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Disturbances in time limited storage of sensory information after right temporal lobectomy

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Abstract. Our previous study performed on subjects with no brain damage suggested that processes involved in the storage of sensory information are lateralized to the right hemisphere. The present research aimed at verifying this hypothesis by studying the effect of unilateral temporal lobe lesion on performance in a sensory information storage test. Seventeen patients who had undergone a unilateral temporal lobectomy for the relief of intractable epilepsy (8 subjects - left hemisphere damage, 9 subjects - right hemisphere damage) and 11 normal control subjects with no brain damage were tested. The subjects were presented with geometrical Vanderplas type figures exposed in pairs, each for 100 ms, one after another, with short (50 ms and 500 ms) and long (3,000 ms) interstimulus intervals (ISI). The task of the subjects was to judge whether the second stimulus was the same as, smaller or bigger than the first one. The first stimulus in each pair was exposed unilaterally, randomly in the left (LVF) or right (RVF) visual field, and the second one in the centre of the screen. In short ISI condition the RH-damaged group performed worse than both the control group and the LH-damaged group. In long ISI condition the RH-damaged group did not differ from the controls. On the contrary the LH-damaged group did not differ significantly from the controls in any ISI condition. The results show that temporal lobe structures are involved in time limited storage of sensory information. Moreover, they provide further evidence for the right-hemispheric locus of this storage.

Short communication

Key words: sensory memory, temporal lobectomy, hemispheric

The two brain hemispheres may functionally differ at all stages of visual information processing or, alternatively, at only some of them. One possible approach to this problem is to study the effect of interstimulus interval (ISI) on hemispheric asymmetry. Such an approach is based on the assumption that at different ISIs the second stimulus is compared to different representations (memory traces) of the first one.

In our previous studies (Szatkowska et al. 1993) we measured reaction times in a test requiring size comparison of two visual stimuli presented with various intervals. The sample stimulus was presented unilaterally, either in the right or in the left visual field, and then after 50, 500, or 2,000 ms the test stimulus appeared at fixation to probe the subject's memory of the sample. The results showed shorter reaction times on the left visual field presentation conditions than on the right visual field presentation conditions at the 50 ms and 500 ms interstimulus interval. However, no laterality effect emerged at the 2,000 ms ISI.

The results suggested that processes involved in the time-limited storage of sensory information are lateralized to the right hemisphere. The present study aimed at verifying this hypothesis on a group of brain damaged patients. Specifically we investigated whether left and right unilateral temporal lobe lesions differentially affect the performance in the previously used stimulus size comparison task.

Seventeen patients, each of whom had undergone unilateral temporal lobectomy for the relief of pharmacologically intractable epilepsy (8 left--sided, 9 right-sided), and 11 control subjects with no brain damage were examined. The medical assessment of the patients has been recorded by two of the authors (O.S. and R.S.) in Central Hospital of the Medical Academy in Warsaw. The removals from the temporal region always included the anterior temporal neocortex (5-8 cm along the Sylvian fissure) and amygdala, but varied in the amount of hippocampus excised. In 4 subjects (2 left sided and 2 right sided) the excision extended into the body of hippocampus. In 13 subjects the removal did not exceed the pes.

Patients were characterized by normal intellectual functions (IQ= 101-125 as measured with Wechsler-Bellevue scale). In all cases they were able to perform professional work. They were right-handed, aged 35-40 and on the average had reached a secondary school level of education. The control subjects were selected to match patients in all these respects.

Set of tests, which we call sensory information storage tests (Szatkowska et al. 1993), consisted of presentations of Vanderplas-type figures (Vanderplas and Garvin 1959). The stimuli were exposed for 100 ms in pairs, one after another, on a computer screen. The first stimulus was presented either 2 deg left or 2 deg right of the fixation point. The second stimulus was presented in the centre of the screen with a 50 ms, 500 ms or 3,000 ms delay. The subject's task was to decide whether the second stimulus was smaller, bigger or the same size as the first one. They responded by pressing one of three buttons indicating their choice. The figures used in the study had two different shapes and four different sizes (Fig. 1). Figures presented in a pair always had the same shape and either the same or different size. The first stimulus in a pair had the size indicated as 2 or 3 in Fig. 1. The second stimulus could be either the same, smaller or bigger. The three different delays were blocked into separate sessions, each con-

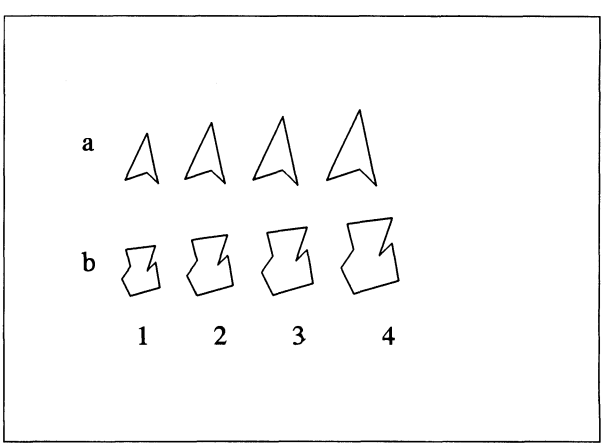

Fig. 1.Examples of stimuli used in the study. Four different sizes (1-4) and two shapes (a,b) were used.

sisting of 96 exposures. Each session was performed twice, once with the left and once with the right hand. The order of sessions was randomly generated by the computer. The order of trials in a session was pseudorandom: the same relation between the two stimuli (same, bigger and smaller) could not repeat consecutively more than three times and the laterally presented figure could not appear consecutively more than three times in the same visual field.

Number of errors was analysed. Two-way repeated measures MANOVAs with group of subjects (controls/patients with left temporal lobectomy/patients with right temporal lobectomy) and field of exposure (left/right) as variables were performed on short and long delay condition data.

Figure 2 illustrates the mean percent of errors committed by the three groups of subjects on the short interstimulus interval condition (the data for 50 ms and 500 ms ISI were pooled). The analysis performed on these data showed a significant effect of group ($F_{2,25}$=4.03; P<0.03). More detailed group comparison revealed that patients with right temporal lobectomy performed worse than controls ($F_{1,19}$=7.94; P<0.01) and worse than patients with left temporal lobectomy ($F_{1,16}$=4.75; P<0.04) who did not differ significantly from the controls. The analysis revealed also close to significance effect of visual field ($F_{1,26}$=3.86; P<0.06): left visual field presentations resulted in slightly higher performance scores than the right visual field presentations. The analysis performed on the long interstimulus interval condition data did not reveal any significant main effect or interaction.

The results showed a differential effect of interstimulus interval on the scores obtained by patients with right temporal lobectomy and the two other subject groups (patients with left temporal lobectomy and controls). When very short interstimulus intervals were used, patients with right lobectomy performed worse than the control subjects and worse than patients with left lobectomy. At longer interstimulus interval patients with right lobectomy did not differ from the controls and from patients with left lobectomy. Moreover, left visual-field presentations resulted in a slightly higher performance than the right visual-field presentations. All these data corroborate our earlier hypothesis of the right-hemispheric specialization in a time limited storage of sensory information. Moreover, the present results point to the right temporal lobe structures as the potential locus of that very short-term memory storage.

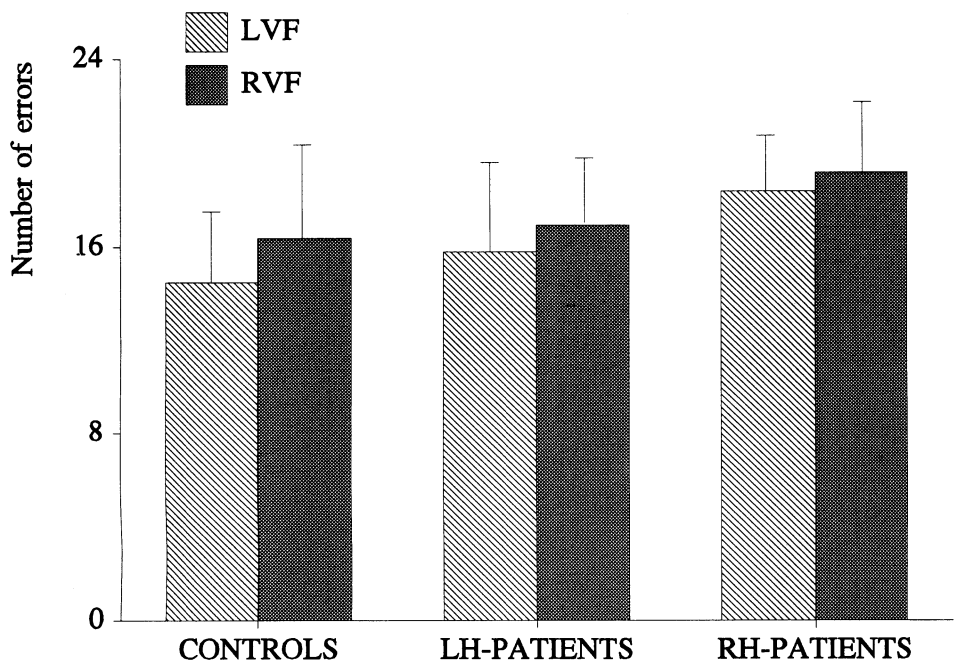

Fig. 2. Mean number of errors committed by three groups of subjects on short interstimulus interval condition. LVF, left visual field presentation; RVF, right visual field presentation.

There is much evidence showing that temporal lobes are essential for memory function (see Squire 1992 and Squire et al. 1993 for review). Bilateral surgical removal of medial temporal lobe results in severe amnesia (Scovile and Milner 1957, Milner 1965). Moreover, unilateral temporal lobectomies have been found to impair the delayed recall tasks (e.g. Jones-Gotman 1986, Smith and Milner 1989). It is a matter of question, however, whether temporal lobe structures are also involved in the memory processes occurring shortly after stimulus presentation. It has been shown that amnesia may occur against intact immediate memory tested by conventional digit span test (Baddeley and Warrington 1970, Milner 1971, Cave and Squire 1992). It can be argued, however, that digits are verbally labelled while they are encoded into memory and that this may prevent memory traces from decay. Recent studies using nonverbal patterns in visual short--term memory tests provided evidence against such a possibility as patients with damage to the temporal lobe structures did not show deficits in those tests (Cave and Squire 1992, Piggot and Milner 1994). It has to be stressed, however, that the relevance of those data to our results is limited as the authors used longer interstimulus intervals (of the order of several seconds) than we did. Similar opinion is expressed by Piggot and Milner (1994) who argue that "the visual short-term memory has been differentiated from sensory memory because it is not affected by the introduction of mask in the retention interval (Phillips and Christie 1977)".

Further studies are needed to elucidate which of the complex temporal lobe structures actually contribute to sensory memory. Our previous study showed that combined lesions to the anterior part of the hippocampus and medial part of the amygdala did not impair performance in the sensory information storage test (Grabowska et al. 1994). Other structures (e.g. temporal cortex) should thus be considered as a potential locus of that storage.

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