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Neurobiology of Aging 33 (2012) 1012.e1–1012.e10

NEUROBIOLOGY OF AGING

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Abnormal temporal dynamics of visual attention in Alzheimer's disease and in dementia with Lewy bodies

Frédéric Peters[a,*], Anne-Marie Ergis[b], Serge Gauthier[c], Bénédicte Dieudonné[d], Marc Verny[d], Pierre Jolicoeur[e,f], Sylvie Belleville[a,e]

[a] Institut Universitaire de Gériatrie de Montréal, Montréal, Québec, Canada
[b] Institut de Psychologie, FRE 3292 CNRS, Université Paris Descartes, Paris, France
[c] McGill Center for Studies in Aging, Montréal, Québec, Canada
[d] Service de Gériatrie, Groupe Hospitalier Pitié-Salpêtrière, Paris, France
[e] Department of Psychology, Université de Montréal, Montréal, Québec,Canada
[f] Centre de Recherche en Neuropsychologie et Cognition et International Laboratory for Brain, Music, and Sound Research, Montréal, Québec, Canada

Received 29 January 2011; received in revised form 4 August 2011; accepted 21 October 2011

Abstract

Although attentional control processes are disproportionately impaired in dementia with Lewy bodies (DLB) compared with dementia of the Alzheimer type (DAT), previous studies have not compared directly the temporal dynamics of visual attention in DLB and DAT. We examined the magnitude of the attentional blink (AB) effect in these patients, to determine the degree to which each patient group exhibited a deficit in selecting and processing visual stimuli presented in rapid succession. Eighteen DAT, 15 DLB patients, and 33 elderly controls were tested in a rapid serial visual presentation task. Participants were asked to report 1 (single-target condition) or 2 target letters (dual-target condition) embedded in a sequence of digit distracters. The temporal dynamics of visual attention was examined by varying the number of intervening distracters between the 2 targets in the dual-target condition and by estimating the attentional blink effect as the decline in the ability to report the second target correctly after successfully identifying the first. Patients with DLB performed significantly worse than patients with DAT and controls in both the single and dual-targets conditions. In contrast, DAT patients showed a selective impairment in the dual-target condition as compared with controls. As predicted, we found that both patients with DAT and DLB showed a more pronounced and protracted attentional blink than controls, indicating a reduced ability to re-engage attention on the second target. Furthermore, when DAT and DLB patients were able to report the second target, they frequently failed to identify the first, an effect that was absent in elderly controls and particularly large and long-lasting in DLB patients. This study suggests that both DLB and DAT patients show abnormal temporal dynamics of visual selective attention, presumably due to a greater intertarget competition for limited processing capacity. More generally, these findings reinforce the notion that deficits of attentional control processes are more severe in DLB patients as compared with DAT patients.

Keywords: Alzheimer's disease; Dementia with Lewy bodies; Attentional blink; Visual selective attention; Temporal dynamics of attention

1. Introduction

Dementia with Lewy bodies (DLB) has been recognized as a separate disease entity (McKeith et al., 2005, 2004). However, its differential diagnosis remains difficult, essentially because of the overlap of clinical symptoms between DLB and other related neurodegenerative diseases, notably dementia of the Alzheimer type (DAT). In spite of these similarities, recent studies have suggested that differences in attentional functioning capacities could distinguish DLB and DAT patients (for a review, see Metzler-Baddeley, 2007). Attentional control processes, such as divided attention, inhibition, or shifting processes, are impaired in both forms of dementia, but these deficits are often more prominent in DLB as compared with DAT (Calderon et al., 2001;

* Corresponding author at: Centre de Recherche de l'Institut Universitaire de Gériatrie de Montréal, 4565 Chemin Queen-Mary, Montréal, H3W 1W5 Québec, Canada. Tel.: (+1) 514 340 3540; fax: (+1) 514 340 3548.
E-mail address: Frederic.Peters@criugm.qc.ca (F. Peters).

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doi:10.1016/j.neurobiolaging.2011.10.019

Collerton et al., 2003; Johns et al., 2009; Lambon Ralph et al., 2001; Simard et al., 2000). Attentional deficits in DLB also include impaired selective attention, especially in the visual modality (Ballard et al., 2001; Calderon et al., 2001; Noe et al., 2004). However, few studies have investigated the temporal dynamics of visual attention in these patients. In particular, little is known about their capacity to allocate attention selectively to relevant stimuli presented in rapid succession.

The rapid serial visual presentation (RSVP) paradigm provides a useful framework in which to examine visual selective attention and its temporal dynamics (Shapiro et al., 1997). RSVP involves presenting visual stimuli at the same location and in rapid succession. Consider the situation in which subjects have to select and process 2 targets (e.g., letters; T1 and T2) that are distinguishable on some dimension from distracters (e.g., digits). Typically, the temporal dynamics of visual attention is examined by varying the number of intervening distracters between the 2 targets. When the 2 targets are presented with 1 (or a few) intervening distracters in the RSVP stream, report of T2 is lower (sometimes considerably lower) than when a long time elapses between target presentations (Broadbent and Broadbent, 1987; Raymond et al., 1992). This lower accuracy for T2 is referred to as the "attentional blink" (AB). The AB effect is usually largest when the temporal interval between T1 and T2 is in the range of 200–500 ms, but depends on the nature of the task (Jolicoeur, 1999b).

Several theoretical models have been developed to explain the AB effect. According to limited-processing capacity models, the AB is hypothesized to result from a capacity limitation in which the processing of T2 is either postponed or less efficient when processing mechanisms are already busy with T1 (e.g., Chun and Potter, 1995; Jolicoeur, 1998, 1999b; Jolicoeur and Dell'Acqua, 1998; Visser, 2007; Vogel et al., 1998). The selection of T1 from distracters is made possible through the activation of an attention filter that reacts to the presentation of T1, allowing T1 to be selected efficiently for further processing. During this time, processing capacity cannot be used for T2 (or must be shared between T1 and T2), leading to difficulties in identifying T2 or storing T2 for later report (Dell'Acqua et al., 2003; Jolicoeur, 1999a; Jolicoeur, 1998; see also Tombu and Jolicoeur, 2005). Other accounts of the AB have been proposed that do not rely on limited processing capacity. Most of them emphasize the importance of the item directly following T1 rather than T1 itself. The temporary loss of control model (Di Lollo et al., 2005) postulates that the AB arises from a temporary inability to filter incoming information when an attentional control system, called the "central processor," is already busy. The central processor is necessary for supervising the selection of targets among distracters, but also for controlling the storage of the information already selected. Hence, if T1 is identified and further processed, and if the stimulus directly following T1 is a distracter, the selection filtering system is exogenously reset in favor of the distracter's features, leading to difficulties in identifying T2 for some period of time (see also the "eSTST model," Wyble et al., 2009, or the "boost and bounce" model, Olivers and Meeter, 2008, for recent models in which the AB is thought to result from a competitive regulation of attention by excitatory and inhibitory feedback responses elicited by targets and distracters).

Although several studies have investigated the AB in normal aging (Georgiou-Karistianis et al., 2006; Maciokas and Crognale, 2003; Male et al., 2009), this effect has only been examined once in DAT and never in DLB. Kavcic and Duffy (2003) showed an exaggerated AB (greater loss of accuracy for T2 at short lags, and a longer lasting effect) in a group of DAT patients relative to healthy elderly participants. In addition, the results of this study also showed that DAT patients produced more errors in report of T1 at lag 1 than controls, presumably reflecting greater intertarget competition. The authors termed this T1 lag-1 effect "attentional masking" errors (mainly omissions or incorrect reports of T1 when T2 was correctly identified). Overall, these findings suggest that patients with DAT show an increased difficulty of re-engaging attention within a short period of time for 2 temporally discrete targets. No previous studies investigated the temporal limits of visual selective attention in DLB.

The aim of the present study was to examine the temporal dynamics of visual attentional processing in DLB and DAT. We hypothesized a greater temporal limitation of visual selective attention in DAT, to be revealed by an exaggerated AB effect during the RSVP task in DAT patients compared with healthy elderly controls (Kavcic and Duffy, 2003). We also anticipated evidence of lower processing capacity revealed by lower report accuracy for T1 at the shortest lag conditions. In DLB patients, an even more pronounced and protracted AB and lower performance for T1 at lag 1 were expected relative to DAT. More generally, the major deficits in selective attention in DLB patients might also result in an overall decrease in performance (e.g., Ballard et al., 2001; Bradshaw et al., 2006).

2. Methods

2.1. Participants

We recruited 18 patients (11 women; mean age [standard deviation]: 74.8 [8.5]) suffering from dementia of Alzheimer type at a mild stage (DAT), 15 patients (8 women; mean age [standard deviation]: 85.1 [4.7]) suffering from dementia with Lewy bodies at a mild stage (DLB) and 2 groups of 18 (NC1) and 15 (NC2) control elderly volunteers matched for age and gender to the DAT group and DLB group, respectively. Subject summary statistics are shown in Table 1. Patients with DAT and control participants for the NC1 group were recruited in Montreal, Canada, whereas patients with DLB and control participants for the NC2