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Weak central coherence in patients with Alzheimer's disease

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Abstract

Central coherence refers to the ability to interpret details of information into a whole. To date, the concept of central coherence is mainly used in research of autism, Asperger's syndrome and recently in the research on eating disorders. The main purpose of the present study was to examine central coherence in patients with Alzheimer's disease. Nine Alzheimer's disease patients and ten age- and gender-matched control subjects, who differed significantly in neurological assessment, were shown a picture of a fire. Compared to control subjects, the Alzheimer's disease patients described the picture in a fragmented way by mentioning details and separate objects without perceiving the context of the fire. In conclusion, patients with Alzheimer's disease are at the weak end of central coherence, and hence suffer from a fragmented view of their surroundings. The findings have important clinical implications for the understanding of patients with Alzheimer's diseaseand also for the possibility of caregivers to meet the Alzheimer's disease individual in an appropriate way in the everyday care.

Key Words

neural regeneration; neurodegenerative diseases; clinical practice; Alzheimer's disease; senile dementia; central coherence; cognition; perception; information processing; neuroregeneration

Research Highlights

(1) Alzheimer's disease patients are at the weak end of central coherence, which implies that they suffer a fragmented view of their surroundings.
(2) Weak central coherence in patients with Alzheimer's disease has important implications for the understanding of the Alzheimer patient's perception of their surrounding world as well as their ability to interpret their surroundings.
(3) The everyday care of patients with Alzheimer's disease needs to be redefined, making an effort to help them create meaning and understanding of their environment and everyday tasks.

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INTRODUCTION

Central coherence refers to the human ability to understand details of information as a whole[1]. The aim of the present study is to explore central coherence in Alzheimer's disease. Based on clinical findings, it is assumed that Alzheimer's disease patients have a different way of interpreting a context, seeing just the details and not being able to infer them into a whole. It is of clinical interest to investigate how Alzheimer's disease patients perceive their surrounding in order to better understand and care for individuals with Alzheimer's disease. In a recent example, a woman asked a relative whose drawer it was over there. The drawer was part of the kitchen interior in her own kitchen (an example from clinical practice). This is an example of seeing a detail, in this case, a drawer, and not being able to refer

it to the whole, the kitchen interior. Using the concept of central coherence in the context of Alzheimer's disease was an explorative approach. To the best of my knowledge, this is the first study to relate central coherence to Alzheimer's disease.

Central coherence

The definition of central coherence was first developed by Frith[1] as a term to describe an important aspect of normal information processing: being able to construct meaning in a context by integrating parts of a stimulus into a whole. Central coherence is a term used primarily within the research area of autism and Asperger's syndrome and recently also in the research on eating disorders[2-9]. The notion of weak central coherence was invoked to describe the information processing in the autistic individual. Weak central coherence is characterized as not being able to see the whole, the context, but only the separate details of a stimulus. Frith and Happé[5] later suggested that central coherence is a cognitive style of information processing, representing a continuum of normal information processing where individuals' performance ranges from weak to strong.

Central coherence in autistic individuals has been established using, for example Hooper Visual Organization test[10], the Object Integration test[3] and Scenic test[3], and the Block design test[11]. Recent research within the domain of central coherence is concerned with finding out what cognitive capacities are associated with the concept of central coherence. There has been evidence that the visuospatial construction aspect of central coherence is associated to executive control[12]. So far, there is no empirical data on the neural bases of weak central coherence.

Alzheimer's disease

The etiology of Alzheimer's disease remains unclear, although extensive research is conducted to understand the changes of the brain leading to Alzheimer's disease[13-15]. Key incidences of the Alzheimer's disease brain are the accumulation of extracellular senile plaques and intracellular neurofibrillary tangles[16]. Senile plaques comprise β-amyloid protein and are accumulated abnormally in the Alzheimer's disease brain. Neurofibrillary tangles are abnormal aggregates of hyperphosphorylated tau[13]. It has been proposed that the tau pathology can reflect cognitive symptoms of Alzheimer's disease[15]. Alzheimer's disease is characterized by a general and progressive impairment in cognitive abilities such as memory, language, and thinking[17-19]. With continuing disease impairment, semantic concepts lose their specific characteristics and are no longer well represented semantically. The semantic breakdown in Alzheimer's disease could be interpreted as loss of complexity and meaning and has implications for how the surrounding world is perceived[20-22]. In relation to language deterioration, Alzheimer's disease patients' grammatical structure in fluent speech tests has been found to differ from that of healthy controls. Amongst other measures, the Alzheimer's disease patients used fewer nouns but more pronouns than did the control subjects[23-24]. Forbes-McKay and Venneri[25] along with others have found additional language changes, like efficiency of description, in early Alzheimer's disease when asking patients to report orally on a picture[26].

Tests used in the present study

Due to the expected overall cognitive impairment in Alzheimer's disease patients, the tests used in testing central coherence are considered uncertain due to confounding of cognitive abilities. For example, the visuospatial construct ability is overall significantly impaired. This ability is measured by figure drawing in for example Mini Mental State Examination (a 30-point test for screening of cognitive impairment[27]) and Alzheimer's Disease Assessment Scale-cognitive subscale (assessment of cognitive functioning in Alzheimer's disease[28]). Tests of central coherence that puts demand on visuospatial construct ability (*e.g*. the Block design test) were therefore excluded. The final decision on a test suitable for testing central coherence in Alzheimer's disease was oral reporting on the context of a picture of a fire. Reporting the context in a picture would imply normal central coherence meaning an ability to understand details of a picture as a whole. The oral reporting can be broken down into a grammatical description of what constitutes the story and allow for an analysis of the stories, word by word in a grammatical sense.

The hypotheses are:
(1) Alzheimer's disease patients are at the weak end of the central coherence continuum, as compared to matched control subjects.
(2) Alzheimer's disease patients differ from matched control subjects in what constitutes their stories.

RESULTS

Context analysis

In analyzing the stories of the participants, it was found that none of the Alzheimer's disease patients explicitly

mentioned the context of the fire. Although one patient, in the very last sentence of his description, said that this man (pointing at a man in a phone booth) is probably calling the fire department. This comment implies that the patient could relate a part of the picture to the fire, though he did not in any other way reveal that he perceived the context of the fire in the picture. There were two patients who did not mention fire or flames at all. Among the control subjects all, but two, mentioned the context of fire, and everyone mentioned flames. The difference between the groups was significant ($F_{(1,17)}$ = 15.35, P < 0.001). The picture comprised 60 separate objects. In the Alzheimer's disease group, 7.9 objects were mentioned and in the control group, significantly more objects, 28.6 objects were mentioned ($F_{(1,17)}$ = 29.67, P < 0.001). On average, the Alzheimer's disease patients used 189 seconds to describe the picture while the control subjects used 124 seconds. The difference in time used was not significant ($F_{(1,17)}$ = 3.55, P > 0.05).

The overall analysis of text implies that the patients have no concept of the context of the fire. They described the picture in a fragmented way, reporting each object by itself. An example of describing details and not seeing the whole of the picture is a woman who, as she continued the description of the picture, repeatedly referred to the picture as several pictures, she said: "…and then in the next picture there is a…and in the next picture…".

Text analysis

The structure of the stories according to grammatical categories is reported in Table 1.

Table 1 Amount words generated per individual and separated into grammatical categories

Grammatical category	Control subjects (n = 10)	Alzheimer's disease patients (n = 9)	P
Verbs	43.8	42.6	n.s.
Adjectives	4.5	5.3	n.s.
Concrete nouns	35.4	16.9	< 0.01
Abstract nouns	5.1	3.7	n.s.
Pronoun	45.9	49.9	< 0.05
Total amount of words generated	245.5	221.6	n.s.

Data are expressed as mean, and were analyzed using two-way analysis of variance. n.s.: Nonsignificant.

There were no differences between groups in total amount words generated. The two groups used the same amount of verbs, adjectives and abstract nouns to describe the picture. However, the groups differ in usage of concrete nouns and pronouns where the Alzheimer's disease patients used fewer concrete nouns but more pronouns than did the control subjects.

DISCUSSION

The overall aim of this study was to explore central coherence in Alzheimer's disease patients by two hypothesis:

First, patients with Alzheimer's disease are at the weak end of central coherence, as compared to matched control subjects. According to the theory on central coherence by Frith and Happé[5], results of the present study suggest that Alzheimer's disease patients are at the weak end of central coherence. This is manifested in the fact that the Alzheimer's disease patients in the study described the picture in a fragmented way by mentioning details and separate objects without perceiving the context of the fire. This is referred to as a fragmented description of the picture. Furthermore, this is in line with the results on the semantic attribute test reported by Mårdh, Nägga and Samuelsson[21], *i.e*., with continuing disease impairment, concepts lose their specific characteristics and are no longer well represented semantically which could be inferred as a fragmentation of the interpretation of the surrounding world[20-21].

Second, patients with Alzheimer's disease differ from control subjects in what constitutes their stories. The patients expressed themselves somewhat differently in terms of grammatical structure; they used fewer concrete nouns but more pronouns in their descriptions than did the controls. These findings are in accordance to findings from Bucks *et al* [23] and Almor *et al* [24]. There was no significant difference in how long they talked about the picture (in seconds) or in how many words they used in describing the picture. That is, the frames (time and amount of words) were the same but the content was different. The patients' stories can be seen as a line up of objects rather than a description on the semantic content of the picture. It seems as if they lack context awareness. Although no predictions about impairments as to specific elements of language were made, it is interesting to note that Alzheimer's disease patients showed an abundance of pronouns in their protocols. Previous studies on language in Alzheimer's disease have documented perseveration of pronoun processing[29]. Similarly, investigations involving neurophysiological or neuroradiological methods have

suggested differences between processing of pronouns and other forms of syntactic processing. Most notably, Hammer *et al* [30] found that processing of personal pronouns activated areas in the (left) parietal cortex, whereas processing of sentences of similar complexity engaged temporal areas. Thus, it is possible that pronouns are spared because neuronal systems related to pronouns and biological referents are relatively spared in many Alzheimer's disease patients[31]. The question of sparing of pronoun processing and usage clearly warrants further study.

There are concepts that could be assumed to interfere with the interpretation of the current research results, particularly based on the choice of method, orally reporting on a picture. Although the method was chosen in an attempt to take the profile of the cognitive erosion in Alzheimer's disease into account, testing cognitive abilities in individuals with cognitive deterioration is a challenge. As mentioned earlier, other tests of central coherence would have more obvious interference with regards to Alzheimer's disease than the test chosen. Although it is of value to mention for example "active visual perception" described by Luria *et al* [32], Luria argued that for a proper interpretation of a complex visual scene, relevant information has to be collected and interpreted. The active exploration that has to take place in order to capture the general meaning of the scene was considered to have prefrontal features, hence a prefrontal impairment as in Alzheimer's disease would interfere with this ability. Apart from this, Alzheimer's disease patients have been found to have deterioration in visual search performance[33]. It might be argued that "deterioration in visual search would influence performance on a picture description task". The visual search performance in autistic individuals (who are also at the weak end of central coherence) is superior to that of controls[34]. Hence, visual search may not be linked to central coherence in a straightforward manner. Another possible explanation for the present results is the linguistic deficit displayed in Alzheimer's disease. Linguistic deficits could make it difficult for the patients to describe the picture adequately. Despite of these possible biases, the conclusions of the present study remain on the basis that the result was entirely conclusive in that none of the patients mentioned the context of the fire although they used many words to describe the picture.

Conclusion and clinical implications

Alzheimer's disease patients are at the weak end of central coherence and display a fragmented understanding of a complex picture. It can be assumed that weak central coherence is a feature of Alzheimer's disease. In contrast to individuals with autism, it could be expected that Alzheimer's disease patients had normal central coherence prior to disease onset. It would be possible to assume that Alzheimer's disease patients slide down the continuum of central coherence as a function of disease. A logical continuation in the research on Alzheimer's disease and central coherence would be to compare degree of coherence to level of dementia. With the knowledge emerging from the present study in mind, it is important to redefine the everyday care of Alzheimer's disease patients, taking extra care into creating an environment that is perceived as safe and meaningful. One could argue that not being able to interpret your surroundings would make the individual feel a lack of meaning and understanding, leading to feelings of uncertainty. This is important to consider in the interaction with the Alzheimer's disease patient and has clinical implications for the everyday care of Alzheimer's disease patients. Emphasis has to be put into creating a safe and meaningful everyday life and making the Alzheimer's disease patient feel it.

SUBJECTS AND METHODS

Design

A non-randomized, concurrent control study.

Time and setting

All subjects were tested individually at the Department of Geriatrics, Linköping University Hospital in Linköping, Sweden, between March 1999 and August 2000.

Subjects

Nine patients with Alzheimer's disease and ten age-, gender-, and education-matched healthy control subjects were included in this study. The moderate number of subjects was due to the extensive analysis of data and to the novel and explorative character of the approach on central coherence in relation to Alzheimer's disease. The patients with Alzheimer's disease were diagnosed by the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA)[19] and Statistical Manual of Mental Disorders, Fourth Edition (DSM-III) criteria[35] in the Department of Geriatrics, Linköping University Hospital, Sweden. The healthy controls were recruited from a local senior-citizens organization, all with a mini-mental state examination

score above 25. Demographic characteristics of the participants are outlined in Table 2. The research protocol was approved by the Ethical Committee of Linköping University (No.: 11825). All participants, and in the case of Alzheimer's disease patients, also the spouse, were given informed consent prior to the study. All patients asked and agreed to participate in the study, and they all accomplished the tests.

Table 2 Baseline information of Alzheimer's disease patients and control subjects

Item	Controls	Patients	*P*
Age (year)	75.6 (66–84)	76.2 (62–84)	n.s.
Gender (female/male, *n*)	7/3	7/2	n.s.
Years of education	8.3 (6–20)	7.3 (6–11)	n.s.
MMSE (score)	28.0 (26–30)	15.9 (8–24)	< 0.01
BDS (score)	14.5 (12–19)	5.9 (1–14)	< 0.01
ADAS-cog (score)	5.9 (2–11)	27.6 (13–44)	< 0.01

Data are expressed as mean (range), and data comparison was made by repeated *t*-tests for age, years of education, MMSE, BDS and ADAS-cog. For gender, data were compared by binomial test. MMSE: Mini Mental State Examination; BDS: Behavioral Dyscontrol Scale; ADAS-cog: Alzheimer's Disease Assessment Scale-cognitive subscale; n.s.: nonsignificant.

Methods

Procedure

A trained neurological examiner conducted the tests. The tests were part of a larger study on awareness, metacognition and emotions in patients with Alzheimer's disease, which is reported elsewhere[36]. Apart from the test on central coherence, neurological assessments were made on both groups, *i.e.*, Mini Mental State Examination[27], Behavioral Dyscontrol Scale (assessment of frontal lobe function[37]) and Alzheimer's Disease Assessment Scale-cognitive subscale[28].

In the test on central coherence, the subjects were shown a detailed picture of a fire in a building and its surroundings. The instructions from the neurological examiner were: "I want you to describe what you see in this picture." The subjects were encouraged to take as much time as they felt they needed to fully describe the picture. Their stories were taped and transcribed.

Materials

A black and white line drawing of a fire was used (see Jolliffe and Baron-Cohen[3], for similar line drawings). The picture had all the characteristics of a fire, for example, flames from a building, people running out of the building, and people in the windows screaming. The picture comprised 60 separate objects.

Text analysis

In order to relate theories on central coherence to the picture used, a text analysis was performed on the individuals' stories. All stories were transcribed and an analysis of the stories was performed. An assessment of context awareness was made. Context awareness was made a dichotomy variable, "aware of context"/"not aware of context".

Also, the stories were broken down into separate words which in turn were classified into grammatical categories. These categories made it possible to compare the structure of the stories between the patients and the controls, and also a comparison could be made on awareness of detail. The grammatical categories that were considered relevant for analysis of the text were adjectives, verbs, pronouns, concrete nouns, and abstract nouns. Words used by the subjects that did not belong to any of the mentioned grammatical categories were tagged as "unlabelled". For example, "…someone who comes running very fast…" would be tagged as follows: "…someone [pronoun] who [pronoun] comes [verb] running [verb] very [unlabelled] fast [unlabelled]…". The grammatical classification of the stories was made by two independent assessors with complete concurrence, thus concluding that the classification was reliable. The stories were anonymous at the time of assessment. Although in many cases it was possible to infer which group (Alzheimer's disease patients or control subjects) the story belonged to due to the character of the story, hence making complete blindness in assessing the stories impossible.

The amounts of words in every category were counted (Table 1). Apart from grammatical categorization, the total amount of words used by the subjects to describe the picture was counted as well as the time it took for them to describe the picture. Furthermore, the number of objects in the picture that were mentioned was counted.

Statistical analysis

The differences between the groups in their description of the picture were calculated using between subjects two-way analysis of variance. The demographic data was compared test by test (*i.e.*, age, years of education, Mini Mental State Examination, Alzheimer's Disease Assessment Scale-cognitive subscale, Behavioral Dyscontrol Scale) by independent samples *t*-tests. Gender proportion was compared using binomial test. All statistical analyses were made using IBM SPSS Statistics 19.0.

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Author contributions: Selina Mårdh performed the study, analyzed data, wrote the paper and approved the final version of the paper.

Conflicts of interest: None declared.

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