *79*(3), 307–316.

Geary, D. C. (1989). A model for representing gender differences in the pattern of cognitive abilities. *American Psychologist*, *44,* 1155–1156.

Geary, D. C., & DeSoto, M. C. (2001). Sex differences in spatial abilities among adults from the United States and China: Implications for evolutionary theory. *Evolution and Cognition*, *7,* 172–177.

Halpern, D. F. (1992). *Sex differences in cognitive abilities*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Halpern, D. F. (1997). Sex differences in intelligence: Implications for education. *American Psychologist*, *52*(10), 1091–1102.

Kimura, D. (1996). Sex, sexual orientation and sex hormones influence human cognitive function. *Current Opinion in Neurobiology*, *6*(2), 259–263.

Piccinelli, M., & Wilkinson, G. (2000). Gender differences in depression. *British Journal of Psychiatry*, *177,* 486–492.

Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, *32,* 3–25.

Postma, A., Izendoorn, R., & De Haan, E. H. F. (1998). Sex differences in object location memory. *Brain and Cognition*, *36,* 334–345.

Spelke, E. S. (2005). Sex differences in intrinsic aptitude for mathematics and science. *American Psychologist*, *60*(9), 950–958.

Weiss, E. M., Kemmler, G., Deisenhammer, E. A., Fleischhacker, W. W., & Delazer, M. (2003). Sex differences in cognitive functions. *Personality and Individual Differences*, *35,* 863–875.