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Assessment of implicit language and theory of mind in multiple sclerosis

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ABSTRACT

Background. Increasing evidence suggests that social cognition, especially theory of mind (ToM), is impaired in individuals with multiple sclerosis (MS). ToM appears to be a determining factor for social functioning, but research has shown a connection between ToM and pragmatic language disorders among people with neurological or psychiatric disorders. Yet, pragmatic language remains a domain rarely referenced in MS.

Objective. We investigated the effect of MS in terms of the ability for making inferences via pragmatic understanding and ToM.

Methods. We included 21 individuals with MS and 21 healthy controls matched for age, education and linguistic skills who performed verbal tasks involving pragmatic language (Implicit Information Management Test, Narrative Discourse Task), ToM (test of social faux pas) and a visual task of making inferences (Visual Inferences Test).

Results. Performance was significantly lower for individuals with MS than controls in the test of social faux pas (total score), but performance in pragmatic tasks did not differ. Performance was significantly lower for MS individuals for logical inference on the Implicit Information Management Test and pragmatic inference on the Visual Inferences Test. Additionally, for the MS group, the total score on the Implicit Information Management Test was correlated with the faux pas test total score and hits.

Conclusion. Even with lack of marked cognitive decline and disability in individuals with MS and lack of differences between groups in pragmatic tasks, the MS group showed lower performance in making inferences and interpreting implicit and social situations. This study highlights the link between pragmatic language and ToM difficulties in MS.

Key words: multiple sclerosis, social cognition, pragmatic language, theory of mind

Introduction

The emotional or social skills as well as the experiences that individuals undertake to adapt to human relationships refer to the concept of social cognition. Social cognition appears to be essential to ensure daily quality in social interactions and includes various psychological processes. Within this concept, Gil [1] integrated the notions of theory of mind (ToM) and pragmatic language.

The interest in social cognition in multiple sclerosis (MS) is at its beginning but tends to be exploited. The concept appears to be an important aspect of the cognitive disorders related to the pathology. More importantly, it represents a potential predictive factor for social functioning and quality of life [2] among individuals who show significant psychosocial difficulties including employment and interpersonal issues [3, 4]. Two recent meta-analyses designed to quantify the magnitude of social cognition troubles [2, 5] found a deficit in both facial emotion recognition and ToM in individuals with MS.

ToM is a heterogeneous concept referring to the ability to attribute mental states (i.e., intentions, beliefs, emotions, goals) to oneself or others and required abilities to make cognitive or affective inferences [6]. Inferences are interpretations that are not explicitly available. In 1978, Harris and Monaco [7] suggested distinguishing two types of inferences: pragmatic and logical. Pragmatic inferences consist of operations partially or totally based on our general knowledge, which is stored in semantic memory and associated with information from the narrative context (e.g., “it’s hot in here”). Logical inferences are implications that are necessarily true, independent of the context and deduced from premises (e.g., “A is taller than B, C is smaller than B. Which one is the smaller?”). The notion of inference is central in the pragmatic field. Pragmatic language refers to the ability to appropriately use language in a

social context through an integration favourable to infer meaning especially in non-literal language [8].

Although communication skills are crucial to achieve social well-being [9], we have no data quantifying the effect of pragmatic deficits on the quality of life of people with MS. Therefore, individuals and their families frequently complain about this situation. Additionally, an impairment in the pragmatic abilities in MS has been demonstrated [9, 10, 11], which underlines the importance of taking this cognitive and social dimension in account. Many studies have pointed out the existence of ToM and pragmatic language connections in neurological disorders (i.e. right hemisphere damage [12], amyotrophic lateral sclerosis [13] and MS [9]) and in the psychiatric field [14].

The present study aimed to evaluate the ability of individuals with MS for ToM and pragmatic language (on the comprehension side). Additionally, we discuss the relationship between these 2 concepts. More precisely, we compared the abilities of individuals with MS without language disorders to make inferences with those of healthy controls. To achieve this goal, participants performed verbal tasks involving pragmatic language and ToM tests and a visual task devoted to promoting cognitive or affective inferences. We proposed that MS individuals will show 1) lower performance than healthy controls in the tests and 2) more difficulties in making pragmatic inferences than logical inferences in the visual versus verbal tasks [15]. Indeed, according to the semiotic approach of Bachimont [16], an image is a sign that “shows” but not a sign that “says”, in contrast to the linguistic approach. The linguistic sign is characterized by an arbitrary relationship between the “signifier” and the “signified” content. An image is strongly related to the “signified” content, which involves a strong analogy to the visible world. Thus, an image is not the equivalent of words. Bachimont concludes that images must be associated with an explicit “semiotization”. Accordingly, a few seconds are sufficient to develop some meaning from the vision of an image. Considering this

deeply, more complex meanings and more sophisticated sequences of meanings can be reached. This process of interpretation is probably impaired in MS, especially for pragmatics. Finally, we discuss a potential effect of disease duration (short vs long evolution) on MS individuals' performance, according to the approach of Banati et al. [6].

Materials and methods

This study was conducted in accordance with the Helsinki declaration. Consent for participation was obtained from all participants and their privacy rights were observed.

Participants

We performed a cross-sectional study of MS participants [17] from the neurological department of the University Hospital of Saint Etienne who were recruited from September 2014 to March 2015 from the EDMUS database. Included criteria were 1) French mother tongue, 2) age 25 to 45 years, 3) education level greater than 9 years, 4) absence of comorbidities (psychiatric, neurological), 5) absence of sensory disorders providing communication troubles, 6) preserved cognitive efficiency and 7) absence of language disorders. We recruited healthy controls from the general population and matched them to MS participants (1:1) on the same criteria.

Preliminary neuropsychological measures

A battery of preliminary neuropsychological tests was administered to all subjects to identify and eliminate impairments in 1) global cognitive efficiency, 2) oral and written comprehension or 3) verbal working memory. Concerning cognitive efficiency, participants were excluded if they obtained a Montreal Cognitive Assessment [19] score < 26 (oral and written comprehension were evaluated for both lexical and syntactic aspects, with the 5 most

difficult items from the tasks dedicated to these functions from the French battery MT 86 [Protocole Montréal-Toulouse d'examen linguistique de l'aphasie (20)]. Written comprehension of a text was assessed by reading aloud a text from the MT 86. Finally, working memory skills, especially the phonological loop functioning, were checked with the sentences repetition task (Boston Diagnostic Aphasia Examination [21]). The results are summarized in the Table.

Experimental testing

Participants who responded to criteria of the preliminary assessment underwent the main test phase of the study. The variables are presented in the Figure.

- *Similarities of the WAIS-IV* [22]: this task aimed at measuring verbal concept formation and reasoning. Two words representing common objects or concepts are presented to the subject who is asked to describe how similar they are.

- *Written inferences comprehension* (on the reception side)

- *Implicit Information Management Test, part B* (La gestion de l'implicite [23]): assessment of the ability to comprehend written textual inferences. We presented 20 short texts describing a verbal interaction or a scene involving interlocutors. Participants were asked to read and answer verbally 3 questions about the text by responding "Yes", "No" or "I cannot answer". Questions were subdivided into 5 categories (explicit, logical, distractor, pragmatic and others), which require different types of reasoning. These questions allow for determining whether the participant has made the inference.

- *Narrative Discourse Task*, taken from the Protocole Montréal d'évaluation de la Compréhension de Poche [24]: this test also assesses the abilities to make inferences from a text. It consists of listening to a text and repeating the story paragraph after paragraph. This first step allows for checking the ability to memorize and understand complex linguistic

information as well as narrative discourse skills. Then, the subject has to summarize the full story and give it a title. Eventually, the subject is asked to answer questions concerning the text comprehension. Using all these answers, the experimenter evaluates whether the inferences have been made.

- *Visual inferences comprehension* (on the side of the reception)

Visual Inferences Test (created by Nathalie Bedoin): a picture A is presented to the subject showing the beginning of a scene. Then, a picture B appears representing the end of the story. Subjects are asked to choose, among 3 pictures, the one that best explains what happened in between pictures A and B, proceeding to a creation of an inference, cognitive or emotional.

- *Theory of mind*

Test of social faux pas (Mini-SEA [25]): consists of 10 short stories, 5 including a faux pas (“hits”) and 5 not including a faux pas (“rejects”). In the first set, a character unwittingly says something socially inappropriate that might hurt someone. After reading aloud the text to subjects, they first answer a question (Does someone say something he or she should not have said or something awkward?) and questions about understanding the “faux pas” (author of awkwardness, content and cause of the faux pas and emotional mental states of the victim). Second, 2 control questions are asked to verify the comprehension of the explicit elements of the story.

Procedure

The assessment involved 2 sessions, first for the consent form and the preliminary neuropsychological evaluation and second for the experimental testing.

Statistical analysis

To compare the MS participants and control scores for all the tests, we used nonparametric analysis with the Mann-Whitney test for independent samples. Other intragroup analyses involved the Wilcoxon test. Correlations between variables were evaluated by the Spearman correlation coefficient. The Bonferroni correction was applied to adjust the number of comparisons ($p=0.0083$). We used Statistica for all analyses. $P<0.05$ was considered statistically significant.

Results

Among the 21 MS participants included, 19 had relapsing-remitting MS, one secondary-progressive MS and one primary-progressive MS. The mean (SD) Expanded Disability Status Scale [18] score was 4.2 (2) (range 1 to 7.5) and mean disease evolution 10 (7) years (range 2 to 24). MS participants and the 21 healthy controls did not differ in age, education level or preliminary neuropsychological measures (Table). However, the ToM total score but not subscores (hits, rejects and control questions) was lower for MS participants than controls ($Z = 2.7$; $p = 0.006$).

Concerning pragmatic language skills, Narrative Discourse Task scores did not differ between MS participants and controls. However, MS participants performed significantly lower than controls only for the questions “other” on the Implicit Information Management Test ($Z = 2.29$; $p = 0.02$). Nevertheless, MS participants performed significantly poorer in logical than pragmatic inferences ($Z = 2.39$; $p = 0.016$), which was not the case for control participants. Similarly, the 2 groups did not differ on the Visual Inferences Test for all measures, but for MS participants, pragmatic items were significantly less well-performed than logical items ($Z = 2.35$; $p = 0.018$).

Concerning a possible effect of disease duration, subgroup analysis (short vs long disease duration) showed no differences in the Faux Pas Test (hits, total score), Visual Inferences Test (pragmatic inferences, logical inferences) or Implicit Information Management Test (total score, pragmatic inferences, logical inferences).

Within the MS group, we found a correlation between the total score of the Implicit Information Management Test and the total score of the faux pas test ($r = 0.64$; $p=0.001$) and subscore “hits” ($r = 0.67$; $p = 0.0008$). We found no correlation between similarities and pragmatic inferences and logical inferences for both groups.

Discussion

The main purpose of the current study was to evaluate pragmatic and ToM skills in individuals with MS and to investigate their ability to create inferences according to different mediums. Individuals with MS and healthy controls did not differ in the ability to make inferences from a visual task (Visual Inferences Task). However, only the MS group showed lower performance for making pragmatic than logical inferences.

Pragmatic inference generation is a complex process involving several cognitive operations [26]. It requires especially attention skills to select and integrate relevant clues from the context and to associate them with our general knowledge. Our result seems to indicate that MS individuals can fail to extract and process non-verbal contextual cues providing elements to understand a chain of events, for instance, the interaction between protagonists or facial expressions. Yet, other findings suggest that MS individuals underperform healthy controls in facial emotion recognition tasks [2, 5, 27], especially anger and fear [5], and in emotional awareness [27]. Furthermore, the reasoning process allows for understanding actions and requires access to the knowledge or facts concerning the protagonist or the contextual circumstances. According to the situation, several meanings can

be deduced from the same facial expression. Seeing somebody crying drives one to deduce an internal sadness, but placed in a happy context, the protagonist's tears will be interpreted as the expression of a feeling of enjoyment. Then, the reasoning process requires a wider functioning in addition to the decoding [28]. Visuospatial processing, selective attention and organization of each element are required for the analysis and comprehension of pictorial inferences within a given context [29]. Evidence suggests an impairment in these cognitive domains in MS individuals [30].

Concerning pragmatic language assessment, the results of the Narrative Discourse Task taken from the MEC-P [24] revealed no significant differences in both inter- and intragroup analyses. Similarly, the Implicit Information Management Test [23] did not discriminate the MS from the control group for the global score and subscores (explicit and distractive questions, logical and pragmatic inferences). However, only the MS group showed a significant difference in performance between pragmatic and logical inferences. In the verbal modality, pragmatic elements included in the statement did not suggest difficulties for MS individuals, contrary to the processing of the literal utterance. Making logical inferences is based on the text and is involved in deductive and inductive reasoning, which allow for establishing a relationship between premises and conclusion [31]. We can link this result to reasoning difficulties, especially on non-verbal modality, as previously noted [4]. Besides, to determine a potential link between scores obtained for logical and pragmatic inferences and the similarities subtest (WAIS IV), a correlation analysis appeared non-conclusive. We did not observe any connections with this explicit verbal reasoning task.

Concerning ToM abilities, the global score obtained in the Faux Pas Test [25] enabled differentiation of the 2 groups, with lower performance for MS individuals. This result corroborates other conclusions [6], even though the literature data appear inconsistent. The discriminating power of this task appears to diverge according to the methodology used [2, 5,

6, 15, 27, 32]. Cotter et al. [2] highlighted the alterations endured by this subtle task through translation, modifications and child version use.

We divided the MS group into 2 subgroups according to disease evolution, short or long, to verify the impact of this variable on examined functions. Despite being matched on demographic and cognitive criteria, the 2 subgroups did not differ in the tests examined, which corroborates the result of Banati et al. [6]. ToM and pragmatic language difficulties seem present at the very beginning of the disease course. Nevertheless, the weakness of our sub-group size suggests caution with this interpretation.

We hypothesized potential links between the mechanisms engaged in pragmatic language (Implicit Information Management Test) and ToM tasks (Faux Pas Test) and we found a significant correlation between these 2 verbal tasks. Proofs of this link are available in the literature. Monetta and Champagne [12] reviewed the different hypotheses that may explain the cognitive processes underlying verbal communication disorders after right hemisphere damage, including PL deficits, and one concerns a ToM deficit participation. Bambini et al. [13] demonstrated a stronger link between pragmatic and social cognition deficits than pragmatic and executive deficits in individuals with amyotrophic lateral sclerosis. Carotenuto et al. [9] found similar relations, but they blamed the basic cognitive assessment used. In schizophrenia, Bambini et al. [14] showed an interplay of cognition and social cognition in pragmatic functioning. Others propose a global approach to understand social cognition mechanisms and disturbances, considering a strong implication of multiple cognitive processes [33], especially executive functioning [34].

These arguments give rise to a limitation of our study. We selected participants according to demographic and cognitive criteria to eliminate the presence of a non-social cognitive disorder. Nevertheless, this preliminary evaluation did not include a specific investigation of executive functioning or subtle cognitive components and appears

insufficient. Research has highlighted an intimate relationship between an inferential process for both pragmatic and logical inferences and cognitive functions, especially working memory [35, 36], yet working memory deficits are now accepted to occur in MS [37, 30]. Further investigations are required to determine potential cognitive implications involved in both pragmatic and logical inferences.

Our study has other possible limitations. The results were based on a small sample size. Moreover, our included criteria did not take in account the phenotype of MS, and 2 of 21 participants had progressive MS phenotypes. This element may have had an impact on the group results. Some findings show a disease subtype effect on social cognition performance [5, 27]. Additionally, because most of our participants had relapsing-remitting MS, we cannot generalize our results to all individuals with MS. Finally, intragroup comparisons must be considered with caution in the absence of intergroup differences. This lack of result can be due to a ceiling effect in several tasks (Visual Interferences Test, Implicit Information Management Test). Despite this observation, these findings result in specific weaknesses for processing some kinds of inferences. These preliminary findings need further investigations with the use of more appropriate tools.

For Bora et al. [5], social cognition disruption in MS seems multifactorial, with non-specific (cognitive disorders, fatigue) and specific factors (anomalies within the cerebral regions involved in social cognition). Few studies have investigated the association between irregularities within cerebral imaging and performances in social cognition in MS, particularly through tasks of emotion recognition [38]. A recent study [39] showed that impairment on the Faux Pas Recognition Test in individuals with dementia with Lewy bodies was correlated with atrophy mostly of right structures including frontal regions (right medial frontal gyrus). Hamel and Joannette [40] revealed that individuals with right-hemisphere damage present significantly more difficulties in making inferences, both pragmatic and logical, than those

with a left-hemisphere lesion. Otherwise, results obtained from near infrared spectroscopy among participants without neurological disorders reveal a broad cerebral implication when making logical inference tasks, especially in bilateral frontal areas. These data seem to indicate an anatomical proximity between the regions underlying pragmatics and ToM.

Conclusion

This study highlights the existence of ToM and pragmatic language difficulties and a link between these skills in individuals with MS via a disturbance in making inferences. The type of inference affected depends on the elements provided by the situation, according to its visual or verbal nature. Logical inferences seem to be more in deficit when the information is provided verbally, whereas pragmatic inferences are involved with problems in visual tasks. These results might be qualified considering the lack of differences between performance between MS individuals and controls in pragmatic tasks. Nevertheless, it appears necessary to take into account social disturbance in MS individuals and therefore increase the number of studies in this field, especially in terms of the pragmatic.

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Legend

Figure. Experimental measures for individuals with multiple sclerosis (MS) and healthy controls (HCs). Data are mean (SD). * $p < 0.05$

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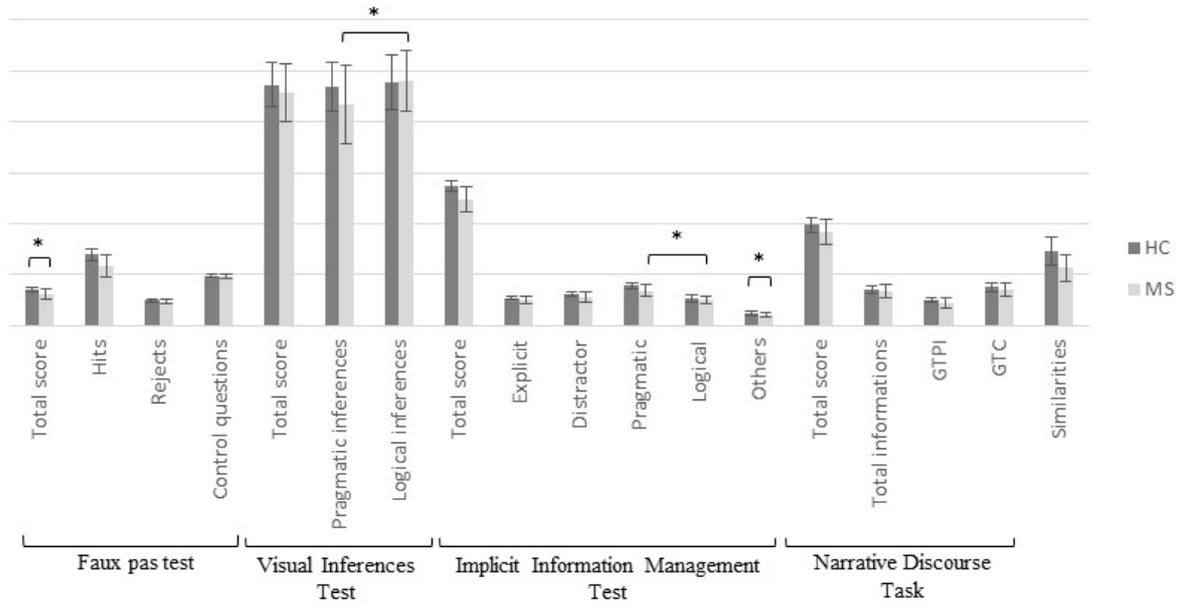
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Figure

Table 1. Preliminary neuropsychological tests for healthy controls and individuals with multiple sclerosis (MS)

Demographic characteristics	Healthy controls (n=21)	MS individuals (n=21)
Sex		
Male	5	6
Female	16	15
Age, years	33.9 (7)	38.8 (5.5)
Education, years	15.1 (2.3)	13.1 (2.4)
MoCa	28.5 (1.36)	26.9 (2.5)
Sentence repetition task (BDAE)	16 (0)	15.14 (1.7)
MT 86		
Lexical awareness in OC	4.8 (0.35)	4.8 (0.35)
Syntactic awareness in OC	4.9 (0.43)	4.6 (0.74)
Lexical awareness in WC	5 (0)	4.85 (0.65)
Syntactic awareness in WC	5 (0)	4.7 (0.78)
Text comprehension	5.3 (0.86)	5.4 (0.69)

Data are mean (SD).

MoCa, Montreal Cognitive Assessment; MT 86, Protocole Montréal-Toulouse d'examen linguistique de l'aphasie; BDAE, Boston Diagnostic Aphasia Examination; OC, Oral Comprehension; WC, Written Comprehension