Multimodal emotion perception in young and elderly patients with multiple sclerosis

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Abstract

Background. Studies suggest that emotion recognition and empathy are impaired in patients with MS (pwMS). Nonetheless, most studies of emotion recognition have used facial stimuli, are restricted to young samples, and rely self-report assessments of empathy. The aims of this study are to determine the impact of MS and age on multimodal emotion recognition (facial emotions and vocal emotional bursts) and on socioemotional sensitivity (as reported by the participants and their informants). We also aim to investigate the associations between emotion recognition, socioemotional sensitivity, and cognitive measures.

Methods. We recruited 13 young healthy controls (HC), 14 young pwMS, 14 elderly HC and 15 elderly pwMS. They underwent a short neuropsychological battery, an experimental emotion recognition task including facial emotions and vocal emotional bursts. Both participants and their study informants completed the Revised-Self Monitoring Scale (RSMS) to assess the participant's socioemotional sensitivity.

Results. There was a significant effect of age and group on recognition of both facial emotions and emotional vocal bursts, HC performing significantly better than pwMS, and young participants performing better than elderly participants (no interaction effect). The same effects were observed on self-reported socioemotional sensitivity. However, lower socioemotional sensitivity in pwMS was not reported by the informants. Finally, multimodal emotion recognition did not correlate with socioemotional sensitivity, but it correlated with global cognitive severity.

Conclusion. PwMS present with multimodal emotion perception deficits. Our results extend previous findings of decreased emotion perception and empathy to a group of elderly pwMS, in which advancing age does not accentuate these deficits. However, the decreased socioemotional sensitivity reported by pwMS does not appear to be observed by their relatives, nor to correlate

with their emotion perception impairments. Future studies should investigate the real-life impacts of emotion perception deficits in pwMS.

Keywords: Multiple sclerosis; aging, social cognition, emotion, empathy, neuropsychology

Highlights:

- pwMS present lower multimodal emotion recognition and socioemotional sensitivity.

-These effects are observed similarly in both young and elderly pwMS.

-Informants do not report lower socioemotional sensitivity in pwMS.

-Multimodal emotion recognition correlates with global cognitive impairment in pwMS.

1. Introduction

Multiple sclerosis (MS) is a chronic, inflammatory, demyelinating, and neurodegenerative disease of the central nervous system (Filippi et al., 2018). Patients with MS (pwMS) present with sensory, motor, neuropsychiatric and cognitive deficits. These impairments can lead to difficulties in daily functioning, relationships, work and leisure activities which are associated to reduced quality of life. Studies have reported that up to 70% of pwMS present with some type of cognitive dysfunction (Chiaravalloti & DeLuca, 2008).

In addition to being impaired on traditional cognitive domains such as processing speed, episodic memory, attention and executive function, it has been shown in the last decade that pwMS also present with social cognition impairments. For example, pwMS show significant deficits in emotion perception (Bora, Özakbaş, Velakoulis, & Walterfang, 2016; Cotter et al., 2016), an individual's ability to detect, discriminate and identify the emotional states of other people. Previous meta-analyses report low to moderate effect sizes for facial emotion recognition impairments in pwMS (Bora et al., 2016; Cotter et al., 2016). The severity of these impairments would be comparable in magnitude to non-social cognitive deficits (Bora et al., 2016; Cotter et al., 2016; Henry & Beatty, 2006; Prakash, Snook, Lewis, Motl, & Kramer, 2008). When looking at individual emotions, social perception deficits would be particularly important for fear, anger (Bora et al., 2016; Cotter et al., 2016) and sadness (Cotter et al., 2016). Previous studies have also investigated which demographic variables and disease characteristics might be associated with such impairments, but relationships with physical disability, disease duration, fatigue and depression are inconsistent (Bora et al., 2016; Cotter et al., 2016). Evidence to date also suggests that facial emotion impairments may occur both independently and secondary to non-social cognitive deficits (Bora et al., 2016; Cotter et al., 2016).

Nonetheless, a few questions remain unanswered regarding emotion perception deficits in MS. First, while facial emotion perception has been extensively studied, the other modalities of emotion perception have rarely been investigated. In real-life settings, individuals don't only rely on others' facial expressions to perceive emotions: they also rely on other cues such as voice and language (prosody, vocal emotional bursts) and body language (posture, gestures). Preliminary evidence shows that deficits in emotion recognition from prosody and body language is also impaired in pwMS (Beatty, Orbelo, Sorocco, & Ross, 2003; Cecchetto et al., 2014; Kraemer et al., 2013). However, the emotion perception from vocal emotional bursts (Belin, Fillion-Bilodeau, & Gosselin, 2008) hasn't been investigated in this population. Furthermore, the real-life impacts of emotion perception deficits in pwMS have been overlooked. Social cognition models suggest that emotional perceptual failure could lead to empathy and social behavior impairments (Henry, von Hippel, Molenberghs, Lee, & Sachdev, 2016). When social cues are missed or misinterpreted, individuals might respond inappropriately (i.e. poor social tact or manners, lack of empathy, communication difficulties, decreased prosocial behavior, etc.) (Henry et al., 2016). While decreased empathy has been reported in pwMS (Almeida, Going, & Fragoso, 2016; Kraemer et al., 2013; Patil, Young, Sinay, & Gleichgerrcht, 2017; Pitteri et al., 2019), most studies have used self-reported questionnaires. To support this finding, it would be critical to investigate if relatives of pwMS also perceive lower empathy. Finally, most studies of emotion perception in MS have been conducted in young adults. While most cases of MS are diagnosed between 20 and 40 years old, an increased incidence of MS in individuals aged 50 years and over has been reported (Solaro et al., 2015). Furthermore, due to advances in treatment, life expectancy of pwMS is increasing (Buhse, 2015; Sanai et al., 2016; Vaughn et al., 2019). Because of that, it is critical to study older pwMS and to understand the isolated and combined effects of age and MS on cognition. A previous

study from our group demonstrated an interaction between the presence of MS and age on executive functions, information processing speed and working memory (but not episodic memory). This signifies that the decline in these functions observed in MS is accentuated by advancing age (Tremblay et al., 2020). Other studies have only found such an interaction for motor abilities (Roy et al., 2017) and not for cognitive functions (Leclercq et al., 2014; Roy et al., 2017). Nonetheless, emotion perception has never been investigated in older pwMS. Although Cotter and colleagues reported in their meta-analysis that older age is associated with greater deficits in facial emotion recognition in pwMS, all the included studies comprised relatively young groups with mean ages between 20 and 50 years old (Cotter et al., 2016).

The first aim of this study is to determine the impact of MS and age on multimodal emotion recognition. To do so, we will compare young and old pwMS and HC on two experimental emotion recognition tasks: one using pictures of facial emotions and one using vocal emotional bursts. We hypothesize that pwMS will be impaired in both modalities. The second aim of this study is to investigate if specific emotions are more incorrectly recognized in pwMS. Based on previous literature, we hypothesize that recognition of fear, anger and sadness will be particularly impaired in pwMS. The third aim of this study is to determine the impact of MS and age on socioemotional sensitivity, as assessed by both the participants and their informant with the Revised Self-Monitoring Scale (RSMS). We hypothesize that socioemotional sensitivity will be reduced in pwMS, in comparison to HC. The fourth aim is to explore the associations between emotion perception, socioemotional sensitivity, and cognitive measures.

2. Methods

2.1 Participants

All participants were involved in a larger study assessing the effect of aging in MS cognitive functioning and agreed to be contacted to participate in other research projects (see (Tremblay et al., 2020) for a detailed description of the selection procedure). The project was approved by the CHUM ethics committee.

2.2.1 Participants with MS. Twenty-nine (29) pwMS were recruited from the MS Clinic of the *Centre Hospitalier de l'Université de Montréal (CHUM).* To be included in the study, pwMS had to meet the following criteria: (1) relapsing-remitting MS (RRMS), or secondary progressive MS (SPMS), or primary progressive MS (PPMS) according to MacDonald's criteria (Polman et al., 2005) ; (2) a maximum score of 7.0 on the Expanded Disability Status Scale (EDSS); (3) fluent in French; (4) able to provide informed consent. Participants with any of the following criteria were excluded: (1) neurological disorders other than MS, psychiatric or other disorders, that may interfere with cognitive functioning; (2) major depression and / or significant symptoms of depression; (3) drug or alcohol abuse; (4) sensory or motor deficits that can interfere with neuropsychological assessment; (5) MS relapse in the last 3 months (90 days); (6) a change in MS-specific medication in the past 3 months (90 days); (7) history of a neurodevelopmental disorder (e.g., ADHD, learning disabilities).

2.2.2 Control subjects. Twenty-seven (27) healthy control subjects (HC), matched for age and sex, were recruited through internet post and announcement, and CHUM staff and relatives. In order to be included in the project, these participants had to be fluent in French and aged 18 years and over. Candidates were excluded if they had any of the following criteria: (1) neurological disease, psychiatric disorder or other conditions that could interfere with cognitive functioning;

(2) major depression and / or significant symptoms of depression; (3) drug or alcohol abuse; (4) sensory or motor deficits that can interfere with neuropsychological assessment; (5) history of a neurodevelopmental disorder (e.g., ADHD, learning disabilities).

2.2 Clinical and cognitive assessment

2.2.1 Procedure. As mentioned before, all participants were involved in a larger study assessing the effect of aging in MS cognitive functioning and agreed to be contacted to participate in other research projects. They were contacted by phone and the new study was explained. If they agreed, an appointment was scheduled. Depending on the availability and mobility of the participants, the evaluations took place either at the *CHUM, the Université du Québec à Montréal (UQAM)* or at the participant's home. First, the consent form was explained, any questions were answered, and the form was signed by the participant. Then the cognitive tasks were administered by a graduate student trained in neuropsychology, supervised by a licensed and qualified neuropsychologist (Quebec Licensing Board for psychologist, I.R.). The assessment session lasted approximately 1.5h (duration may have varied depending on the level of fatigue and the rapidity of each participant). A financial compensation of $40 was given to each participant after the evaluation session was completed

2.2.2 Psychological questionnaires. Questionnaires were administered to control the effect of some confounding variables that could have an impact on cognitive performance: the Beck Depression Index Fast Screen (BDI-FS) was completed to rule out the presence of depressive symptoms (Beck, Steer, & Brown, 1987); the Modified Fatigue Impact Scale (MFIS) was administered to measure the level of fatigue (Fisk, Pontefract, Ritvo, Archibald, & Murray, 1994).

2.2.3. Neuropsychological evaluation. The Montreal Cognitive Assessment (MoCA) was administered to all participants to obtain an overall measure of cognitive functioning (Nasreddine

et al., 2005). Executive functions and information processing speed were assessed with the DKEFS Color-Word Interference Test (Delis, Kaplan, & Kramer, 2001)and the Symbol Digit Modalities Test (SDMT: (Smith, 1973)). The Brief Test of Attention (BTA; (Schretlen, Bobholz, & Brandt, 1996)) was administered to measure auditory divided attention without the influence of motor speed, which can be affected in MS patients. The short version of the Benton Facial Recognition Test (Benton et al., 1994) was also administered to rule out the presence of face processing deficits, which could affect performance on the facial emotion recognition task.

2.2.4. Social cognition evaluation. An experimental multimodal emotion recognition task was administered to all participants. The task included 28 facial emotions pictures from the NimStim stimuli set (Tottenham et al., 2009) and 28 vocal emotional burst sounds from the Montreal Affective Voices stimuli set (Belin et al. 2008). These two stimuli sets have seven emotions in common, which were used in the present study: neutral, happiness, sadness, anger, fear, surprise and disgust. Each emotion was presented eight times (four pictures and four sounds). Half of the stimuli were from male actors and the other half of the stimuli were from female actors. The selected pictures represented actors from different races (white, black, Asian) and ethnicities (latino or not latino). Stimuli presentation alternated between two pictures and two sounds across the 56 items to allow unbiased interpretation between the two modalities. Participants either saw the picture at the top of the screen or heard the sound of the emotion. The seven possible emotional labels were presented in a large font at the bottom of the screen, always in the same order. Participants were asked to select the most appropriate emotion for each of the stimuli and no feedback was given during the task. Repetition of the auditory stimuli was possible if required by the participant.

In addition to the emotion recognition task, both participants and their informants filled the Revised Self-Monitoring Scale (RSMS), a well-validated socioemotional sensitivity questionnaire (Lennox & Wolfe, 1984). The French version of the RSMS, which was shown to be psychometrically robust, was used (Myszkowski et al., 2014). It comprises 13 items answered using a 6-point Likert scale ranging from "Totally disagree" to "Totally agree". It includes items on the individual's sensitivity to expressive behavior (sample item: "The patient is often able to correctly read people's true emotions through their eyes.") and ability to modify their self-presentation (sample item: "I have the ability to control the way I come across to people, depending on the impression I wish to give them.").

2.3 Analyses

Preliminary analyses were performed in order to compare pwMS to HC on demographic variables (age, gender, education) and variables such as fatigue and depression. F tests were performed with continuous variables (age, education, fatigue and depression). Chi-Square analyses were performed with dichotomous and categorical variables (sex and clinical form of MS).

To investigate the effect of group (HC vs pwMS), age (young vs elderly participants) and the group x age interaction on social cognition measures, two-way ANOVAs were carried. Each of the social cognition measure (continuous variables) were introduced as dependent variables, while age and group were introduced as dichotomous independent variables. Independent samples t-test will also be used to compared HC and pwMS on recognition of individual emotions.

To investigate the associations between multimodal emotion recognition, socioemotional sensitivity, neuropsychological and other variables related to MS, partial correlations controlling for age were carried in pwMS only.

3. Results

3.1 Participants

The demographic characteristics of the participants are presented in Table 1. As expected, there was no significant difference between pwMS and HC in terms of age and education. To examine the effect of age, HC and pwMS groups were divided into young and elderly subgroups. No significant differences were noted in terms of age, sex and education between HC and pwMS in young and elderly subgroups. However, there was a significant difference between the pwMS group and the HC group in depression and fatigue. Post-hoc tests showed no difference between young HC and pwMS for both depression and fatigue but significant difference between elderly HC vs pwMS (BDI: $p = .004$; MFIS: $p = .002$).

Finally, elderly were significantly more disabled than young pwMS (EDSS: $F[1,27] = 19.02$, $p < .001$) and had a longer disease duration ($F[1,27] = 7.13$, $p = .013$). As expected, the repartition of MS subtypes was different between young and elderly pwMS (($\chi 2$ [2]=8.78, $p = .012$), SPMS subtype being more frequent in the elderly group.

There was no statistical difference between NC and pwMS for overall cognitive functioning, auditory sustained attention and face processing abilities. However, performance on executive functions and speed of information processing tests were statistically poorer in pwMS than in HC. For these two measures, post-hoc tests showed no difference between young HC and pwMS but significant difference between elderly HC vs pwMS (SDMT: $p = .033$; Stroop-inhibition: $p = .022$).

3.2 Impact of group and age on multimodal emotion recognition

Results are presented in Figure 1A. For the total multimodal emotion recognition score, a significant effect of group ($F [1, 52] = 7.52$, $p < 0.01$, partial $\eta^2 = .13$) and age ($F [1, 52] = 32.2$, p

< 0.001, partial η^2 = .38) was found, with no interaction effect (F [1, 52] = 0.0, p = .959). HC performed significantly better than pwMS, and young participants performed better than elderly participants. Because between-group differences were observed for fatigue and depression scores, we ran an additional analysis, this time controlling for these two scores. Both the group and age effects remained significant, albeit with lower p values.

When considering modalities separately, a significant effect of group (F [1, 52] = 4.62, p < 0.05, partial η^2 = .08) and age (F [1, 52] = 15.2, p < 0.001, partial η^2 = .23) was also found on the facial emotions' pictures recognition score, with no interaction effect (F [1, 52] = 0.4, p = .556). There was also a significant effect of group (F [1, 52] = 4.75, p < 0.05, partial η^2 = .08) and age (F [1, 52] = 25.2, p < 0.001, partial η^2 = .33) was also found on the vocal emotional bursts' recognition score, with no interaction effect (F [1, 52] = 0.4, p = .524).

3.3 Emotion recognition for specific emotions in pwMS vs. HC

When considering emotions separately, performance was significantly lower in pwMS, in comparison to HC, for three different emotions: disgust, fear and anger (p < 0.05) (Figure 2). The recognition of the remaining emotions was not significantly different between the two groups (sadness (p = .899), surprise (p = .337), joy (p = .574), neutral (p = .732)).

3.4 Impact of group and age on socioemotional sensitivity

Results are presented in Figure 3.

For the self-reported socioemotional sensitivity score, a significant effect of group (F [1, 51] = 14.2, p < 0.001, partial η^2 = .22) and age (F [1, 51] = 12.3, p < 0.001, partial η^2 = .19) was found, with no interaction effect (F [1, 51] = 0.9, p = .350). HC report higher socioemotional sensitivity than pwMS, and young participants report higher socioemotional sensitivity than elderly participants.

For the socioemotional sensitivity score reported by the informant, a significant effect of age ($F [1, 48] = 9.3$, $p < 0.005$, partial $\eta^2 = .16$) was found, with no group ($F [1, 48] = 1.8$, $p = .189$) or interaction effect ($F [1, 48] = 0.7$, $p = .414$).

3.5 Correlations between social cognition, neuropsychological and other measures in pwMS

Results are presented in Table 2. Multimodal emotional recognition does not significantly correlate with socioemotional sensitivity in pwMS (controlling for age). It significantly and positively correlates with MoCA (Table 2, Figure 4), but not with any of the neuropsychological measures (BTA, SDMT, Stroop inhibition, Benton face recognition) or other variables (disease duration, depression, fatigue). Socioemotional sensitivity does not correlate with any neuropsychological or other measures.

4. Discussion

The general aims of this study were to determine the impact of MS and age on multimodal emotion perception and on socioemotional sensitivity, as well as to explore the associations between emotion perception, socioemotional sensitivity, and cognitive measures. Overall, we found effects of group (higher scores in HC vs pwMS) and age (higher scores in young vs elderly) on total, facial emotions, and vocal emotional bursts recognition. When looking at specific emotions, anger, fear, and disgust were less accurately recognized by pwMS in comparison to HC. We also found effects of group (higher scores in HC vs pwMS) and age (higher scores in young vs elderly) on self-reported socioemotional sensitivity. However, the decreased socioemotional sensitivity in pwMS was not confirmed by their relatives, as no significant difference of groups was reported on the informant-reported questionnaire. Finally, emotion recognition did not

correlate with socioemotional sensitivity when controlling for age, but it correlated with global cognitive impairment (MoCA).

Individuals rely on multiple cues when perceiving others' emotions: it is therefore critical to understand if emotion perception impairments in pwMS are specific to facial emotions, or if they are multimodal (i.e. impaired in multiple modalities or from various sensory inputs). Our study reports, for the first time, an impairment in recognizing emotions from vocal emotional bursts in pwMS. Facial emotion recognition have been consistently reported as impaired in pwMS (Bora et al., 2016; Cotter et al., 2016), and a few studies report impairments for emotional prosody as well as body postures (Beatty et al., 2003; Cecchetto et al., 2014; Kraemer et al., 2013). Together, these results suggest a multimodal emotion perception impairment in pwMS. Furthermore, the effect sizes observed in the present study for both facial emotions and vocal emotional bursts are comparable to the moderate effect sizes reported in previous meta-analyses (Bora et al., 2016; Cotter et al., 2016). Based on previous literature, we hypothesized that emotion recognition deficits would be particularly important for fear, anger, and sadness (Bora et al., 2016; Cotter et al., 2016). While we indeed observed lower performance for fear and anger in pwMS, we also found lower performance in disgust. This result is not in conflict with the literature, as these meta-analyses also reported some differences for that emotion, although at a lower significance (Bora et al., 2016; Cotter et al., 2016). We did not observe significant difference for the recognition of sadness. This might be due to the inclusion of vocal emotional bursts in our stimuli: sadness was the emotion showing the highest recognition rates in the validation study for the vocal emotional bursts (Belin et al. 2008). These different results based on the specific emotions could be due to various factors. First, they could be due to test items' features that might vary across different emotions. For example, based on stimuli validation studies (Belin et al., 2008; Tottenham

et al., 2009), items from some specific emotions appear to be easier to recognize than others for HC. Furthermore, most studies, including the present one, have not controlled for emotion intensity between the different discrete emotions (Wells, Gillespie, & Rotshtein, 2016). Such factors might affect the sensitivity to detect impairments in clinical populations such as in pwMS and future studies should attempt to control for these. Second, they could be due to the different neural substrates associated with the recognition of each discrete emotion (Fusar-Poli et al., 2009), although some studies report the consistent engagement of a common set of brain regions across different emotions (Xu, Peng, Luo, & Gong, 2021). While a few studies have aimed at identifying the neural correlates of emotion recognition in pwMS (Ciampi et al., 2018; Sabrina Golde et al., 2020; Jehna et al., 2011; Labbe et al., 2020; Mike et al., 2013; Passamonti et al., 2009), more neuroimaging studies using well-controlled emotion recognition tasks are needed to clarify this phenomenon. Our results also suggest that emotion perception impairments are correlated with general cognitive deficits, but not with other cognitive scores, disease duration, fatigue, and depression. However, our ability to detect correlations was diminished by the inclusion of age as a control variable, which was necessary due to age effects observed for most of the variables of interest. Future studies on larger sample sizes and on more homogeneous groups of pwMS should investigate these questions, as evidence to date is highly inconsistent (Bora et al., 2016; Cotter et al., 2016).

While pwMS demonstrate impairments on tests of emotion perception, it is critical to understand the real-life impacts of such deficits. Our results suggest that pwMS have decreased socioemotional sensitivity, as self-reported on a questionnaire investigating their behavior in everyday life. Previous studies using self-reported empathy questionnaires in pwMS are very conflictual, with some showing decreased (Almeida et al., 2016; Kraemer et al., 2013; Patil et al.,

2017; Pitteri et al., 2019) and others preserved empathy (Banati et al., 2010; S. Golde et al., 2020; van der Hiele et al., 2020). Nonetheless, these studies are limited by the biases associated with self-reported questionnaires, which is why we also obtained an external point of view and investigated socioemotional sensitivity as reported by relatives of pwMS. This analysis showed that socioemotional sensitivity is not lower in pwMS, in comparison to HC, when reported by informants. To our knowledge, this is the first study using informants' ratings of socioemotional sensitivity in pwMS. In another study using a story-based empathy task, pwMS also showed preserved empathy (Realmuto et al., 2019). Our study highlights the necessity to investigate empathy and/or socioemotional sensitivity using different measures beyond self-reported questionnaires. Furthermore, social cognition models suggest that emotional perceptual failure could lead to empathy and social behavior impairments (Henry et al., 2016). However, we did not find a significant association between emotion perception deficits and socioemotional sensitivity. These results might be due to a non-optimal sample to detect such correlations (due to the two age groups as previously mentioned), or they might suggest that in MS, emotion perception impairments are not severe enough to cause real-life social behavior changes that are perceptible to the patients' relatives. More studies investigating the associations between emotion perception and social behavior are necessary to truly understand the real-life impacts and clinical relevance of these deficits.

Because incidence of MS in individuals aged 50 years and over (Solaro et al., 2015) and life expectancy of pwMS (Buhse, 2015; Sanai et al., 2016; Vaughn et al., 2019) are increasing, one of the goals of this study was to confirm that social cognition impairments are also present in elderly pwMS. Overall, we found effects of group (higher scores in HC vs pwMS) and age (higher scores in young vs elderly) on total, facial emotions, and vocal emotional bursts recognition as

well as on self-reported socioemotional sensitivity. While this confirms that elderly pwMS also present with social cognition impairments, it also shows that the severity of these impairments is comparable in both age groups (no interaction effect between group and age was found). This information is highly important for prognosis: this suggest that although social cognition deficits are observed in pwMS, these impairments might not progress faster than expected in normal aging. Future studies should investigate social cognition longitudinally in pwMS to confirm this pattern. Finally, our main effects of age for both emotion recognition and socioemotional sensitivity are compatible with previous meta-analyses showing reduced performance in both domains with normal aging (Beadle & de la Vega, 2019; Ruffman, Henry, Livingstone, & Phillips, 2008).

This study has a few limitations. First, pwMS were not very impaired cognitively (MoCA of 28.4 in young pwMS and 25.7 in elderly pwMS), which might be because less cognitively impaired patients tend to accept to participate in cognitive studies more easily. Second, because we wanted to investigate the effect of both the group and age, our sample size is a bit smaller in each group, which might reduce statistical power. As previously mentioned, the correlations between our variables of interest had to be controlled for age, because most of our variables of interest correlated with age.

In conclusion, this study highlights multimodal emotion perception impairments in both young and elderly pwMS, although advancing age does not accentuate these deficits. pwMS also report lower socioemotional sensitivity, which does not appear to be observed by their relatives, nor correlated with their emotion perception impairments. This study highlights the importance of screening for social cognition impairments in pwMS in all age groups. Understanding the real-life impacts of emotion perception deficit, in terms of socioemotional sensitivity and behavior, is critical for patient care as well as for the development of potential interventions.

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Tables

Table 1. Demographic characteristics of the participants as a function of group

	Young N= 27		Elderly N=29		HC vs pwMS
	HC N=13	pwMS N=14	HC N=14	pwMS N=15	F or χ^2 p value
Age	37.3 (7.4)	32.6 (5.2)	64.9 (5.7)	64.1 (5.1)	.525
Sex (W/M)	9/4	10/4	9/5	12/3	.866
Education (years)	15.8 (2.2)	15.7 (2.4)	15.8 (2.1)	13.9 (1.9)	.088
Disability status (EDSS)	-	0.8 (1.2)	-	3.8 (2.4)	-
Disease duration (years)	-	9.2 (3.1)	-	21.7 (17.3)	-
MS course (RRMS/ SPMS/ PPMS)	-	13/0/1	-	7/7/1	-
Depression (BDI-FS)	0.2 (0.4)	1.1 (1.2)	0.8 (1.1)	3.1 (3.0)	<.001[a]
Fatigue (MFIS-Total)	7.0 (7.8)	15.1 (13.1)	11.6 (10.6)	13.1 (14.7)	<.001[a]
MoCA	28.7 (1.0)	28.4 (1.8)	27.4 (1.8)	25.7 (2.5)	.087
BTA	9.6 (0.5)	9.7 (1.3)	8.6 (1.4)	8.2 (1.2)	.176
Stroop inhibition (SS)	12.1 (2.5)	11.6 (1.7)	12.4 (1.9)	9.5 (4.5)	.021[a]
SDMT	69.9 (6.6)	66.1 (12.4)	59.4 (10.1)	49.5 (7.8)	.032[a]
Benton face recognition	24.0 (1.5)	24.2 (2.1)	22.4 (2.2)	21.9 (1.5)	.793

a: significant difference between Elderly HC and Elderly pwMS for post-hoc Tukey test

Table 2. Correlations between socio-emotional tests, neuropsychological measures and disease characteristics

	Emotion recognition - Total	RSMS (Patient)	RSMS (Informant)
Emotion recognition - Total	1		
RSMS (Patient)	0.171	1	
RSMS (Informant)	0.08	0.349	1
MoCA	**0.438***	-0.057	0.02
SDMT	0.116	0.125	0.317
BTA	0.191	-0.155	0.034
Stroop - Inhibition	-0.04	0.074	0.082
BFRT	0.318	0.105	-0.065
Disease duration	-0.209	-0.269	0.004
BDI-FS	0.089	-0.102	0.328
MFIS	-0.037	-0.215	0.334

* $p < .05$

Figures

Figure 1. Impact of group and age on multimodal emotion recognition

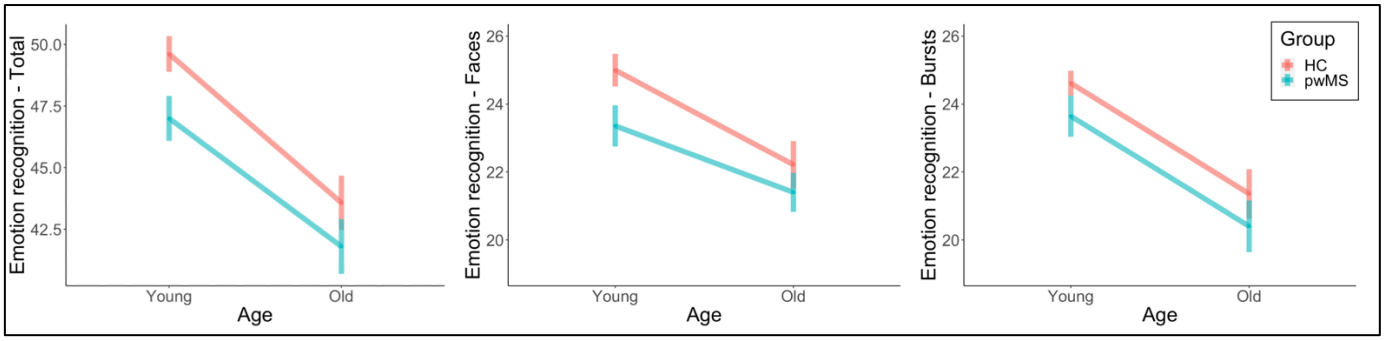


Figure 2. Emotion recognition performance for individual emotions

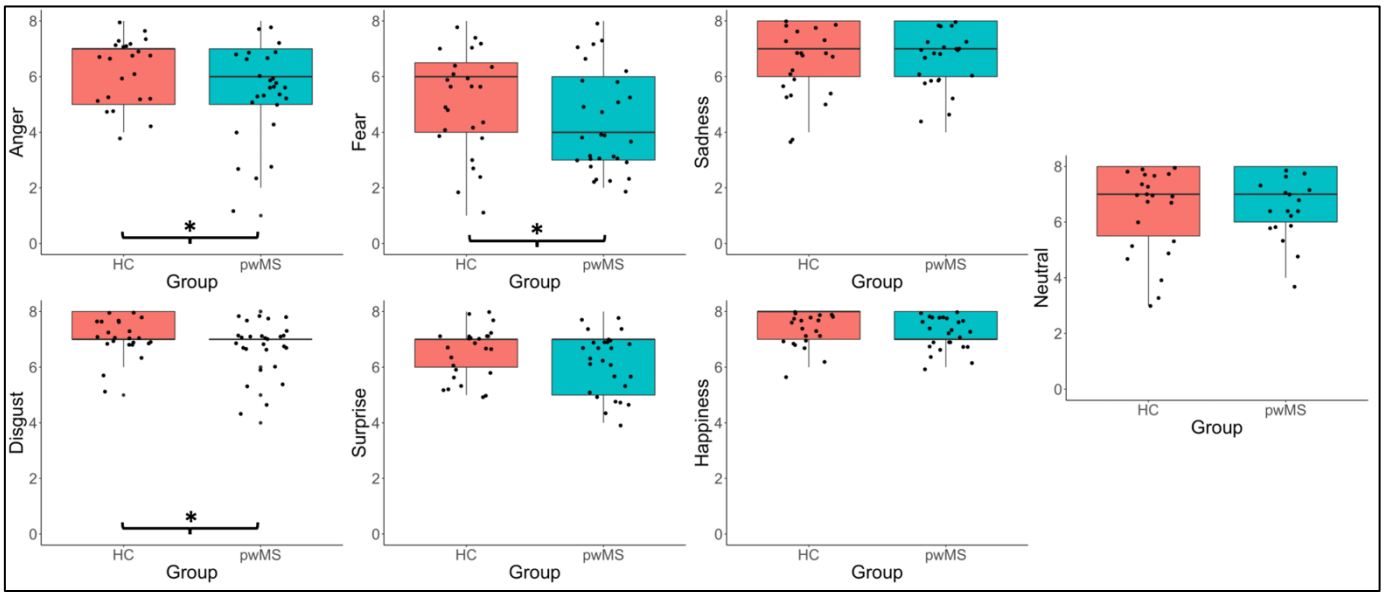


Figure 3. Impact of group and age on socioemotional sensitivity

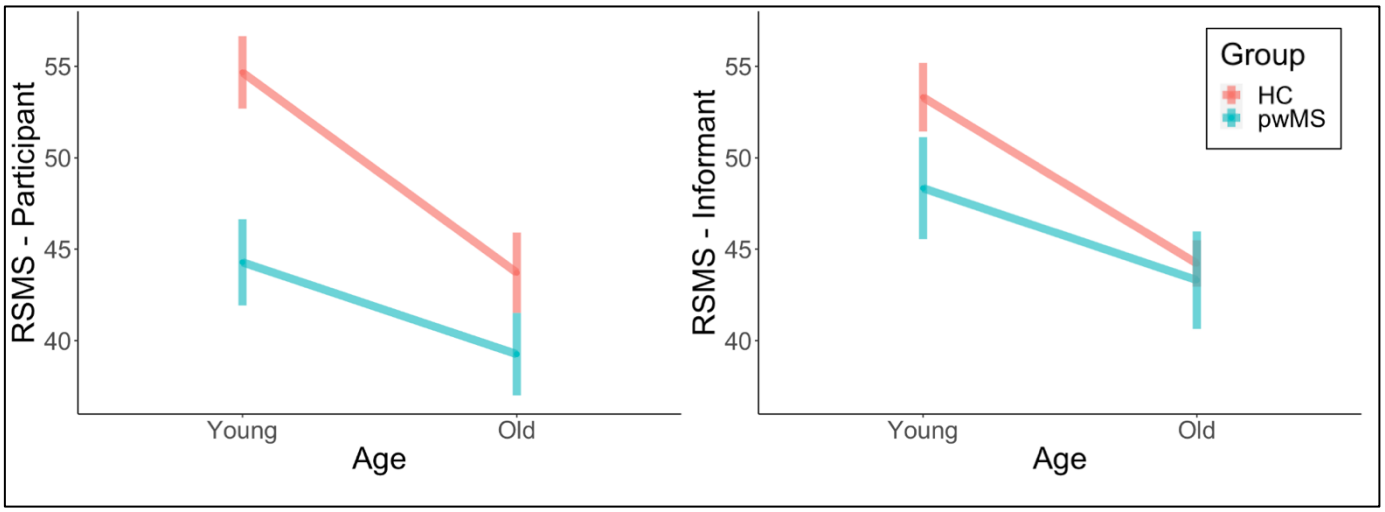
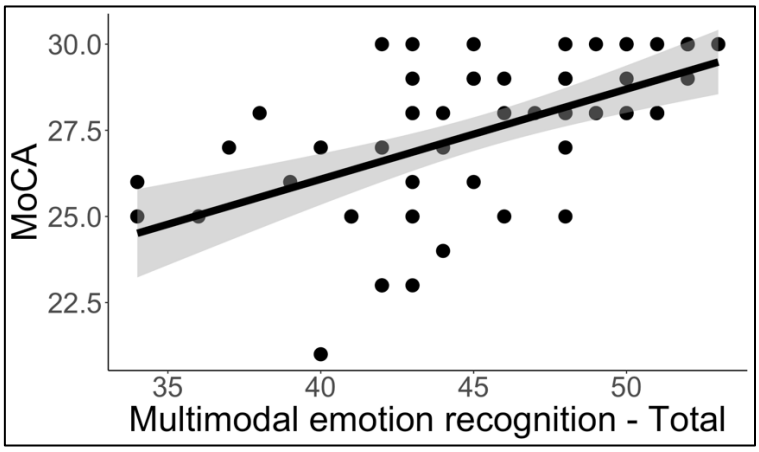


Figure 4. Correlation between multimodal emotion recognition and MoCA in pwMS



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