EXTINCTION TO DOUBLE SIMULTANEOUS STIMULATION

AND

HEMISPACE LATERALIZATION

by

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ABSTRACT

'Extinction to Double Simultaneous Stimulation' (EDSS) is a perceptual disorder which occurs with varying frequency following lateralized brain lesions, predominantly in the right parietal lobe. Correlated with impaired functional recovery of hemiplegic patients, the phenomenon is characterized by faulty or non-recognition of stimuli on the side opposite to that of the damaged cerebral hemisphere when these stimuli are presented simultaneously with stimuli on the ipsilesional side. Yet the phenomenon cannot be explained by a simple sensory deficit since a patient who manifests the syndrome correctly identifies the same stimuli on unilateral presentation. EDSS is considered a (milder) manifestation of the 'neglect' syndrome, that is, the tendency to neglect the contralesional half of body and space following brain damage. Although known for a full century, the psychophysiologic mechanisms underlying the syndromes of EDSS and 'neglect' are still poorly understood and many hypotheses remain speculative. Investigation of an underlying mechanism seems essential for the development of treatment strategies aimed at ameliorating the syndrome and thereby conceivably enhancing the rehabilitation

potential of this patient group. Although the unilateral neglect of stimuli may involve different sensory modalities, the present study focuses on somatosensory stimuli.

The purpose of the present study was two-fold: first, to test two prevailing theories which account for the syndrome of EDSS in hemiplegic patients, and to distinguish between the respective hypotheses; second, to investigate hemispheric asymmetries in the perception of somatosensory stimuli prior to brain injury as a possible basis for the development of unilateral hemineglect after brain lesions. The postulated mechanisms underlying EDSS, stimulus properties and the hemispace in which the stimuli occur, were therefore tested in both a clinical as well as a neurologically intact population.

The research questions were addressed in two parts of the study: in Study A, electrical stimuli at perception theshold, systematically varied with respect to duration and the hemispace in which they were delivered, were presented to 68 subjects free of neurological disease (34 males, 34 females). The subjects' report of perceived stimuli was recorded and errors of detection were analyzed. In Study B, a similar procedure was performed on 19 hemiplegic patients manifesting EDSS.

The results indicate that both sensory characteristics and attentional factors influence perception. The findings of Study A suggest that:

1. The hemispace in which stimuli are presented plays a significant role in their perception.
2. A left hemispace advantage appears to be pre-eminent in females.
3. The right hemisphere may be a better 'watchkeeper' for stimuli directed to the left hemispere than the left hemisphere is for stimuli directed to the right hemisphere.

In hemiplegic patients (Study B), neither of the two tested theories could account by itself, under the experimental conditions of the present study, for the syndrome of 'extinction'. Based on the present findings, EDSS is viewed as a deficiency in neurointegrative functioning altering the physiological processing of stimuli.

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AER	:	averaged evoked responses
ANOVA	:	analysis of variance
CNS	:	central nervous system
CNV	:	contingent negative variation
CVA	:	cerebral vascular accident
DA	:	dopamine
EDSS	:	extinction to double simultaneous stimulation
F	:	female
GSR	:	galvanic skin response
H_0	:	null hypothesis
H_1	:	alternative hypothesis
HRP	:	horseradish peroxidase
HSF	:	hemispatial field
IPL	:	inferior parietal lobe
L	:	left
M	:	male
mA	:	milliampere
MRF	:	mesencephalic reticular formation
msec	:	milliseconds
NE	:	norepinephrine
ns	:	non-significant
pps	:	pulses per second
R	:	right
RAS	:	recticular activating system
RT	:	reaction time
S	:	subject
VFD	:	visual field defect
VHF	:	visual hemifield

CHAPTER ONE

INTRODUCTION

1.0 The Field of Neuropsychology

Neuropsychology is the study of brain-behaviour relationships. While both clinical and experimental neuropsychology investigate the function of the normal brain and study behavioural deficits following brain lesions, clinical neuropsychology concerns itself with the application of these findings to human problems (Melzack, 1984). The fields of neurology and clinical neuropsychology are largely based on empirical findings of experimental neuropsychology using human and animal models. Through the identification and understanding of the behavioural correlates of brain function, it is possible to evaluate the consequences of brain dysfunction for patients (Goldstein, 1974; Reitan, 1966, 1974; Crockett, Clark, & Klonoff, 1981).

Within the last two decades, scientific and clinical interest in neuropsychology has been growing at an accelerating rate. Yet, despite considerable progress in our understanding of brain mechanisms underlying normal and abnormal brain functioning, many

questions regarding the workings of the brain have remained a baffling mystery and await further elucidation.

Although it is well recognized that the brain functions as an integrated system, the progressive lateralization of function with the development of speech and handedness (Luria, 1973; Buffery, 1974; Berent, 1981) has led to increased interest in asymmetrical functional arrangement in brain organization (Bryden, 1982; Segalowitz, 1983). Generally, the notion of lateralization of brain functions has been widely accepted: in most right-handed individuals, the left hemisphere is considered to be responsible for the mediation of speech and more logical, precise analysis, while the right hemisphere plays a more important part in the perception and recall of spatial material and of non-verbal stimuli (McGlone, 1980; Berent, 1981). The great diversity and individual variability in brain organization (Gazzaniga, 1974; Buffery, 1974; Reitan, 1974) has led to the current trend to de-emphasize specific localization of function in the two sides of the brain and to consider brain function in a more holistic fashion (Reitan, 1966; Gazzaniga, 1974).

The task of modern neuropsychology in studying the diseased brain is not only to describe and analyze a syndrome (the particular constellation of symptoms and signs) and to account for it with a particular locus of lesion; it also has to take account of the functional processes subserved by various cortical and

subcortical systems working in concert (Luria, 1970, 1973). The challenge is to 'dissociate' the contributions of lesions in different cerebral loci to the deficit and to find the mechanisms underlying the participation and interconnectedness of several systems in the complex circuitry of brain functions. By setting up hypotheses designed to confirm one postulation while at the same time discounting the possibility of another, the probability of the correctness of one postulation has acquired additional validity (Walsh, 1978).

1.1 'Neglect' and 'Extinction to Double Simultaneous Stimulation'

One of the various syndromes resulting from unilateral damage to the central nervous system is the failure to appreciate stimuli on the side of the body contralateral to the lesion and to ignore the side of space opposite to the site of the neurological insult (Bender, 1952; Critchley, 1949, 1966). This defective perception of corporeal and extracorporeal space (see p. 41 for additional elucidation of the space within and outside the body) in one half of the perceptual sphere has been variously termed 'hemi-neglect' or 'hemi-inattention' (Bender, 1977; Friedland & Weinstein, 1977; Heilman, 1979). The syndrome may comprise a) disturbances of the body scheme, that is, neglect and/or denial of the existence of the opposite side of the body: 'autotopagnosia' or 'anosognosia'

(Denny-Brown & Banker, 1954; Critchley, 1966; Hecaen, Penfield, Bertrand, & Malmo, 1956; Benton, 1979); b) topographical disorientation due to defective analysis of, and memory for, spatial relationships: 'unilateral spatial agnosia/neglect' (Brain, 1941; McFie, Piercy, & Zangwill, 1950; Battersby, Bender, Pollack, & Kahn, 1956; Hecaen et al., 1956; Oxbury, Campbell, & Oxbury, 1974; Chedru, 1976; Bisiach, & Luzzatti, 1978; Denes, Semenza, Stoppa, & Lis, 1982); and c) impairment of visuo-constructive abilities (McFie et al., 1950), including apraxia: 'apractognosia' (Hecaen et al., 1956).

A 'neglect'-related disorder is 'Extinction to Double Simultaneous Stimulation' (hereinafter abbreviated EDSS). A defect of interhemispheric perceptual interaction (Schallert & Whishaw, 1984) accompanying the functional impairment of unilateral neglect (Critchley, 1949), EDSS is characterized by imperception, or distortion (Obersteiner, 1881), of stimuli on the contralesional side of the body when these stimuli are presented simultaneously with stimuli on the opposite (intact) side. Yet, these 'ignored' stimuli are correctly identified when delivered unilaterally; they merely 'extinguish' on bilateral stimulus presentation. This phenomenon was first noted by Oppenheim in 1885 with tactile stimuli (Bender, 1948; Heilman, 1979) and later described by Anton (1899) in the visual sphere (Friedland & Weinstein, 1977).

The defective appreciation of stimuli on the side opposite to the lesion may occur in various sensory modalities (Bender & Feldman, 1952; Welch & Stuteville, 1958; Bender, 1977; Heilman, 1979). Neglect and extinction have been reported in several specific sensory domains, such as in the gustatory, when taste on one side of the tongue is affected (Bender & Feldman, 1952), in the olfactory (Marshall, Turner, & Teitelbaum, 1971), in the auditory (Welch & Stuteville, 1958; Heilman, Pandya, Karol, & Geschwind, 1971; Watson & Heilman, 1979), and in the somesthetic modality where EDSS is characterized by imperception of vibratory (Critchley, 1949) and tactile stimuli (Bender, 1952; Watson, Heilman, & Cauthen, 1973; Watson, Miller, & Heilman, 1978; Dimond, 1978). EDSS is frequently multimodal (Heilman, Pandya, & Geschwind, 1970) and has been observed within and across different sensory modalities (Wortis, Bender, & Teuber, 1948; Critchley, 1949; Bender & Feldman, 1952; Denny-Brown, Meyer, & Horenstein, 1952; Teuber, 1975). 'Cross-modal' interactions in patients, that is, mutual extinction between visual, somatosensory and auditory stimuli, seem to occur only in severe cases of hemi-neglect (Weinstein & Friedland, 1977), and are almost always associated with organic mental impairment (Friedland & Weinstein, 1977).

The phenomenon of EDSS is considered to be a more subtle manifestation of the overall spatial defect of unilateral neglect (Battersby et al., 1956; Heilman, 1979). EDSS is frequently

encountered as a stage of functional improvement from unilateral neglect (Heilman, 1979), and testing for EDSS will often elicit a masked neglect syndrome (Critchley, 1966). If there are differences in the pathogenesis underlying neglect and EDSS, they are at present not understood (Heilman, 1979); the terms neglect and EDSS will subsequently be often used interchangeably. Although the controversy regarding the nomenclature of this phenomenon has not been entirely resolved, the term 'extinction' seems to have been accepted to describe the syndrome; it does not, however, correspond to its meaning in learning theory where 'extinction' refers to the diminishing magnitude of a conditioned response upon withdrawal of its contingent reinforcement (Deese & Hulse, 1958).

1.1.1 Etiology

Lesions at various levels of the central nervous system (CNS) have been shown to produce deficits in orientation to sensory stimuli. Neglect-related disorders are most frequently associated with lesions of the parietal lobe (Brain, 1941; Critchley, 1949, 1966; Denny-Brown, Meyer, & Horenstein, 1952; Denny-Brown & Banker, 1954; Heilman et al., 1971; Heilman & Valenstein, 1972a; Valenstein, Heilman, Watson, & Van den Abell, 1982), but have also been noted after frontal lesions in man (Heilman & Valenstein, 1972b; Damasio, Damasio, & Chang Chui, 1980), in monkeys