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Theory of mind and metacognition in migraine patients

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Abstract

Aim: Theory of Mind (ToM) and metacognition are distinct psychological constructs, involving the understanding of emotions and mental states in oneself and others. Despite their relevance, these concepts have been poorly investigated in adult migraine patients and the findings in the existing literature are inconsistent. Our objective was to assess whether the theory of mind skills and metacognitive abilities were impaired in individuals with migraine.

Materials and Methods: We included 23 individuals with Episodic Migraine (EM), 19 with Chronic Migraine (CM), and 30 Healthy Controls (HCs). To assess Theory of Mind (ToM) skills and metacognitive abilities, participants, including both EM and CM patients and HCs, completed the Beck Depression Inventory (BDI), Reading Mind in the Eyes test (RMET), and Metacognition Scale (MCQ). EM patients were evaluated interictally (the 72-hour headache-free period before and after the evaluation) and CM patients during the headache-free period.

Results: Patients with CM exhibited higher BDI scores compared to both EM patients and HCs ($p=0.018$, $p=0.032$, respectively). Furthermore, the RMET scores of CM patients were significantly lower than those of the HCs ($p=0.011$). MCQ scores did not show significant differences between the groups ($p=0.288$). Notably, MCQ scores were positively correlated with BDI scores ($r=0.42$, $p<0.0001$), and RMET scores were negatively correlated with the duration of migraine ($r=-0.46$, $p=0.003$).

Conclusion: Our findings highlight the presence of impairments in ToM skills in adult migraine patients, particularly associated with the chronicity of the disease. Managing migraine in patients should consider addressing the observed low ToM skills as part of the overall approach.

Introduction

The concepts of Theory of Mind (ToM) and metacognition encompass distinct psychological constructs involving the discernment of emotions and mental states, both within oneself and in others.

Theory of Mind (ToM) refers to one's capacity to envision the thoughts, emotions, desires, and intentions of others, using such insights to comprehend and estimate their behavior [1, 2]. Positioned within the broader framework of social cognition, ToM is instrumental in shaping our understanding, processing, and interpretation of social information, thereby influencing social interactions. On the other hand, metacognition involves the awareness and management of emotions, encompassing self-reflection and the recognition of emotions in oneself and others [1, 3].

ToM and metacognition have been studied in several psychiatric and non-psychiatric disorders. Studies have shown impairment in ToM skills to be milder in Major Depressive Disorder patients and more severe in bipolar and psychotic patients [4-6]. Findings from research underscore the existence of ToM impairments in various childhood mental and neurodevelopmental disorders. These conditions include but are not limited to autism spectrum disorders, attention deficit hyperactivity disorder, oppositional defiant disorder, Gilles de la Tourette Syndrome, mood disorders, eating disorders, and obsessive-compulsive disorder [7, 8]. It has been suggested that there are also changes

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in Theory of Mind abilities in patients with alcohol and substance addictions [9, 10]. Additionally, ToM characteristics have also been studied in chronic pain patients [11].

Emotional dysregulation, difficulties in the theory of mind, and metacognitive abilities in headaches have gained interest recently. Headache patients have been shown to have more alexithymic properties [2, 12, 13]. Based on the latter finding, metacognitive features and theory of mind abilities, which are thought to be important in emotional regulation have also been examined in migraine patients. Deficits in ToM and metacognitive abilities in pediatric patients with migraine without aura (MWoA) have been studied in several studies [1-3, 13]. However, less evidence is available in adult migraine patients. In a few studies conducted on adult migraine patients, ToM skills and metacognitive abilities were investigated in episodic/chronic migraine and medication overuse headache groups, and impairments in these social cognition skills were revealed compared to healthy controls [14-16]. Studies on social cognition in migraine subjects are not sufficient to make definitive conclusions because of inconsistent results, limited sample sizes, different methodologies, and differences in cognitive and behavioral characteristics.

We aimed to test the hypothesis that the theory of mind and metacognitive abilities were impaired in migraine patients. It was also aimed to examine whether there were differences in social cognition skills between episodic and chronic migraine groups.

Materials and Methods

This is a cross-sectional case–control study conducted at the Headache outpatient clinic of Gazi University Department of Neurology. We enrolled participants with a diagnosis of Chronic migraine (CM) or episodic migraine (EM), and age-matched healthy controls (HC). A headache specialist neurologist performed the diagnosis and the evaluation of inclusion and exclusion criteria. The inclusion criteria for patients were 18-60 years and diagnosis of EM or CM according to the International Classification of Headache Disorders, 3rd edition (ICHD-3) criteria. Of the 42 consecutive patients, 23 had episodic, and 19 had chronic migraine. We enrolled 30 HCs who reported no previous diagnosis of headache disorders after a detailed interview performed by the headache expert. We excluded participants with a diagnosis of secondary headache or other primary headache disorders, cognitive decline, mental retardation, psychosis, and current use of psychoactive drugs.

The present study was approved by the ethics committee of the Gazi University (Approval Number: 2024-131) and conforms to the ethical guidelines of the 1975 Declaration of Helsinki. Written informed consent was obtained from all participants.

The demographic and clinical aspects such as migraine duration and attack frequency per month were recorded. Participants were also administered a series of tests and scales detailed below by an expert psychologist.

The Montreal Cognitive Assessment (MOCA) test was applied to evaluate the global cognitive status and to exclude cases with cognitive impairment [17].

All participants completed the Beck Depression Inventory-II (BDI-II) to assess depressive symptoms. The total score ranges from 0–63, with higher scores reflecting higher levels of depression [18].

To evaluate theory of mind skills and metacognitive abilities, the Reading Mind in the Eyes test (RMET) and Metacognition Questionnaire (MCQ) were performed by episodic and chronic migraine patients and HCs. EM patients were assessed interictally with a 72-hour headache-free period before and after the evaluation and CM patients during the headache-free period.

The Reading Mind in the Eyes test is one of the most widely used tasks to examine the Theory of Mind. The 32-item Turkish version of the RMET has been validated and can be used to evaluate the social, cognitive, and emotional processes in adults. During the test, an image of a pair of eyes in each question is shown to the patients, and they are asked to mark the option that best describes the thought or feeling in the eyes among 4 options (one target, three distractors). Low scores indicate an impairment in ToM skills [19, 20].

Metacognition Questionnaire (MCQ) is a well-known scale that has been shown to have sufficient psychometric properties to evaluate metacognition in Turkish culture. Each item in the MCQ-30 is answered on a 4-unit grading scale with the points "(1) strongly disagree" and "(4) strongly agree". The scores that can be obtained from the scale vary between 30 and 120, and the increase in the score indicates an increase in metacognitive activity in a pathological manner [21, 22].

Statistical analysis

Statistical analyses were carried out with SPSS for Windows software (ver. 22.0; SPSS Inc., Chicago, IL, USA). Kolmogorov- Smirnov test was used to investigate the normal distribution of data. Continuous variables were shown as mean±Standard deviation (SD) or median (25-75 percentiles). Normally distributed continuous variables were analyzed with one-way ANOVA in 3 groups. Post-hoc analysis was conducted using Sidak's multiple comparisons test. Non-normally distributed continuous variables were analyzed with Kruskal-Wallis in 3 groups, and post-hoc analysis was conducted with Dunn's multiple comparisons test. Categorical variables were analyzed with Pearson's chi-square test. All possible correlations between variables were analyzed with the Pearson correlation test.

Results

In total, 23 EM (age 39.3± 10.1), 19 CM (42.6±10.7), and 30 HC (37.6±9.7) were included in our study. The groups were comparable in terms of age, sex, and educational level (p=0.265, p=0.478, p=0.300, respectively). The socio-demographic data of the groups are shown in Table 1.

The groups differed in terms of BDI scores (p=0.039). CM group had higher BDI scores (median (25.-75. Percentile), 14 (7-18)) than the EM (8 (5-11)) and HC groups (median=7 (3.75-14)) (p=0.018, p=0.032 respectively) (Figure 1). Additionally, RMET scores differed between the

Table 1. Demographic characteristics of the study population.

	CM	EM	HC	P
Age [years (mean±SD)]	42.6±10.7	39.3± 10.1	37.6±9.7	0.265
Sex				
Female (%)	73.7%	60.9%	56.7%	0.478
Male (%)	26.3%	39.1%	43.3%	
Education				
Primary school (%)	15.8	13.0	10.0	0.300
Secondary/Tertiary school (%)	5.3	26.1	10.0	
Undergraduate/graduate (%)	78.9	60.9	80.0	

CM; Chronic migraine, EM; Epizodic migraine, HC; Healthy control.

three groups (p=0.014). CM patients revealed significantly lower RMET scores (19.79±3.99) than the HC group (23.32±3.89) (p=0.011). Although RMET scores tended to be lower in the EM group (21.95±3.65) compared to the HC group, they didn't reach statistical significance (p=0.538) (Figure 2). MCQ scores were similar between the groups [CM (72.84±14.67), EM (67.57±19.27), and HC (76.04 ±14.52)] (p=0.288) (Figure 3).

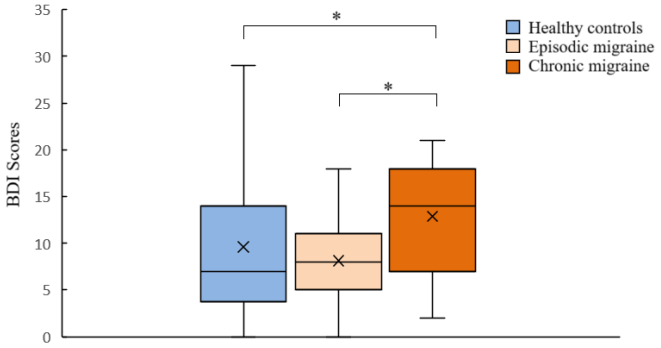

Figure 1. Whisker-box plots (whisker: full range; line: median) of the BDI scores. BDI scores of the CM patients were higher compared to EM patients and healthy controls (p = 0.018 and p = 0.032 respectively).

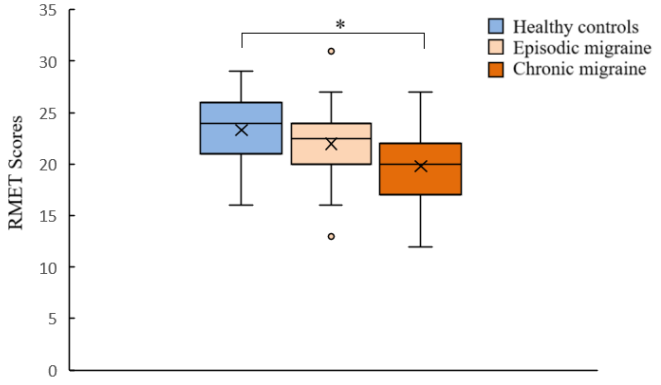

Figure 2. Whisker-box plots (whisker: full range; line: median) of the RMET scores. RMET scores of CM patients were significantly lower than those of healthy controls (p = 0.011).

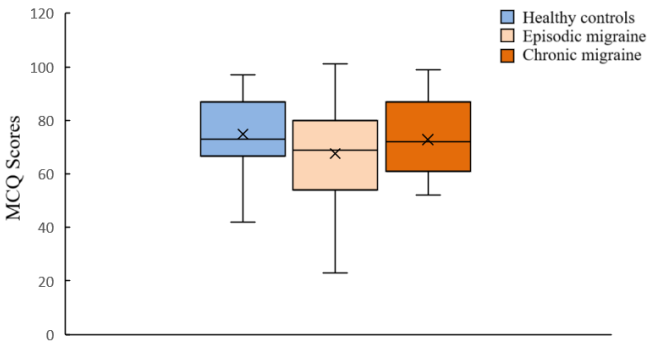

Figure 3. Whisker-box plots (whisker: full range; line: median) of the MCQ scores. MCQ scores were comparable between the three groups (p=0.288).

BDI scores were positively correlated with the number of monthly migraine headache days (r=0.42, p=0.006) and MCQ scores (r=0.42, p<0.0001). The RMET scores were negatively correlated with the duration of migraine (r=-0.46, p=0.003).

Discussion

In the current study, we revealed that CM patients have worse ToM skills than healthy controls, but are similar to normal individuals in metacognitive abilities. When episodic and chronic migraine patients were compared, they were similar in terms of ToM and metacognitive skills, whereas depression scores were higher in the chronic migraine group. Moreover, our findings highlighted the negative correlation between ToM abilities and migraine duration, in addition to the positive correlation between metacognitive skills and depression scores. The depression scores were also correlated with the number of monthly migraine days.

Our study is one of the few studies investigating ToM skills and metacognition in adult migraine patients. In 2021, Bouteloup and colleagues, in their study on a small group of patients, showed that migraine patients had difficulty understanding mental states compared to HCs [14]. Bouteloup et al. included a heterogeneous migraine group. In contrast, we focused on social cognitive skills in distinct migraine subtypes and revealed that social cognitive impairment was different in the EM and CM groups.

Later, in 2022, Raimo et al. reported that CM patients performed significantly worse than HC on tasks assessing ToM [23]. Our findings align with Raimo's outcomes in the context of CM. However, their study exclusively encompassed CM patients and there was no EM group. Their conclusion highlighted a significant correlation between ToM skills and migraine severity, along with executive and memory dysfunctions in CM patients. However, our study revealed that ToM deficits were specifically linked to the duration of the disease. Meanwhile, given that our study included only patients with normal cognition, it could be suggested that our results regarding ToM are more directly related to migraine chronicity.

Romozzi et. al. also investigated social cognition in migraine; however, their study population differed from ours. They conducted a comparison between EM and Medication-Overuse Headache (MOH) groups but did not incorporate a CM group [16]. Their observation of no difference in ToM skills between EM patients and the HC group aligns with our findings.

Recently, Bottirolli et al. reported deficits in ToM within the CM group, mirroring our findings. It's worth noting that their study cohort included patients with MOH in addition to CM [15].

Based on the ToM studies in the literature that include adult participants, our study is unique since it evaluates all EM, CM patients, and HC groups together in cognitively normal adults. This contribution adds to the existing literature in the field of ToM studies. The inclusion of patients with normal cognitive states is a strength of our study since cognitive impairment has the potential to negatively impact ToM test performance.

We observed that the existing literature on metacognitive skills focuses heavily on the adolescent group, as is the case with ToM skills [1-3, 13]. In particular, there are a limited number of studies in this field that combine data from adults with migraine [24, 25]. In a study involving adult migraine groups, Zucca et al. reported metacognitive dysfunctions associated with the chronicitization of the disease and medication overuse. They further identified a robust correlation between BDI scores and metacognitive processes, a finding that aligns with our results [24]. Previous studies have indicated a correlation between anxiety and depression and maladaptive metacognitive processes consistent with our findings. These processes, as reported, create a vulnerability in patients, leading to heightened rumination on negative thoughts and the excessive focus on distressing thoughts that may disrupt neural networks, potentially contributing to an aberrant perception and modulation of pain [26, 27].

The early onset and chronic nature of migraines are believed to exert an influence on mentalization and emotional awareness [2, 11]. Poor performance on ToM tests is hypothesized to be linked to a lack of ability or desire to explore mental states in the context of persistent pain syndromes [3, 11, 15]. In particular, migraine headaches affect social interactions, which may make patients less able to understand the mental states of others. Challenges in identifying and expressing one's emotions may contribute to the development of more negative metacognitive beliefs.

Besides chronic pain, we believe that the elevated BDI scores in our CM group have also played a role in the diminished performance on ToM tests. This aligns with existing literature indicating that social cognitive skills tend to be impaired in the presence of depression and anxiety [28]. Understanding the interplay between chronic pain, depression, and social cognition is a complex matter that necessitates comprehensive investigation through detailed studies.

Both mentalization and metacognition are regarded as integral components of executive functions, encompassing higher-order cognitive processes associated with the cerebral cortex. In particular, it has been reported that setting-shifting abilities tend to negatively affect metacognitive control processes. It is suggested that the predominantly affected cortical regions related to social cognition include the dorsolateral prefrontal cortex, ventromedial prefrontal cortex, medial frontoparietal network, and various prefrontal areas within the frontal lobe more broadly [3, 23, 29]. Neuroimaging studies related to the theory of mind have also reported that these areas are the anterior paracingulate cortex, superior temporal sulcus, and bilateral temporal poles [30].

In our study, revealing the existence of social cognitive impairment in chronic migraine patients is important in terms of developing therapeutic strategies as well as providing additional information on the pathophysiology. In this patient group, adding treatment strategies targeting metacognitive and theory of mind skills to the treatment, in addition to the treatment of accompanying psychiatric comorbidities, seems to be an appropriate approach.

Limitations

One of the limitations of our study is the relatively small sample size, which may limit the generalizability of the findings. Future studies are required in larger samples to increase external validity. The cross-sectional design of the study can also be considered a limitation. A longitudinal approach could offer insights into how ToM and metacognitive abilities may alter with the progression of migraine or treatment efficacy. Another limitation is that we did not investigate the role of prophylactic migraine treatments, medication overuse, the severity of migraine, and comorbid conditions on ToM and metacognitive abilities. To evaluate these factors, studies with larger series are needed. Although the depression scores of the participants were evaluated, the fact that additional psychological factors such as resilience or emotional intelligence, which may be related to social cognition, were not addressed in the study can be considered as another limitation.

Conclusion

In conclusion, we suggest that there are impairments in ToM and metacognition skills in adult migraine patients, especially related to the chronicity of the disease. Future studies that include different migraine subgroups will create the potential to provide additional information on pathophysiology and for the development of new treatment strategies.

Ethical approval

The present study was approved by the ethics committee of the Gazi University (Approval Number: 2024/131).

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