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Mind the Mood: Momentary Depression and Anxiety Moderate the Correspondence between Subjective and Objective Cognitive Functioning in Fibromyalgia

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Abstract

Objective: Subjective cognitive dysfunction (SCD) affects 55–75% of individuals with fibromyalgia (FM) but those reporting cognitive difficulties often lack corresponding objective deficits. Symptoms of depression and anxiety are prevalent in FM and may account for part of this discrepancy. We investigated whether momentary (within-day, across 7 days) changes in mood moderated the relationship between within-the-moment SCD and mental processing speed performance.

Methods: 50 individuals with FM (mean age 44.8, mean education 15.7 years, 88% female, 86% White) completed momentary assessments of subjective cognitive functioning, depressive and anxious symptoms, and a test of processing speed. Assessments were completed 5X/day for 8 consecutive days on a study-specific smartphone application.

Results: Momentary ratings of SCD were positively associated with mean reaction time (p<0.001) and variability of processing speed; (p=0.02). Depressive symptoms moderated the relationship between SCD and processing speed, with lower correspondence when depressive symptoms were higher (p = 0.03). A similar moderating effect was shown for both depression (p = 0.02) and anxiety (p = 0.03) on the association between SCD and variability in processing speed performance.

Conclusion: Individuals with FM may be more accurate in their self-perception of momentary changes in mental processing speed during periods of less pronounced mood symptoms based on their corresponding objective processing speed performance. However, during moments of heightened depression and anxiety, we found increasingly less correspondence between SCD and objective performance, suggesting psychological symptoms may play an important role in self-perception of cognitive dysfunction in FM as it relates to mental processing speed.

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Introduction

Fibromyalgia (FM) is a chronic musculoskeletal pain disorder commonly accompanied by symptoms of depression, anxiety, fatigue, and cognitive dysfunction (1–4). Subjective cognitive dysfunction (SCD) refers to a person's perception of a reduction in their cognitive capacity and is reported by approximately 55–75% of adults with FM (5). SCD encompasses a wide range of cognitive domains including aspects of attention, mental processing speed, executive functioning, and memory (2, 6, 7) with significant negative effects on daily functioning, occupational outcomes, and quality of life, making it one of the most troubling symptoms for people with FM (2, 6–12).

Despite the prominent impact of SCD, individuals with FM do not consistently demonstrate deficits on objective measures of cognition (6, 12–15). Rather, there is often a 'cognitive discrepancy' (i.e., an over- or under-estimation of subjective cognitive functioning relative to objective performance) observed in FM (12, 16–18). One plausible explanation for this observed cognitive discrepancy is the influence of mood symptoms, such as depression and anxiety, on an individuals' perception of their cognitive abilities (15, 19).

Symptoms of depression and, to a lesser extent, anxiety are common in individuals with FM (4). Prior research suggests that symptoms of depression and anxiety can contribute to cognitive biases that can negatively affect perception of cognitive function, such as negative self-directed thinking patterns (20), underestimation of true capabilities (21), and excessive worry and hopelessness during cognitive challenges (22). However, it remains unclear whether SCD corresponds with objective cognitive dysfunction and to what extent mood symptoms contribute to any discrepancy between SCD and objective performance.

A potential limiting factor of previous research is that the majority of studies have utilized single timepoint assessments and cross-sectional designs to assess cognition in FM which fail to account for the evidence that cognitive functioning and mood symptoms tend to fluctuate within individuals across short periods of time, even within a single day. These approaches also do not allow for the examination of the effects of transient mood states on the association between perceived and objective cognition. Thus, more intensive approaches to data collection that use multiple within-day assessment may shed additional light on this perplexing issue.

Overall, the possible moderating influence of depressed and anxious mood on the relationship between SCD and objective cognitive performance is understudied in FM. This limitation poses challenges in understanding the nature of SCD and in identifying focused interventions for SCD in FM. Therefore, the goal of the present study was to assess the influence of momentary changes in self-reported symptoms of depression and anxiety on the relationship between SCD and objective cognitive performance in individuals with FM. To this end, we utilized a micro-longitudinal study design wherein adults with FM completed self-report measures of cognitive functioning (SCD), depression and anxiety, and completed an objective measure of mental processing speed multiple times a day. We hypothesized that there would be a significant, negative association between momentary ratings of SCD and

processing speed. Further, we expected a weaker relationship between SCD and objective performance at times when symptoms of depression and anxiety were higher.

MATERIALS AND METHODS:

Participants.

Participants with FM were eligible if they fulfilled the 2016 American College of Rheumatology survey criteria (23), were ≥18 years of age and had at least a 6th grade reading level in English. Individuals were excluded if they had 1) a comorbid neurologic disorder, learning disability, or cognitive impairment; 2) current alcohol or recreational drug use dependence or prolonged (≥5 years) history of substance dependance; 3) visual or hearing impairment that would preclude cognitive assessment; 4) a diagnosis of untreated obstructive sleep apnea; 5) atypical sleep/wake pattern (e.g., night-shift workers).

STUDY PROCEDURES.

All study procedures were approved by the Medical Institutional Review Board at the University of Michigan prior to study initiation. Participants were recruited through existing patient registries, community groups, placement of fliers in health centers and community settings, and advertisement on a university-based recruitment website (www.UMHealthreserach.org). This paper addresses one of the primary study aims; previous papers from the study have shown that ambulatory measures are able to detect cognitive dysfunction in FM relative to individuals without FM (24), that cognitive test performance is worse when participants are distracted (25), and subjective and objective cognitive functioning is worse in those with FM when pain intensity is high (26).

Procedures for this study have been described previously (24, 25). Study participation involved a ~90-minute baseline visit followed by an 8-day home monitoring period (i.e., a 1-day run-in period followed by 7 days of data collection). At the baseline visit, enrolled participants completed a battery of self-report measures and standardized cognitive testing (baseline self-report and cognitive testing data were reported previously (24)) and were given data collection devices. At the conclusion of the home monitoring period, participants returned the devices via a postage-paid return box to the laboratory for data processing. Participants were compensated up to $175 for full completion of the study. Participants were issued a ZTE Axon 7 mini smartphone, with a 5.2” display (1,080 × 1,920 pixels) and programmed with a customized study-specific app to administer ecological momentary assessment (EMA) measures and ambulatory cognitive tests. Participants were instructed to initiate the first of the 5 daily EMA and cognitive testing sessions upon waking. For the following 4 sessions, the smartphone was programmed to play an audible alert to prompt the respondent to complete EMA and cognitive assessments. Alerts were programmed on a quasi-random schedule based on each person’s typical waking time, with scheduled intervals between prompts ranging between 3 and 4.5 hours (27).

Measures.

Baseline self-report measures.—Participants completed surveys of demographics and medications and validated symptom surveys. Results of the additional symptoms surveys have been reported previously (24).

Ambulatory Assessments.—A study-specific smartphone app was programmed to administer EMA measures and cognitive tests in a single assessment/testing session.

Subjective cognitive dysfunction (SCD).—Two items from the PROMIS applied general concerns item bank (28) were used and adapted for momentary assessment. The items "How slow is your thinking right now?" rated on a scale of 0–100 (where 0 = my thinking is very fast, and 100 = my thinking is very slow) and "How foggy is your thinking right now?" rated on a scale of 0–100 (where 0 = my thinking is very clear, and 100 = my thinking is very foggy) were averaged to produce an aggregate score where higher scores indicate worse SCD.

Objective cognitive functioning.—Participants completed a test of processing speed (Symbol Search) at each assessment timepoint. During the task, participants were shown a row of four symbol pairs at the top of the screen and two symbol pairs at the bottom of the screen. Participants were instructed to decide which symbol pair at the bottom matched a symbol pair at the top and to select the matching pair as quickly as possible by touching their response on the screen. Stimuli were presented until a response was provided. A lure stimulus wherein only one of the symbols in a pair matched one of the symbols presented at the top, but the pair did not match, was presented during 75% of the trials. Each testing session contained 16 trials. Reaction time (milliseconds) and accuracy were recorded. Accuracy during each session was used to gauge participant's effort during the symbol search task. Indiscriminate selection of responses with little or no effort would be consistent with accuracy rates of about 50%. Intentional poor performance (i.e., "faking bad") would likewise be expected to correspond with low accuracy and could be expected to play a role in cases where accuracy was <50%. To ensure adequate task engagement, accuracy of <70% was used as a conservative cut point to indicate poor task engagement which is consistent with validation procedures used in the development of this task (27). Two variables were calculated for each testing session: mean reaction time and standard deviation (SD) of reaction time. The SD of reaction time was considered because within-person variability has been identified as an independent indicator of poor cognitive functioning and as a risk factor of future cognitive decline (29–31).

Mood/Affect.—A subset of items from the Profile of Mood States (POMS; (32)), adapted for use as a momentary measure, was used to assess mood/affect. Participants were prompted with, "right now, I feel…" and rated each mood items on a 5-point scale, ranging from 0 (not at all) to 4 (extremely). Momentary depressed mood was assessed with three items: sad, hopeless, and discouraged. Momentary symptoms of anxiety were assessed with three items: anxious, on edge, and uneasy. For depressed and anxious mood, the three items were averaged to produce a single scale score.

DATA ANALYSIS

Preliminary Analyses.

Descriptive statistics were generated for sociodemographic and study variables. As the first day of home monitoring was a training/run-in day, data from Day 1 were excluded from all analyses. Person-averaged variables for Symbol Search performance (mean response time, SD of response times), depression, and anxiety were created by averaging each participant's scores across the assessment period. Person-centered variables for Symbol Search performance (mean response time, SD of response times), depression, and anxiety were created by subtracting each participant's score for the assessment period (average of 16 trials for Symbol Search performance variables) from their person-averaged score.

Primary Analyses.

First, multilevel models (MLM) tested the within-person association between momentary changes in Symbol Search performance and SCD. MLMs are able to model both between- and within-person variance and retain all cases (regardless of missing data within-person). Person-centered Symbol Search mean response time and SD of response times were included in separate models. Models were adjusted for person-averaged Symbol Search performance (to control for between-person variance), within-day timepoint (ordinal variable; to control for within-day variation in associations), age, and education. Next, MLMs tested momentary depression and anxiety as moderators of the within-person momentary association between Symbol Search performance and SCD. The models included the person-centered Symbol Search performance and psychological symptom (depression and anxiety) variables and interaction terms for each combination of person-centered Symbol Search performance variable and person-centered psychological symptom variable. These models were adjusted for person-averaged Symbol Search performance and psychological symptoms, timepoint, age, and education. Maximum likelihood estimation accounted for missing data. The critical alpha threshold was specified at $p<.05$. All analyses were performed using IBM SPSS Statistics v26.

RESULTS

Fifty participants with FM enrolled and completed study activities. Descriptive statistics for sociodemographic characteristics and study variables are reported in Table 1. Participants were on average 44.88 years old (SD=13.95 years) with an average of 15.70 years of education (SD=2.03 years). The majority were female (88.0%) and White (86.0%).

Objective Cognitive Functioning. At the within-person level, moments of slower processing speed (higher Symbol Search mean response time) were associated with more severe SCD (B=.003, $p<.001$; Table 2). Additionally, moments of higher variability in processing speed (Symbol Search SD of response times) were associated with more severe SCD (B=.002, $p=.020$).

Analysis of Effort on Ambulatory Symbol Search Task.

Accuracy on the Symbol Search task suggested good effort. Accuracy was >70% for 1784/1813 (98.4%) of sessions (range=43.75–100.00%; Median=100.00, Mean=95.81,

SD=6.83). Eight individuals were identified as having had at least one session with <70% accuracy. Of these, three participants had multiple sessions with low accuracy (range=5–12 sessions) and were identified as possible cases of low effort. No reaction time variables were calculated for low-accuracy sessions. Sensitivity analyses, excluding the three participants who demonstrated repeated low accuracy/effort, were conducted for all ambulatory cognition analyses. The results with/without these three people did not change the magnitude or significance of any results. Therefore, results for the full sample are reported, aside from the several sessions with low accuracy scores.

Moderating Role of Momentary Depression.

Momentary depression significantly moderated the within-person association between momentary Symbol Search mean response time and SCD (B=−.003, p=.03; Table 3; Figure 1a). Specifically, the correspondence between moments of slower processing speed and more severe SCD were strongest when depressive symptoms were lower. In contrast, when depressive symptoms were higher than usual, the correspondence between SCD and reaction time was weaker. In moments of more severe depression symptoms, SCD was relatively high across the range of Symbol Search mean response times. Depression also significantly moderated the within-person association between momentary Symbol Search SD of response times and SCD (B=−.005, p=.02; Figure 1b). That is, moments of higher variability in processing speed were related to more severe SCD, but this association was weaker (smaller positive association) when depression symptoms were higher. In moments of more severe depression symptoms, SCD was relatively high regardless of Symbol Search SD of response times.

Moderating Role of Momentary Anxiety.

There was no significant moderating effect of momentary anxiety ratings on the association between momentary Symbol Search mean response time and SCD (p=.34). However, momentary anxiety ratings significantly moderated the within-person association between Symbol Search SD of response times and SCD (B=−.004, p=.02; Table 4; Figure 2). Specifically, moments of higher variability in processing speed were related to more severe SCD, but this association was weaker (smaller positive association) when anxiety symptoms were higher.

DISCUSSION

SCD is prominent in FM and thus far our understanding of the factors influencing the relationship between SCD and objective cognitive performance is limited. This is the first study to use a microlongitudinal design to assess the moderating role of momentary level of depression and anxiety on the association between SCD and processing speed performance in FM.

The highest correspondence between SCD and processing speed performance (mean reaction time and standard deviation) occurred when symptoms of depression and anxiety were at their lowest, suggesting that individuals were able to gauge their cognitive performance more accurately when affective symptoms were minimally influencing their

self-perception. However, when momentary ratings of depression and anxiety were higher, there was an increased discrepancy between SCD and mental processing speed as well as more variability in performance, supporting our hypothesis of the moderating influence of depression and anxiety on the association between SCD and objective cognitive performance.

Landro and Colleagues (16) who studied a group of people with chronic nonmalignant pain found that self-reports of cognitive functioning were largely consistent with objective neuropsychological assessment. In contrast, Tesio and colleagues found that while self-perception and objective performance correlated for some domains (e.g., working memory), there were poor correlations for the majority of cognitive domains assessed (33). Our findings expand on that previous work in several important ways. First, a key difference is in our study design, which used multiple momentary assessments rather than a single assessment point, allowing for examination of changes within persons. Second, our momentary assessments capturing the changes in state experienced by participants occurred in "real-time," and are not as subject to recall biases as other measures that rely on recollection of cognitive symptoms over the past 7 days (33). Finally, rather than relying on a broad measure of SCD, we selected two specific questions, one which corresponded directly to the processing speed task at hand (i.e., "how slow is your thinking right now") and another which captured a general cognitive complaint (i.e., "how foggy is your thinking").

These findings can be interpreted within the context of theoretical frameworks that suggest that having symptoms of depression can make a person more prone to certain cognitive biases that affect perceptions of self, including perceived cognitive functioning (20–22). Although this study did not study depressed individuals, research on people with depression show that more severe depressive symptoms are related to underestimation of cognitive abilities due to mood-related biases such as negative self-schemas and negative perceptions of thoughts and behaviors (34). Evidence for the role of depressive symptoms in cognitive biases related to perceived cognitive functioning is further bolstered by research showing that after depressive symptoms have remitted people tend to overestimate their own cognitive abilities (35). This framework aligns well with our findings showing that SCD becomes more disparate from objective functioning when depressive symptoms are higher, supporting the notion that depression may influence perception of cognitive performance within the domain of mental processing speed (17). Because we have only considered processing speed in this study, it will be important for future work to determine whether heightened symptoms of depression also influence perception of other cognitive abilities.

Anxiety can also negatively impact processing speed and self-perception of cognitive abilities; however, the influence of anxiety on the correspondence between SCD and objective performance may be somewhat different than that found in depression. In one of the few studies to examine the moderating effects of mood symptoms on the relationship between SCD and cognitive performance, Baker and colleagues (36) found that individuals with chronic pain who reported more severe symptoms of anxiety showed better correspondence between SCD and objective performance as compared to individuals with milder symptoms. Other work suggests that when symptoms of anxiety are severe there

is a negative impact on processing speed performance; however, anxiety can actually prove beneficial for rapid responding when symptoms are mild (37). While people's experience of mood symptoms and psychological distress are often considered to be primary factors in their self-perceived cognitive difficulties, it will be important to disentangle the different effects depression and anxiety may have on the subjective/objective cognitive discrepancy. Future research should also seek to determine potential methods for determining at what point an individual's mood symptoms may be the primary factor influencing cognition beyond other FM symptoms. Then, focused intervention may be developed and administered for those individuals identified at the highest risk of developing cognitive symptoms to stave off the negative impact such symptoms may have on daily functioning.

These factors should be considered in the context of treatment of cognitive and psychological symptoms in FM and suggest that focused treatment on mood symptoms may lead to a more accurate self-appraisal of cognitive functioning. However, longitudinal data are needed to support this hypothesis. CBT has been shown to be effective in reducing both pain catastrophizing, pain severity, and has effects on brain functioning associated with such symptoms (38). Thus, a more individually tailored approach to such an intervention which capitalizes on the daily experience of the individual may help alleviate aspects of SCD. Utilizing an EMA informed approach to interventions such as these could lead to identifying what emotional states, life events, or diurnal factors most strongly impact variability in SCD and cognitive performance in FM.

This research has several limitations which potentially limit the generalizability of our findings. Despite the various cognitive difficulties reported by individuals with FM (9) , our objective assessment was limited to mental processing speed. Processing speed was selected as it is often impaired in depression and anxiety and represents a foundational cognitive skill underlying most other cognitive functions, and therefore is likely to be sensitive to momentary fluctuations. Additionally, we attempted to achieve the highest possible concordance between descriptions used in our subjective ratings and the cognitive domain assessed (i.e., "how slow is your thinking right now"). Future research will be strengthened by incorporating assessments of multiple cognitive domains to extend these findings. Given that our primary research questions focused on the moderating effects of mood symptoms, we did not evaluate the effects of momentary pain in our analyses. However, recent population-level data suggests that pain and mood symptoms may differentially influence cognitive symptoms (5). Nonetheless, it will remain important to disentangle these variables in order to develop a more thorough understanding of the myriad factors influencing cognitive appraisal in FM. Finally, it is important to consider task engagement and effort when interpreting performance on cognitive assessments. While this study did not include a standalone measure of effort or performance validity, we instituted a conservative cutoff score (70% accuracy) as a means of detecting poor effort or engagement on the processing speed task. Further, individual's trials which did not meet that cutoff were not analyzed for reaction time or included in analysis. Sensitivity analyses also determined that there was no significant impact of including the "valid" trials for the individuals (trials that were >70%) accuracy who may have had several trials below our designated cutoff for accuracy. Future research will benefit from including standalone measures to ensure adequate effort on task performance. However, in a *research* context, individuals with fibromyalgia typically

perform within normal limits on standalone measures of task engagement suggesting that when disability or other medico-legal aspects are not involved, there may be less concern about performance validity in the context of fibromyalgia research (39). Finally, our own data which compared people with and without FM, found that rates of instances of poor accuracy were nearly identical for the two groups suggesting that people with FM do not show higher rates of poor effort on the specific tests used in this study (24).

In conclusion, these data suggest that individuals with FM can formulate a more realistic self-appraisal of their objective cognitive ability when symptoms of depression and anxiety are less prominent. This highlights the importance of thorough mental health assessment of psychological symptoms during evaluation of SCD in FM. Identifying mood symptoms during routine clinical care may assist patients with accessing necessary, cost-effective interventions. Research in this area will likely continue to benefit from exploring SCD using within-person research designs to adequately account for the numerous interactions among the co-morbid symptoms observed in FM.

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Significance and Innovations:

- This is the first study to evaluate the influence that momentary changes in mood have on the relationship between objective and subjective cognitive functioning using ecological momentary assessments.
- Our findings suggest that individuals with fibromyalgia may be more accurate in their perception of momentary changes in mental processing speed (i.e., better correspondence between subjective and objective measures) when mood symptoms are minimal.
- Increasing mood symptoms (i.e., higher ratings of depression and anxiety) lead to a larger discrepancy between perceived cognitive functioning and objective cognitive performance suggesting an influence of psychological symptoms on cognitive self-appraisal.

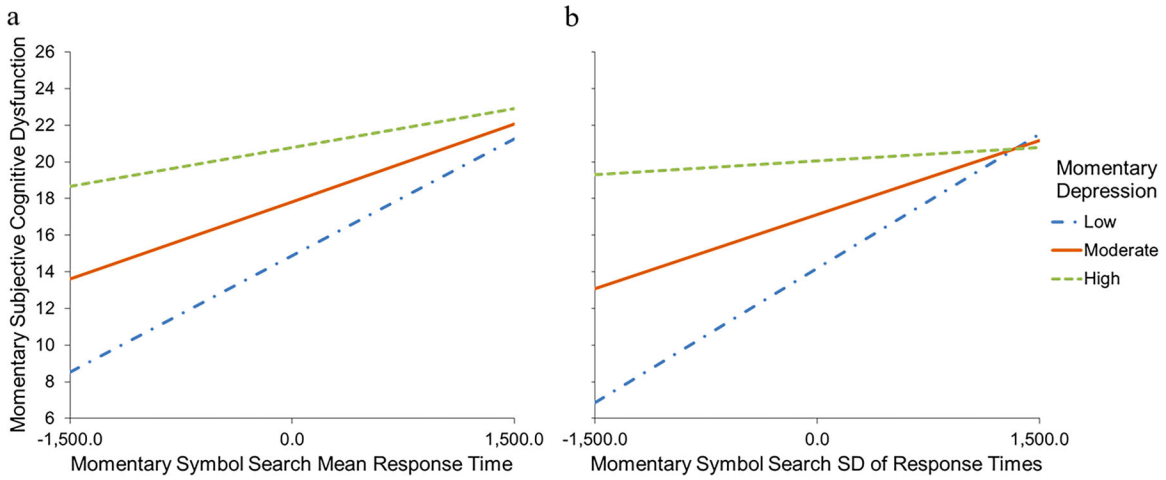

Figure 1:

a) Simple slopes depicting momentary depression ratings as a moderator of within-person association between momentary Symbol Search mean response time and subjective cognitive dysfunction, b) Simple slopes depicting momentary depression symptoms as moderator of within-person association between momentary Symbol Search standard deviation (SD) of response times and subjective cognitive dysfunction.

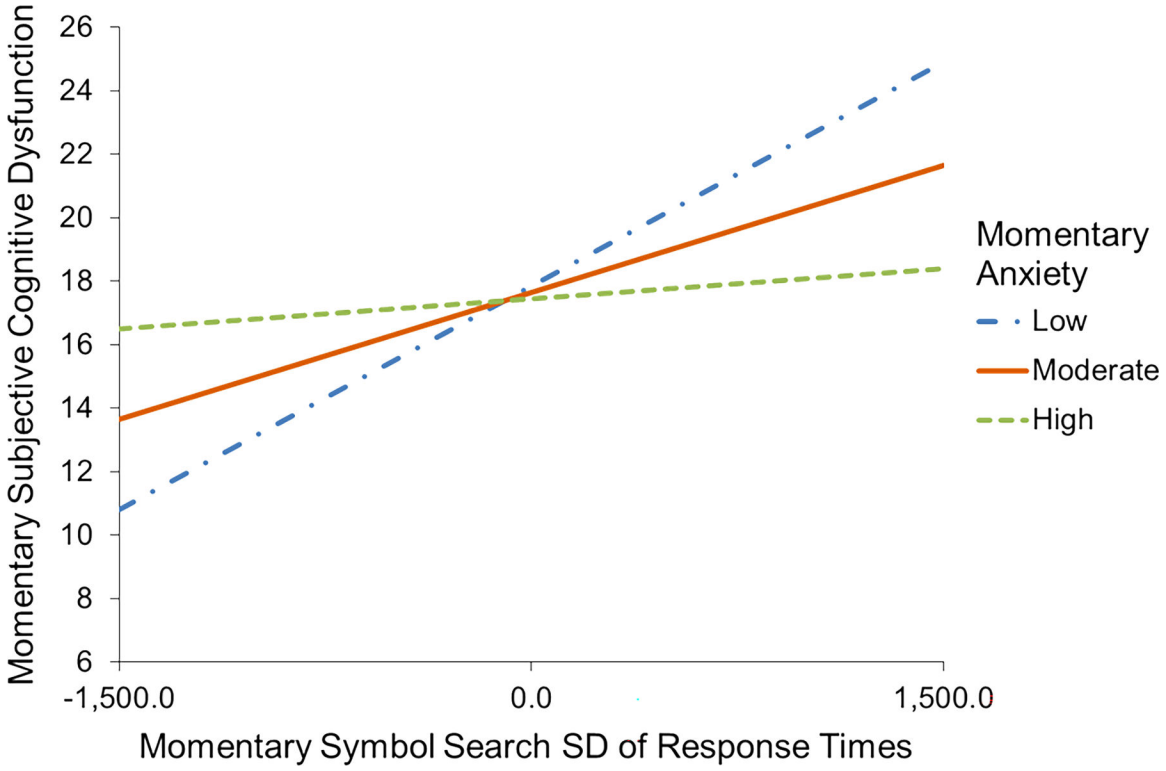

Figure 2.

Simple slopes depicting momentary depression symptoms as moderator of within-person association between momentary Symbol Search standard deviation (SD) of response times and subjective cognitive dysfunction.

Table 1.

Descriptive statistics for sociodemographic characteristics and study variables ($N = 50$).

Variable	Mean (SD) or Number (%)	Possible Range	Observed Range
Age (Years)	44.88 (13.95)		20 – 70
Sex (Female)	44 (88.0%)		
Race/Ethnicity			
white	43 (86.0%)		
African American/Black	5 (10.0%)		
Bi/Multi-Racial	2 (4.0%)		
Education (Years)	15.70 (2.03)		10 – 21
Symbol Search Mean RT (ms) *	2444.19 (752.39)		1108.23 – 4400.40
Symbol Search SD of RT (ms) *	1027.99 (344.84)		240.69 – 1769.45
EMA Subjective Cognitive Dysfunction *	49.04 (16.65)	0 – 100	3.64 – 94.82
EMA Depression *	.66 (.77)	0 – 4	0.00 – 3.56
EMA Anxiety *	.78 (.64)	0 – 4	0.00 – 2.45

Note.

* = person-averaged; RT = response time; SD = standard deviation; ms = millisecond; EMA = Ecological Momentary Assessment

Table 2.

Results of multilevel models testing the within-person association between momentary Symbol Search performance (mean response time, SD of response times) and subjective cognitive dysfunction.

	Subjective Cognitive Dysfunction			
Random Effect	**Est.**	**SE**	***p***	**95% CI**
Intercept	241.54	52.17	**<.0001**	158.17, 368.84
AR(1)	.22	.03	**<.0001**	.16, .27
Residual	202.75	7.69	**<.0001**	188.21, 218.40
Fixed Effect	B	SE	*p*	95% CI
Between-Person Variables				
Intercept	40.29	18.60	**.04**	2.87, 77.71
Symbol Search Mean RT *	.01	.004	**.03**	.001, .02
Within-Person Variables				
Δ Symbol Search Mean RT	.003	.001	**<.001**	.001, .004
	Subjective Cognitive Dysfunction			
Random Effect	Est.	SE	*p*	95% CI
Intercept	257.72	55.56	**<.0001**	168.91, 393.22
AR(1)	.22	.03	**<.0001**	.16, .28
Residual	204.05	7.75	**<.0001**	189.40, 219.82
Fixed Effect	B	SE	*p*	95% CI
Between-Person Variables				
Intercept	37.44	19.58	.06	−1.96, 76.85
Symbol Search RT *SD**	.01	.01	.17	−.005, .03
Within-Person Variables				
Δ Symbol Search RT *SD*	.002	.001	**.02**	.000, .004

Note. All models adjusted for age, education, and within-day timepoint of the assessment. Est. = covariance parameter estimate. B = unstandardized beta. SE = standard error. CI = confidence interval. SD = standard deviation. Ref = reference category.

* = between-person term. Δ = within-person term. RT = response time.

Table 3.

Results of multilevel models testing momentary depression symptoms as a moderator of the within-person association between momentary Symbol Search performance (mean response time, SD of response times) and subjective cognitive dysfunction.

	Subjective Cognitive Dysfunction			
Random Effect	**Est.**	**SE**	***p***	**95% CI**
Intercept	203.87	45.61	**<.0001**	131.50, 316.06
AR(1)	.21	.03	**<.0001**	.16, .27
Residual	178.70	6.78	**<.0001**	165.89, 192.50
Fixed Effect	B	SE	*p*	95% CI
Between-Person Variables				
Intercept	17.84	18.59	.34	−19.64, 55.31
Symbol Search Mean RT *	.01	.003	**.03**	.001, .01
Depression *	−.74	4.09	.86	−8.99, 7.51
Anxiety *	8.82	6.51	.18	−4.31, 21.94
Within-Person Variables				
Δ Symbol Search Mean RT	.003	.001	**<.0001**	.001, .004
Δ Depression	6.70	.88	**<.0001**	4.97, 8.43
Δ Anxiety	−.63	.82	.44	−2.24, .97
Δ Symbol Search Mean RT X Δ Depression	−.003	.002	**.03**	−.01, −.000
	Subjective Cognitive Dysfunction			
Random Effect	Est.	SE	*p*	95% CI
Intercept	225.06	50.20	**<.0001**	145.35, 348.47
AR(1)	.22	.03	**<.0001**	.16, .28
Residual	179.92	6.85	**<.0001**	166.99, 193.85
Fixed Effect	B	SE	*p*	95% CI
Between-Person Variables				
Intercept	17.12	19.75	.39	−22.69, 56.94
Symbol Search RT *SD**	.01	.01	.35	−.01, .02
Depression *	−.08	4.32	.99	−8.78, 8.63
Anxiety *	6.65	6.76	.33	−6.98, 20.29
Within-Person Variables				
Δ Symbol Search RT *SD*	.003	.001	**.003**	.001, .004
Δ Depression	6.67	.89	**<.0001**	4.93, 8.40
Δ Anxiety	−.57	.82	**.49**	−2.18, 1.03
Δ Symbol Search RT *SD* X Δ Depression	−.005	.002	**.02**	−.01, −.001

Note. All models adjusted for age, education, and within-day timepoint of the assessment. Est. = covariance parameter estimate. B = unstandardized beta. SE = standard error. CI = confidence interval. SD = standard deviation. Ref = reference category.

* = between-person term. Δ = within-person term. RT = response time.

Table 4.

Results of multilevel models testing momentary anxiety symptoms as moderator of within-person association between momentary Symbol Search performance (mean response time, SD of response times) and subjective cognitive dysfunction.

	Subjective Cognitive Dysfunction			
Random Effect	**Est.**	**SE**	***p***	**95% CI**
Intercept	203.99	45.63	**<.0001**	131.58, 316.24
AR(1)	.21	.03	**<.0001**	.15, .27
Residual	178.99	6.79	**<.0001**	166.17, 192.80
Fixed Effect	B	SE	*p*	95% CI
Between-Person Variables				
Intercept	18.12	18.59	.34	−19.36, 55.61
Symbol Search Mean RT *	.01	.003	**.03**	.001, .01
Depression *	−.73	4.09	.86	−8.98, 7.51
Anxiety *	8.83	6.51	.18	−4.30, 21.96
Within-Person Variables				
Δ Symbol Search Mean RT	.003	.001	**<.0001**	.002, .004
Δ Depression	6.69	.89	**<.0001**	4.95, 8.42
Δ Anxiety	−.52	.82	.52	−2.13, 1.08
Δ Symbol Search Mean RT X Δ Anxiety	−.001	.001	.34	−.004, .001
	Subjective Cognitive Dysfunction			
Random Effect	Est.	SE	*p*	95% CI
Intercept	225.70	50.33	**<.0001**	145.78, 349.42
AR(1)	.22	.03	**<.0001**	.16, .27
Residual	179.62	6.82	**<.0001**	166.73, 193.50
Fixed Effect	B	SE	*p*	95% CI
Between-Person Variables				
Intercept	17.65	19.77	.38	−22.22, 57.52
Symbol Search RT *SD**	.01	.01	.35	−.01, .02
Depression *	−.06	4.32	.99	−8.77, 8.66
Anxiety *	6.53	6.77	.34	−7.12, 20.18
Within-Person Variables				
Δ Symbol Search RT *SD*	.003	.001	**.003**	.001, .004
Δ Depression	6.63	.89	**<.0001**	4.89, 8.37
Δ Anxiety	−.39	.82	.64	−2.00, 1.22
Δ Symbol Search RT *SD* X Δ Anxiety	−.004	.002	**.02**	−.01, −.001

Note. All models adjusted for age, education, and within-day timepoint of the assessment. Est. = covariance parameter estimate. B = unstandardized beta. SE = standard error. CI = confidence interval. SD = standard deviation. Ref = reference category.

* = between-person term. Δ = within-person term. RT = response time.