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Stroop test performance in individuals with chronic neck pain: Relationships with pain intensity, duration, and functional disability

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Abstract

Objective: Chronic neck pain (CNP) has traditionally been conceptualized as a predominantly sensory and musculoskeletal condition; however, growing evidence suggests that chronic pain may also influence higher-order cognitive processes. This study aimed to investigate executive function performance in individuals with CNP using the Stroop Test and to examine the associations between Stroop performance and clinical pain parameters.

Materials and methods: Twenty-five individuals with CNP and 25 age-, sex-, and education-matched healthy controls were included in this cross-sectional study. Pain intensity was assessed using the Visual Analog Scale (VAS), functional disability using the Neck Disability Index (NDI), and pain duration was recorded in months. Executive functions were evaluated using all five subtests of the Stroop Test. Group comparisons were performed, and correlations between clinical variables and Stroop performance were analyzed within the CNP group.

Results: Individuals with CNP demonstrated significantly longer completion times across all Stroop subtests compared to healthy controls ($p<0.05$), with moderate-to-large effect sizes ($r=0.40$-0.59). No significant associations were found between Stroop performance and pain intensity, pain duration, or disability level (all $p>0.05$).

Conclusion: The findings indicate that individuals with chronic neck pain exhibit impaired executive function, particularly in cognitive inhibition processes. However, this impairment does not appear to be directly explained by conventional clinical pain parameters. These results suggest that CNP may involve alterations in executive control–related neural networks and highlight the importance of incorporating cognitive assessment into the clinical evaluation of chronic neck pain.

Keywords: Chronic neck pain, Executive function, Stroop test, Cognitive inhibition, Selective attention.

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Introduction

Neck pain is the second most common musculoskeletal disorder after low back pain (1). Structural impairments involving the cervical muscles, joints, intervertebral discs, and neuromuscular junctions may contribute to the development of neck pain. In addition, aging can compromise the functional integrity of cervical structures, thereby increasing susceptibility to pain. Accordingly, advancing age is considered one of the major risk factors for neck pain (2). Conversely, excessive use of technological devices in ergonomically unfavourable postures has led to an increased prevalence of neck pain among young and middle-aged individuals (3).

Although neck pain often resolves within days or weeks, approximately 10% of cases may become chronic depending on the underlying cause (4). Chronic neck pain (CNP) results in severe disability in nearly 5% of affected individuals (5). Importantly, CNP does not solely impair the mechanical functions of the cervical spine; due to the extensive connections between cervical afferent inputs, the proprioceptive system, and the central nervous system, it may also influence postural control, sensory integration, and cognitive processes (6,7). In particular, abnormal nociceptive and proprioceptive inputs originating from the cervical region are thought to alter central network processing mechanisms and cortical resource allocation (8). These findings suggest that pain should not be regarded merely as a peripheral phenomenon, but rather as a multidimensional experience capable of modulating cognitive resource distribution.

The Stroop Test, frequently used to assess cognitive functioning, is a well-established neuropsychological paradigm that measures selective attention, cognitive inhibition, and executive control processes (9). In the Stroop task, individuals are required to suppress the automatic tendency to read a word and instead name the ink color in which it is printed, thereby engaging inhibitory control and attentional regulation mechanisms. Consequently, Stroop performance is considered a sensitive indicator of executive functions, particularly those mediated by the prefrontal cortex.

An increasing body of literature highlights alterations in cognitive functioning in individuals with chronic pain (8). The persistent presence of pain may capture attentional resources, thereby reducing the cognitive capacity available for executive functions (10). In particular, processes such as attention, inhibition, and cognitive flexibility have been reported to be vulnerable in chronic pain conditions. Therefore, the aim of the present study was to evaluate Stroop Test performance in individuals with chronic neck pain and to investigate the relationships between Stroop performance and pain intensity, pain duration, and functional disability. By examining these associations, this study seeks to provide a more comprehensive understanding of the potential impact of chronic pain on executive functioning within a clinical framework.

Materials and methods

Participants

We obtained both verbal and written consent from all participants in accordance with the Declaration of Helsinki. Ethical approval was obtained for the study from the university (decision no: 2023/1463).

This study was conducted in patients who presented to the neurosurgery outpatient clinic with complaints of neck pain. Due to the exploratory nature of the study and limited patient availability during the study period, a convenience sample of patients who met the inclusion criteria was included. A detailed medical history was obtained from all participants. Twenty-five patients with CNP, defined as neck pain persisting for at least three months and not requiring surgical intervention based on clinical examination and magnetic resonance imaging findings (e.g., cervical lordosis straightening or early-stage cervical disc herniation), were included in the study. All patients were diagnosed with chronic mechanical neck pain and had no clinical signs of cervical radiculopathy, such as radicular pain, sensory deficits, or motor weakness on neurological examination. Educational status, duration of neck pain, and pain intensity measured by the Visual Analog Scale (VAS) were recorded. Additionally, the Neck Disability Index (NDI) was administered to assess functional disability. The control group consisted of 25 healthy individuals matched for age and sex. Participants were excluded if they had a history of traumatic neck injury or surgery, cognitive impairment (Montreal Cognitive Assessment score < 21), neurological disorders, or uncorrected visual impairment.

Clinical measures

Visual analog scale (VAS): Pain intensity was assessed using the VAS, where participants rated their pain on a 10-cm horizontal line ranging from 0 (no pain) to 10 (worst imaginable pain).

Neck disability index (NDI): Neck-related functional impairment was assessed using the NDI, a widely used self-report instrument designed to evaluate the impact of neck pain on daily activities. The Turkish version of the scale was culturally adapted and psychometrically validated by Kesiktaş et al., demonstrating strong reliability and construct validity. The NDI comprises 10 items covering domains such as pain intensity, personal care, lifting, reading, work, headaches, concentration, sleeping, and recreation. Each item is rated on a 6-point scale (0–5), yielding a total score ranging from 0 to 50, with higher scores reflecting greater functional limitation. The Turkish version has demonstrated high internal consistency, with a reported Cronbach's alpha coefficient of 0.88 (11).

Stroop Test: Executive functions, selective attention, and cognitive inhibition were assessed using the Stroop Test TBAG Form. The Turkish validity and reliability study was conducted by Karakaş et al (9). The full battery was administered to all participants.

- Stroop 1: Color words printed in black ink; participants were asked to read the words aloud.

- Stroop 2: Color words printed in incongruent ink colors; participants were instructed to read the words.
- Stroop 3: Colored circles were presented, and participants were asked to name the color of each circle.
- Stroop 4: Meaningful words printed in incongruent ink colors; participants were instructed to state the ink color rather than read the word. This condition assesses inhibitory control under cognitive conflict.
- Stroop 5: The second card was repeated; however, participants were required to name the ink color instead of reading the word.

Completion times for each subtest were recorded.

Statistical analysis

Statistical analyses were performed using IBM SPSS version 21. Normality of data distribution was assessed using the Shapiro–Wilk test. Normally distributed variables were presented as mean ± standard deviation, whereas non-normally distributed variables were expressed as median (min–max) [Q1-Q3]. Between-group comparisons were performed using the independent samples t-test for normally distributed data and the Mann–Whitney U test when the assumption of normality was not met. Correlations between variables were analyzed using Pearson correlation for normally distributed variables and Spearman correlation for non-normally distributed variables. A p-value < 0.05 was considered statistically significant.

Results

There was no statistically significant difference between groups in terms of age. The mean age was 32.84±8.09 years in the control group and 31.60±8.53 years in the chronic neck pain group ($t(48)=0.527$, $p=0.600$). Similarly, gender distribution did not differ significantly between groups ($\chi^2(1)=0.397$, $p=0.529$). In the control group, 68% were female (n=17) and 32% were male (n=8), whereas in the chronic neck pain group, 76% were female (n=19) and 24% were male (n=6). Educational status did not differ significantly between groups ($\chi^2(3)=1.057$, $p=0.787$). In the control group, 24% (n=6) had primary school education, 4% (n=1) had secondary school education, 28% (n=7) had high school education, and 44% (n=11) had a university degree. In the chronic neck pain group, 24% (n=6) had primary school education, 8% (n=2) had secondary school education, 36% (n=9) had high school education, and 32% (n=8) had a university degree.

The mean NDI score was 22.36±8.57 (95%CI: 18.82-25.90), indicating a moderate level of disability. The mean pain duration was 36.00±25.32 months (95%CI: 25.55-46.45), with a median duration of 24 months (range: 3-96 months). The mean pain intensity measured by the VAS was 6.92±2.16 (95% CI: 6.03-7.81), with a median score of 8 (range: 2–10).

Table 1: Stroop test performance by group

Stroop subtest	Control (n=25)	Chronic neck pain (n=25)	Z	p	r
Stroop 1	7.82 (5.94–11.21) [7.39–8.30]	9.73 (6.61–17.63) [9.20–11.92]	-4.201	<0.001	0.59
Stroop 2	9.07 (6.24–18.88) [7.35–9.79]	10.84 (7.29–23.57) [9.71–13.79]	-3.037	0.002	0.43
Stroop 3	10.88 (8.10–14.10) [9.84–11.55]	13.33 (7.29–29.61) [11.57–15.29]	-3.881	<0.001	0.55
Stroop 4	13.41 (9.20–20.10) [12.31–14.51]	18.32 (9.18–58.30) [14.50–21.96]	-3.629	<0.001	0.51
Stroop 5	18.44 (10.34–33.80) [15.37–23.59]	24.52 (9.68–72.45) [22.03–35.25]	-2.794	0.005	0.40

As presented in Table 1, Stroop test performance differed significantly between the control and chronic neck pain groups across all subtests ($p<0.05$). Individuals with chronic neck pain demonstrated significantly longer completion times compared to controls in Stroop subtests.

No significant associations were found between NDI scores, VAS scores, and other Stroop subtests (all $p>0.05$). The relationships between the variables are presented in Table 2.

Table 2: Correlation matrix among clinical variables and stroop performance (chronic neck pain group, n=25)

Variable	1	2	3	4	5	6	7
1. NDI	—						
2. Pain duration	r=0.096 (0.649)	—					
3. VAS	r=0.389 (0.055)	r=0.220 (0.292)	—				
4. Stroop 1	r=-0.116 (0.582)	r=-0.355 (0.082)	r=-0.265 (0.201)	—			
5. Stroop 2	r=-0.099 (0.636)	r=-0.400 (0.057)	r=-0.281 (0.173)	r=0.687 (<0.001)	—		
6. Stroop 3	r=-0.232 (0.264)	r=-0.198 (0.344)	r=-0.191 (0.360)	r=0.739 (<0.001)	r=0.505 (<0.001)	—	
7. Stroop 4	r=-0.158 (0.452)	r=-0.149 (0.478)	r=0.092 (0.661)	r=0.676 (<0.001)	r=0.433 (0.002)	r=0.887 (<0.001)	—
8. Stroop 5	r=-0.083 (0.694)	r=-0.180 (0.390)	r=0.084 (0.691)	r=0.572 (<0.001)	r=0.383 (0.006)	r=0.831 (<0.001)	r=0.901 (<0.001)

VAS: Visual analog scale, NDI: Neck disability index. Values in parentheses are p-values. The r value represents the correlation coefficient.

Discussion

In this study, Stroop Test performance was examined in individuals with CNP, and the relationships between Stroop performance and pain intensity, pain duration, and

functional disability were evaluated. The findings revealed that individuals with CNP demonstrated significantly poorer performance across all Stroop subtests compared to healthy controls. Notably, however, no significant associations were found between Stroop performance and pain intensity, pain duration, or functional disability.

Cognitive functions encompass higher-order mental processes such as attention, inhibition, cognitive flexibility, and executive control, enabling individuals to generate goal-directed and contextually appropriate responses to environmental stimuli (12). In particular, executive functions involve suppressing automatic responses, resolving cognitive conflict, and prioritizing task-relevant information. These mechanisms are essential for planning daily activities, problem solving, decision making, and regulating social interactions. Given that impairments in executive functioning can directly compromise an individual's functional capacity, they hold a central role in clinical assessment. The Stroop Test is a well-established neuropsychological paradigm widely used to assess cognitive inhibition and selective attention and is regarded as a "gold standard" measure of executive control (13). The Stroop task is particularly sensitive to executive networks associated with the prefrontal cortex and anterior cingulate cortex, which has led to its extensive application in both clinical and research settings (14). Moreover, its brief administration time, practical implementation, and lack of requirement for specialized equipment make it a reliable and valid tool in neuropsychological evaluations. Its demonstrated sensitivity in detecting executive dysfunction across various neurological and psychiatric populations has established the Stroop Test as one of the reference methods for assessing cognitive control processes.

The relationship between chronic pain and cognitive functions has received increasing attention in recent years (15-18). In a study conducted by Tanık et al. involving 62 individuals with CNP, the interaction between pain intensity, functional status, and cognitive as well as psychological variables was examined (16). The authors reported that nocturnal pain, in particular, negatively affected decision-making self-esteem and careful decision-making style. These findings suggest that CNP is not merely a physical condition but also has significant cognitive dimensions, underscoring the importance of considering cognitive parameters in both assessment and treatment processes. Furthermore, the literature indicates that the cognitive decline observed in individuals with chronic pain may be more closely related to the pain experience itself rather than to the anatomical location of the pain (15).

Experimental studies also support this association. Bjekić et al. investigated the relationship between pain induced by the cold pressor test and executive functions in healthy adults and reported that pain-related measures were specifically associated with cognitive inhibition as assessed by the Stroop test (18). As Stroop performance improved—that is, as individuals' ability to suppress interference increased—pain threshold and tolerance increased, whereas pain sensitivity decreased. Similarly, a review study demonstrated that patients with chronic pain responded more slowly to pain-related and negatively valanced words in the Emotional Stroop task, indicating a pronounced attentional bias (17). Increased activation in brain regions involved in pain and emotion regulation, such as the anterior cingulate cortex, insula, and somatosensory cortex, further supports the close interaction between chronic pain

and cognitive–affective networks. Consistent with this literature, our findings showed that individuals with CNP performed worse on the Stroop test compared to healthy controls, suggesting a reduced ability to suppress interference. This result indicates that cognitive inhibition processes may be particularly affected in chronic neck pain.

The relationship between chronic neck pain and cognitive functions is grounded in the notion that pain is not merely a sensory experience, but a complex process that influences attentional and executive control networks within the central nervous system. Persistent nociceptive input leads to sustained activation in shared brain regions—such as the prefrontal cortex and anterior cingulate cortex—that are involved in both pain processing and the regulation of inhibition and attention (19). This ongoing activation may result in the allocation of limited cognitive resources to the monitoring and evaluation of pain, as described by the resource competition model (20). In other words, when a portion of executive and attentional capacity is continuously directed toward pain processing, performance may be compromised in tasks requiring selective attention, cognitive inhibition, and conflict resolution.

On the other hand, no significant association was found between Stroop test performance and pain intensity, pain duration, or level of disability in the present study. This finding suggests that the impact of pain on the cognitive system may not always follow a direct and linear pattern (21). Chronic pain–related stress responses, elevated cortisol levels, and long-term neuroplastic changes may influence network connectivity—particularly between the prefrontal cortex and hippocampus—thereby exerting pressure on executive functions such as working memory, processing speed, and cognitive flexibility. Nevertheless, interindividual compensatory mechanisms, psychological factors (e.g., anxiety, depression, catastrophizing), and the central salience of pain may contribute to either the preservation or the variable modulation of cognitive performance. Therefore, the relationship between chronic neck pain and cognition should be conceptualized not as a simple pain severity–performance association, but rather as a dynamic and multidimensional interaction at the level of central nervous system networks.

In the present study, individuals with CNP demonstrated significantly longer completion times across all Stroop subtests compared to the control group. The moderate-to-large effect sizes observed indicate that chronic neck pain is not merely a physical condition but may also have clinically meaningful effects on higher-order cognitive processes such as attention, cognitive inhibition, and executive control. In particular, the slowing observed in Stroop performance suggests a potential risk of reduced efficiency in daily life situations that require divided attention, decision making, multitasking, and cognitive flexibility. These findings may suggest that chronic neck pain could influence cognitive processes that are important for daily activities requiring attention and decision-making. Therefore, the assessment of individuals with chronic neck pain should not be limited to pain intensity and functional disability; executive functions should also be considered, and when necessary, cognitive-supportive or multidisciplinary interventions should be incorporated into the treatment plan.

Limitations

This study has several limitations. First, the relatively small sample size may have limited the statistical power, particularly in detecting associations between clinical variables and cognitive performance. Second, due to the cross-sectional design, the causal direction of the relationship between chronic neck pain and executive functioning cannot be determined. Executive functions comprise multiple domains, including working memory, cognitive flexibility, and processing speed; however, in the present study, cognitive performance was evaluated only using the Stroop test. Therefore, the exclusive use of the Stroop test may limit the comprehensive evaluation of other executive domains. Psychological factors such as anxiety, depression, sleep quality, and pain catastrophizing were not evaluated in the present study and may have influenced cognitive performance. Finally, medication use and treatment history related to pain were not analyzed in detail, which may represent potential confounding factors affecting cognitive outcomes. Considering these limitations, future prospective studies with larger samples and multidimensional cognitive assessments are warranted.

Conclusions

This study demonstrated that individuals with chronic neck pain exhibited significantly poorer performance across all Stroop subtests compared to healthy controls. These findings indicate that chronic neck pain is not solely a sensory and physical condition but may also affect higher-order cognitive processes such as attention, cognitive inhibition, and executive control. However, the absence of significant associations between Stroop performance and pain intensity, pain duration, or level of disability suggests that cognitive impairment may not be directly explained by clinical pain parameters alone. Overall, these results support the notion that chronic neck pain may influence executive function–related neural networks at the central nervous system level and highlight the importance of incorporating cognitive considerations into the clinical evaluation process.

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Research concept and design: BB
Data analysis and interpretation: BB
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