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Inhibitory processing in visuospatial attention in healthy adults and schizophrenic patients

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Abstract

This study assessed visuospatial attention in healthy adults and medicated schizophrenic patients. Participants performed a visual orientation task in which a peripheral cue was followed, at different intervals, by a target presented either at valid or invalid locations. When the long stimulus onset asynchrony (SOA) was used, participants were presented with either a single peripheral cue (single-cue condition) or two cues, the peripheral cue followed by a central cue (the double-cue condition). Healthy adults showed marginal facilitation effects with the short SOA and similar inhibition of return effects with the long SOA in both single-cue and double-cue conditions. Schizophrenic individuals showed a big facilitation effect with the short SOA and normal inhibition of return with the long SOA in both cue conditions. Results with the short SOA replicated previous findings (Huey, E.D., Wexler, B.E., 1994. Schizophrenia Research 14, 57–63) but, in contrast, we did not observe blunted inhibition of return with the long SOA. An inspection of the differences in the procedures used in both studies may help both to account for the discrepancies and to reveal what processes involved in visuospatial attention are affected in schizophrenia.

Keywords: Inhibitory processing; Schizophrenia; Visuospatial attention

1. Introduction

Attentional abnormalities associated with schizophrenia have been reported in a great variety of studies [for a review, see Frith (1992)]. Most attentional deficits in schizophrenia have been associated with executive functions (DiGirolamo and Posner, 1996; Posner and DiGirolamo, 1998) and concretely with inhibitory processing impairments (Beech et al, 1989; Salo et al., 1996; Fuentes and Santiago, 1999). However, few studies have addressed both facilitatory and inhibitory processing in visuospatial orientation in these patients. One of these studies was reported by Huey and Wexler (1994). They tested facilitatory and inhibitory functioning of spatial attention by using an inhibition of return (IOR) paradigm (Posner and Cohen, 1984). In their experiment, a group of medicated schizophrenic individuals and a group of healthy controls were presented with a spatial cuing task (Posner, 1980) in which: (1) the cue was not predictive regarding the target location; (2) the cue-target stimulus onset asynchrony

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(SOA) values were 100, 200, 700 or 1200 ms. Healthy adults showed facilitation (benefits) at the 100 ms SOA and inhibition (IOR) at the 1200 ms SOA. No significant effects were found at 200 and 700 ms SOAs. Schizophrenic individuals, in contrast, showed benefits at 100 and 200 ms SOAs, but IOR with the longer SOAs was not significant. These results suggest that schizophrenic patients show an unbalance between facilitatory and inhibitory processing in visuospatial attention.

Nonetheless, in recent studies we have observed preserved IOR effects in schizophrenic individuals when simple detection (Fuentes and Santiago, 1999) or color naming (Fuentes et al., 1999c) responses were required. These results led to Fuentes and Santiago (1999) to argue that the differences in procedure inter-experiments may have been crucial to observe IOR in schizophrenic individuals. Huey and Wexler (1994) used a single-cue procedure. The cue (a larger box) was presented in one of the peripheral boxes and remained on until the target was presented. Healthy adults usually show benefits with short SOAs and IOR with long SOAs, in such conditions (Posner and Cohen, 1984). It is assumed that after a rather long interval from the onset of the non-predictive cue, the participant shifts his(her) attention to the central position before the target is presented. However, some authors have shown that certain neurological patients, like adults with Alzheimer's disease, failed to show IOR with a single-cue procedure but they showed normal IOR with a double-cue procedure (e.g. Faust and Balota, 1997). In the double-cue procedure, the peripheral cue is followed by a central cue before the target is presented. The central cue may help participants to reorient their attention back to the center (e.g. Posner and Cohen, 1984; Abrams and Dobkin, 1994; Faust and Balota, 1997; Fuentes et al., 1999a,b). Fuentes and co-workers (Fuentes and Santiago, 1999; Fuentes et al., 1999c) found preserved IOR in medicated schizophrenic individuals using the double-cue procedure.

In the present study, we sought to investigate how the cuing procedure (single-cue versus double-cue) affects the balance between facilitatory (benefits) and inhibitory (IOR) processing in a visuospatial task, in healthy adults and in medicated patients diagnosed with schizophrenia.

2. Methods

2.1. Participants

14 healthy adults and 14 medicated patients diagnosed with schizophrenia participated in this experiment. Healthy adults were recruited from the staff of the Hôpital Civil de Strasbourg. They ranged in age from 23 to 42 years, with a median of 26.5 years. Schizophrenic participants were medicated outpatients ranging in age from 20 to 55 years, with a median of 34 years. The schizophrenic individuals signed a consent form and were paid for their participation. Overall, the schizophrenic group had less years of education than the healthy adult group. All the participants had normal or corrected-to-normal vision and were naive about the purpose of the experiment.

2.2. Stimuli and apparatus

Three boxes arranged horizontally were used as stimuli for cuing purposes. The boxes subtended viewing angles of 5.4° by 1.3° when seen from the viewing distance of 60 cm. The inner sides of the two peripheral boxes were each located at 4.9° from fixation. All the stimuli were presented on the color monitor (VGA card) of an IBM/ PC compatible computer, and participants' responses were recorded through the computer keyboard.

2.3. Procedure

Fig. 1 shows the stimuli and exposition duration used in the experiment. Participants sat approximately 60 cm from the computer and the experimenter explained to them the task verbally. Each trial began with a fixation point (a plus sign) presented in the middle of the screen until the participant initiated the trial. Three white boxes then replaced the fixation point and were presented for 1000 ms. Next, one of the peripheral boxes became thicker for 200 ms. This served as a cue to attract attention to the periphery. From this point

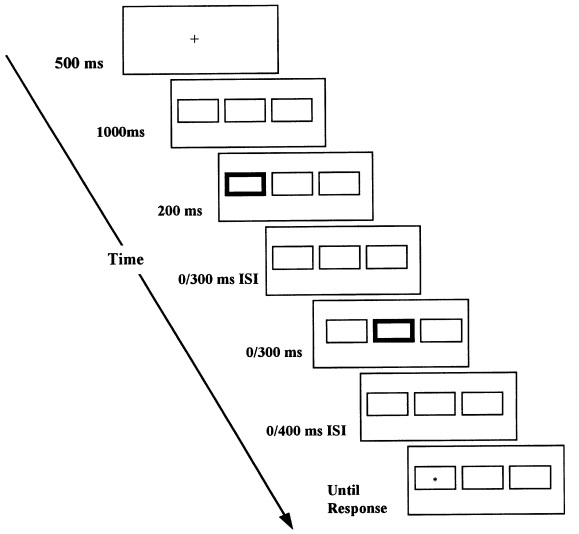

Fig. 1. Sequence of events and exposure durations of stimuli in the experiment. For the 200 ms SOA, the three boxes appearing between the peripheral cue and the target were not presented (0 ms of exposition duration). For the long SOA, the central box became thicker only in the double-cue condition.

the sequence of events changed for each cuing condition. For the single-cue condition, the boxes were then presented containing the target (an asterisk) after 0 or 1000 ms from the offset of the peripheral cue (producing a 200 ms or a 1200 ms cue-target SOA respectively). The target could be presented inside the box that served as the peripheral cue (the cued location) or inside the opposite peripheral box (the uncued location). For the double-cued condition, only the long SOA value (1200 ms) was used. After the peripheral cue was off the boxes were presented for 300 ms followed by a thicker central box (the second cue) for 300 ms. The boxes were then all presented for 400 ms. The target was subsequently presented an equal number of times either at the cued or uncued location. In all conditions the target remained on until the participant responded. Participants were informed about the sequence of events in each trial. They were told to pay attention to the changes taking place on the monitor screen but just to push the space bar on the keyboard as soon as they detected the target. Participants ran one practice block of 32 trials and two experimental blocks of 96 trials.

3. Results

The data are presented in Table 1. Two analyses were performed on means of median reaction times (RTs) from healthy adults and schizophrenic individuals. In the first analysis we assessed the effect of SOA in the single-cue condition. This allowed us to compare facilitatory and inhibitory effects in the visual orientation task in healthy adults and schizophrenic patients. The second analysis assessed the effects of the second cue (the double-cue condition) in the IOR effect.

3.1. Facilitation and inhibition effects as a function of SOA

RTs data were submitted to a $2\times2\times2\times2$ mixed analysis of variance (ANOVA) with group (healthy adults versus schizophrenic individuals) as the between-subjects factor and SOA (short versus long), location (cued versus uncued) and target visual field [left visual field (LVF) versus right visual field (RVF)], as the within-subjects factors. The main effects of group, SOA and visual field were significant: $F(1, 26)=19.7$, $p<0.001$; $F(1, 26)=41.6$, $p<0.001$; and $F(1, 26)=34.7$, $p<0.001$ respectively. The schizophrenic group produced longer RTs than the healthy adult group (541 ms versus 383 ms); the short SOA produced longer RTs than the long SOA (493 ms versus 432 ms); and targets in the LVF were detected faster than in the RVF (443 ms versus 482 ms). The following interactions were also significant: group × SOA, group × visual field, and group × SOA × location: $F(1, 26)=4.2$, $p=0.05$; $F(1, 26)=5.96$, $p<0.05$; and $F(1, 26)=4.0$, $p=0.05$ respectively.

The three-way group × SOA × location interaction indicated that, at the short SOA, patients showed faster RTs in the cued than in the uncued location (558 ms versus 605 ms), $F(1, 13)=12.3$, $p<0.01$; i.e. schizophrenic individuals showed facilitation in detecting targets due to shifts of attention to the peripheral cue. Healthy adults, however, showed only a marginal significant difference (398 ms versus 411 ms), $F(1,13)=3.95$, $p<0.07$. Most important, the difference in the facilitation effect between the two groups of parti-

Table 1
Means of median reaction times and standard deviations (in parentheses) as a function of SOA, location, and visual field for healthy adults and schizophrenic individuals

SOA and group	LVF		RVF	
	Cued	Uncued	Cued	Uncued
200 ms SOA				
Healthy adults	389 (46)	397 (60)	407 (64)	425 (74)
Schizophrenic patients	528 (116)	577 (133)	589 (170)	634 (173)
1200 ms SOA (single cue)				
Healthy adults	363 (45)	339 (59)	390 (58)	357 (72)
Schizophrenic patients	490 (110)	460 (108)	544 (107)	509 (125)
1200 ms SOA (double cue)				
Healthy adults	372 (47)	328 (46)	393 (86)	328 (42)
Schizophrenic patients	487 (101)	465 (129)	537 (136)	491 (122)

cipants was significant, as stated by the group × location interaction at that SOA value, $F(1, 26) = 5.23$, $p < 0.05$.

At the long SOA, both groups of participants showed IOR. RTs were longer in the cued than in the uncued location (33 ms for schizophrenic individuals versus 29 ms for healthy adults: $F(1, 13) = 6.8$, $p < 0.05$, and $F(1, 13) = 27.4$, $p < 0.001$ respectively). However, contrary to the facilitation effect with the short SOA, the magnitude of IOR did not vary between the two groups, as stated by the non-significant group × location interaction at that SOA value, $F < 1$.

The group × visual field interaction indicated that the advantage of the LVF in detecting targets was more pronounced in the schizophrenic group (55 ms) than in the healthy adult group (23 ms).

3.2. Inhibition of return as a function of cuing condition

In these analyses, RTs data from both the single-cue and double-cue conditions were submitted to a $2 \times 2 \times 2 \times 2$ mixed analysis of variance (ANOVA), with group (schizophrenic individuals versus healthy adults) as the between-subject factor and location (cued versus uncued), cuing (single versus double), and visual field (LVF versus RVF) as the within-subjects factors. The main effects of group, location, and visual field were significant: $F(1, 26) = 18.4$, $p < 0.001$; $F(1, 26) = 44.6$, $p < 0.001$; and $F(1, 26) = 20.9$, $p < 0.001$ respectively. Schizophrenic individuals were slower than healthy adults (498 ms versus 359 ms). Responses were slower in the cued than in the uncued location (447 ms versus 410 ms), i.e. we observed IOR effects. Also, left targets were detected faster than right targets (413 ms versus 444 ms) although the difference was more pronounced in the schizophrenic group (44 ms) than in healthy adult group (16 ms), as indicated by the significant group × visual field interaction, $F(1, 26) = 4.5$, $p < 0.05$. The fact that we did not observe any group × location × cuing interaction demonstrates that both groups of participants showed comparable IOR effects in both cuing conditions (schizophrenic group: 33 ms for the single-cue condition versus 34 ms for the double-cue condition; healthy adult group: 29 ms for the single-cue condition versus 55 ms for the double-cue condition).

4. Discussion

Results from healthy adults replicated those found by Huey and Wexler (1994), despite the difference in the procedure used in both studies. Note that the previous study used four peripheral boxes instead of the two peripheral boxes used in the present study. This means that the number of cues is not a relevant factor to account for the present IOR effects.

IOR was observed with the long SOA, but only a marginal facilitation (benefits) effect was found

with the short SOA. This suggests that the facilitatory effect begins to disappear at that short interval (200 ms), maybe coinciding with the development of the inhibitory processes that lead to IOR (Posner and Cohen, 1984). As expected, healthy adults also showed similar IOR effects irrespective of the cuing procedure. This confirms that healthy adults reoriented their attention to the center of the screen without the help of a central cue.

Contrary to healthy adults, schizophrenic individuals showed a clear facilitation effect with the short SOA. Huey and Wexler (1994) also found facilitation effects with 200 ms SOA in the schizophrenic group. They claimed that the failure of their patients to show normal IOR effects with longer SOAs could be due to their difficulty to overcome the large initial facilitatory effect of a valid cue. If that were the case, we should also expect our schizophrenic patients to show blunted magnitude of IOR as in the Huey and Wexler (1994) study. The results showed that schizophrenic individuals exhibited similar IOR effects to those exhibited by healthy adults, despite the fact that their overall RTs were longer than those of healthy adults. Most important, the IOR effects with both cuing procedures were similar in the two groups of participants.

These results suggest that, as with healthy adults, medicated patients did not need the central cue to reorient their attention to the center in advance to target presentation. Then why, contrary to the present study, did the Huey and Wexler (1994) patients show blunted magnitude of IOR? One likely explanation for the different results maybe that in the Huey and Wexler (1994) study the duration of the peripheral cue coincided with the SOA value. As mentioned before, schizophrenic individuals showed more benefits from valid cues than healthy adults when a short SOA was used, a result that has been replicated here. This suggests that the cue produced a greater level of activation in the schizophrenic group than in the healthy adult group. In the present study, the cue only lasted 200 ms, so that, with a long SOA, by the time the target was presented the level of activation produced by the peripheral cue could have vanished enough to be similar in both groups of participants, producing comparable sizes of IOR effects. In the Huey and Wexler (1994) experiment, the larger activation produced by the cue in the schizophrenic group could increase even more because it was on the screen until the target was presented. As a consequence, the patients could have had problems overcoming such a high level of activation, producing a failure in the IOR effect. If that is true, the failure in IOR observed by Huey and Wexler (1994) in the schizophrenic could be due to a very high long-lasting level of activation produced by the peripheral cue, a level that these individuals found very difficult to overcome. This locates the visuospatial attention deficits observed in these tasks in the control of processes leading to IOR rather than in IOR per se.

Finally, the differences in RTs between patients and healthy adults when the left hemisphere was involved agree with the ample evidence of studies that have shown left hemisphere dysfunction associated with schizophrenia. Importantly, this lateralized deficit is not restricted to visual orientation tasks [e.g. Posner et al., 1988; the present study], but it is also found when attention is allocated within the semantic domain [for recent evidence, see Fuentes and Santiago (1999)].

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