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Lexical deterioration in Alzheimer's disease

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Abstract

This research aimed to assess the validity of the retrogenesis hypothesis applied to the lexico-semantic knowledge. According to this hypothesis neurodegenerative mechanisms would reverse the order of acquisition in normal development. We present two studies comparing the development and loss of semantic knowledge. Study 1 compares the development of semantic knowledge about objects in children aged from 5 to 9 years old and its loss in Alzheimer's disease. Study 2 compares the performances of children and patients with Alzheimer's disease in a picture naming task. Both studies exhibited mirrored evolution of semantic knowledge extending the retrogenesis theory to lexico-semantic knowledge.

Key words: retrogenesis, Alzheimer's disease, semantic knowledge, lexical access

Introduction

Lexico-semantic network is the result of a progressive construction across lifespan. During childhood, the features of objects and their verbal labels are progressively stored to build our semantic knowledge and language. In AD, both sides, language and semantic knowledge, can be affected as demonstrated by word finding difficulties, circumlocutions, paraphasia and/or semantic errors.

The specific aim of this research is to analyze whether the understanding of lexico-semantic knowledge constitution in childhood brings clarification about its deterioration in AD. Retrogenesis theory (Reisberg, 1984) suggests that the earlier an ability is developed, the stronger it will resist to aging and to degenerative processes such as AD. Thus, one can expect a retrogenic trajectory of lexico-semantic aspects in AD manifested by the loss of semantic knowledge following a path opposite to their acquisition.

Some studies have highlighted results suggesting that this hypothesis of retrogenesis should be considered (e.g. Mello et al., 2008). The results of these studies show that the lexico-semantic aspects that are acquired later in development are also the most vulnerable in AD. The goal of the present study was then to test the retrogenic hypothesis by applying it to the lexico-semantic deterioration in normal aging and in AD.

Study 1: Semantic knowledge

Our first study aimed to investigate the development of semantic knowledge about objects in children aged from 5 to 9 years old and to compare this acquisition to the semantic loss in Alzheimer's disease.

Method

A total of 191 French native speakers were enrolled in the experiment. 93 children were allocated into 3 age groups: 5-year-olds ($n=30$, 17 girls); 7-year-olds ($n=30$, 20 girls) and 9-year-olds ($n=33$, 19 girls). 32 healthy elderly and 66 AD patients were also tested. AD patients were divided into three groups depending on their global cognitive deterioration measured by their performance at the Mini-Mental State Examination (MMSE): Mild (AD1: $MMSE > 20$, $n=20$); Moderate (AD2: $16 < MMSE < 19$, $n=16$), and Advanced stages (AD3: $MMSE < 16$, $n=30$). No difference of age and socio-cultural level appeared between the four elderly groups ($p < .05$). The Semantic Knowledge Questionnaire (SKQ) was used for all participants. Initially proposed by Laiacona (1993), this tool was revised and adapted in French for children (Simoes Loureiro & Lefebvre, 2015a) and for AD patients (Simoes Loureiro & Lefebvre, 2015b). SKQ contains 120 questions about 30 objects with different levels of hierarchy and attributes in semantic memory (Q1: questions about general superordinate aspects, e.g. Is the ostrich an animal, a plant, or an object?; Q2: questions about intracategorical aspects, e.g. Is the ostrich a four-legged animal, a bird, or an insect?; Q3: questions about perceptual attributes, e.g. Is the ostrich's neck longer than a rooster's neck? ; Q4 : questions about thematical/functional attributes, e.g. Does the ostrich run, walk, or swim?).

Results and discussion

ANOVA on repeated measures were carried out using the errors to each type of question (Q1, Q2, Q3, Q4) as 'within subject factor,' and the groups as 'between subject factor'.

Results indicated a group effect, ($F=43.884$; $p < .001$) demonstrating a decrease of the total number of errors to SKQ in childhood and an increase with the stages of AD, a type of question effect ($F=230.083$; $p < .001$) demonstrating fewer errors at the superordinate level (Q1+Q2) than at the subordinate level (Q3+Q4) and an interaction effect ($F=23.066$; $p < .001$) (for a more detailed description of the results, see Simoes Loureiro & Lefebvre, 2016).

Those results demonstrate an evolution/deterioration of the different levels of hierarchy of semantic knowledge with a slight improvement of general and intracategorical superordinate information from 5 to 9 years old

and a slight deterioration in AD, contrary to the subordinate level (perceptual and thematic/functional), with a later formation in childhood and an earlier deterioration in AD. These results sustain the hypothesis of Reisberg (1984). Indeed, we observed that for the knowledge tested in this study, the earlier the children acquired concepts, the later the AD patients lost it. Study 2 will consider the importance of the developmental trajectory of semantic knowledge by considering the age of word acquisition as a factor in anchoring this knowledge.

Study 2: Naming task

The purpose of study 2 was to compare naming performances of children and patients with AD. Based on the assumption that early acquired words are more robust than late acquired ones, we predicted that the scores of patients at different stages of the disease and those of children at different developmental stages should show a mirror pattern, especially for late acquired words.

Method

A total of 160 participants: 80 AD patients, 60 children and 20 elderly controls participated in the study. The AD group was split into four subgroups depending on the MMSE scores: mild (MMSE = 20-25), moderate (MMSE = 16-19), moderately severe (MMSE = 10-15), and severe (MMSE < 10). Similarly, the children were divided into 3 subgroups: early childhood (MMSE = 10-15, from 3 to 5 years old), middle childhood (MMSE = 16-19, from 5 to 7 years old) and late childhood (MMSE = 20-25, from 8 to 10 years old).

For the naming task, 24 pictures were selected from Rossion & Pourtois (2004): 12 pictures depicted words acquired early (mean AoA = 1,8 years), and 12 pictures corresponded to words acquired later (mean AoA = 2,8 years). Words in both lists were controlled for frequency, name agreement, word length, phonological neighborhood and visual complexity.

Results and discussion

We found a significant effect of group ($p < .0001$), AoA ($p < .0001$), as well as a significant interaction ($p = .001$). Patients with AD showed lower scores compared to other participants, early acquired words displayed higher scores than late acquired words, especially for children and AD patients. Focusing on early acquired words, Post hoc Tuckey analysis showed no significant differences between subgroups except for severe AD patients, who showed significantly lower scores ($p < .0001$). Turning to late acquired words, the

results showed a mirror pattern between the subgroups of AD patients and children.

Globally, our findings are in line with the retrogenesis hypothesis. We also found a strong AoA effect, which had however, a more detrimental effect in AD patients than in children.

Conclusion

Our findings suggest that globally, the retrogenesis hypothesis is relevant and useful for a better understanding of language decline in AD, since developmental changes in the child are better known than changes occurring in AD. Nevertheless, it is also important to take into account the specificities of each population, as AD patients benefit from a cumulative life experience that should not be ignored (Moos, 2011).

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