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Subjective memory complaints in young people; their relationship with objective cognitive performance and the role of neuroticism

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Título: Quejas subjetivas de memoria en jóvenes; su relación con el rendimiento cognitivo objetivo y el papel del neuroticismo.

Resumen: Las percepciones de olvidos recurrentes o episodios de distracción en la vida diaria se denominan quejas subjetivas de memoria (QSM). Su naturaleza se ha estudiado ampliamente en adultos mayores, pero su importancia y relación con el rendimiento neurocognitivo no se han abordado por completo en adultos más jóvenes. Se han sugerido algunos rasgos psicológicos como posibles moderadores de la asociación entre el rendimiento de la memoria objetiva y subjetiva. El primer objetivo de este estudio fue analizar la correspondencia entre la percepción objetiva y subjetiva de los fallos de memoria en jóvenes. En segundo lugar, estudiamos si el rasgo psicológico del neuroticismo podría estar influyendo en esta relación. Para ello, medimos QSM, diferentes dominios cognitivos (memoria episódica y de trabajo y funciones ejecutivas) y neuroticismo en 80 hombres y mujeres jóvenes. Los resultados mostraron que solo la memoria episódica inmediata estaba estadísticamente relacionada con los QSM. Curiosamente, las relaciones negativas entre el rendimiento de la memoria objetiva y subjetiva solo aparecieron en participantes con mayor neuroticismo. Por lo tanto, las quejas de memoria reportadas por los jóvenes podrían reflejar un peor rendimiento de la memoria episódica inmediata, mientras que el neuroticismo jugaría un papel principal en la asociación entre los déficits de memoria y las QSM. Este estudio proporciona datos que pueden ayudar a comprender mejor las QSM en los jóvenes.

Palabras clave: Cognición. Quejas subjetivas de memoria. Memoria episódica. Personalidad. Neuroticismo. Jóvenes.

Abstract: Perceptions of recurrent forgetfulness or episodes of distraction in daily life are referred to as subjective memory complaints (SMCs). Their nature has been extensively studied in older adults, but their significance and relationship with neurocognitive performance have not been fully addressed in younger adults. Some psychological traits have been suggested as possible moderators of the association between objective and subjective memory performance. The first aim of this study was to analyze the correspondence between the objective and subjective perception of memory failures in young people. Second, we studied whether the psychological trait of neuroticism could be influencing this relationship. To do this, we measured SMCs, different cognitive domains (episodic and working memory and executive functions), and neuroticism in 80 young men and women. Results showed that only immediate episodic memory was statistically related to SMCs. Interestingly, the negative relationships between objective and subjective memory performance only appeared in participants with higher neuroticism. Thus, memory complaints reported by young people could reflect poorer immediate episodic memory performance, whereas neuroticism would play a main role in the association between memory deficits and SMCs. This study provides data that can help to better understand SMCs in young people.

Keywords: Cognition. Subjective memory complaints. Episodic memory. Personality. Neuroticism. Young people.

Introduction

People of all ages commonly forget things they planned to do or have to ask what was being discussed because they cannot remember the current topic of conversation. Reporting this type of experience is referred to as subjective memory complaints (SMCs), the perception of recurring forgetfulness, errors in real world planned thought and action, or episodes of absent-mindedness in aspects related to daily life, in the absence of objective cognitive impairment (Broadbent, Cooper, FitzGerald & Parkes, 1982; Carrigan & Barkus, 2016; Molinuevo et al., 2017). SMCs imply the absence of mild cognitive impairment (MCI), but some subtle and non-clinically significant cognitive deficits can exist (Koppara et al., 2015; Molinuevo et al., 2017).

Currently, there is a growing body of research on SMCs and their correspondence with objective performance, in order to detect which cognitive domains could primarily be affected. This relationship has been studied in different clinical populations, such as patients with epilepsy (Feldman, Lapin, Busch & Bautista, 2018), human immunodeficiency virus (Kamkwalala, Hulgan & Newhouse, 2017), or major depressive disorder (Srisurapanont et al., 2018), particularly in older people (Burmester, Leathem & Merrick, 2016). In this age group, a small but significant relationship has been observed between SMCs and cognitive performance (for review see: Burmester et al., 2016), as well as an association between SMCs and a greater risk of the long-term development of dementia (Jessen et al., 2010; Mitchell, Beaumont, Ferguson, Yadegarfar & Stubbs, 2014). These results have been corroborated longitudinally, given that an eight-year study showed that a subtle cognitive deficit preceded SMCs, and the latter reflected cognitive impairment over time (Koppara et al., 2015). In addition, hippocampal atrophy was found to precede SMCs in a four-year follow-up (Stewart et al., 2011). In contrast, in young people, less is known about the factors contributing to SMCs, apart from their relationship with subjective health (Pearman, 2009) and recent stress experiences (Molina-Rodríguez, Pellicer-Porcar & Mirete-Fructuoso, 2018). Therefore, it is interesting to determine whether SMCs in healthy young individuals are similar to or different from those that occur at older ages, and analyze whether, in addition to personality traits and stress-related factors, subtle cognitive deficits can contribute to explaining the subjective perception of memory failures.

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It is important to understand the correspondence between the objective and subjective state and what these memory complaints really indicate, in order to optimize prevention, diagnosis, and interventions for young people who report SMCs. This relationship has been studied by including young people in mixed-age samples. Some of these studies have found that SMCs could be close to deficits in attention (Ruiz-Sánchez, Llanero-Luque, Lozoya-Delgado, Fernández-Blázquez & Pedrero-Pérez, 2010; Ruiz-Sánchez, Pedrero-Pérez & Lozoya-Delgado, 2014; Söğütlü & Alaca, 2019) or visuospatial abilities (Ruiz-Sánchez et al., 2010), whereas the results for episodic and working memory and executive functions have been contradictory. Thus, some studies have reported significant relationships between SMCs and immediate episodic memory (Montenegro et al., 2013; Ruíz-Sánchez et al., 2010, 2014; Söğütlü & Alaca, 2019), delayed episodic memory, (Ruíz-Sánchez 2010, 2014; Söğütlü & Alaca, 2019), and working memory and executive functions (Ruíz-Sánchez 2010, 2014; Söğütlü & Alaca, 2019), whereas others did not find associations between SMCs and delayed episodic memory (Mendes et al., 2008; Montenegro et al., 2013) or working memory and executive functions (Könen & Karbach, 2020). To the best of our knowledge, only three studies have exclusively included young people (18-35 years old) (Pearman, 2009; Unsworth, Brewer & Spillers, 2012; Wright & Osborne, 2005), and the results were inconsistent. Thus, SMCs were not related to episodic memory performance (Pearman, 2009) or verbal, visual, and spatial components of working memory (Wright & Osborne, 2005). However, a few years later, Unsworth et al. (2012) reported that SMCs were related to poorer working, retrospective, and prospective memory and attention control. However, it is worth noting that all these previous studies did not take the role of depression. In recent years, the relationship between SMCs and depression has been strengthened (Schweizer, Kievit, Emery & Henson, 2018), and so more research is needed to consider the possible confounding role of depression in the relationship between objective and subjective cognition in young people. Clarifying the correspondence between objective and subjective memory in a sample of healthy young individuals will help to elucidate the meaning of SMCs at young ages and further differentiate their origin and nature at more advanced ages.

In addition, the heterogeneous results on the correspondence between objective and subjective memory performance could be explained by some psychological factors that would be interfering with SMCs' reliability in reflecting cognitive performance. Neuroticism, the trait characterized as the tendency to feel negative emotions such as anxiety or depression and the subsequent thoughts and behaviors (McCrae & Costa, 1987, 2010), has been suggested as one of these factors (Sutin, Aschwanden, Stephan & Terracciano, 2020). This trait, along with others, has been related to lower metamemory, understood as people's level of confidence in the state of their memory, considering both objective and subjective memory (Colvin, Malgaroli, Chapman, MacKay-Brandt & Cosentino, 2018).

Neuroticism and SMCs have been positively related in young samples (Könen & Karbach, 2020; Mecacci, Righi & Rocchetti, 2004; Pearman, 2009; Wilhelm, Witthöft & Schipolowski, 2010). Neuroticism is associated with subjective cognitive failures, more precisely, to a failure to maintain a planned action (e.g. what to buy) (Könen & Karbach, 2020; Sutin et al., 2020). Furthermore, neuroticism has been negatively related to episodic and working memory (Munoz, Sliwinski, Smyth, Almeida & King, 2013), and it has been associated with a higher frequency of errors on tasks assessing executive functions (Crow, 2019). Likewise, neurotic people tend to report more mind-wandering during cognitive tasks, lower working memory capacity, and poorer attention control (Robison, Gath & Unsworth, 2017). In this regard, impulsivity, a facet of neuroticism, could explain the relationship between neuroticism and attention control and executive functions, which are partly responsible for memory consolidation (Robinson & Tamir, 2005; Ruíz-Sánchez 2010, 2014; Söğütlü & Alaca, 2019; Unsworth et al., 2012). Mind-wandering could also explain the relationship between neuroticism and memory processes, due to its effect on concentration on ongoing tasks and executive functions (Kane et al., 2017; Robinson et al., 2017). Considering all of the above, neuroticism could be a factor that plays an important role in the relationship between cognitive function and SMCs in young adulthood.

Hence, the current study aimed to examine the associations between SMCs and several different cognitive domains (i.e., episodic memory, working memory, and executive functions), which have not been clearly established in previous studies in young people, and investigate whether neuroticism could be influencing these relationships. To do so, we selected a sample of healthy young individuals with no known medical or psychological conditions that could explain either cognitive deficit or SMCs, per se. In previous literature, SMCs have been related to both memory and executive functions (Ruíz-Sánchez 2010; Söğütlü & Alaca, 2019). Despite this, because we assessed memory complaints, we expected them to be more related to memory performance than to executive function performance. In addition, we hypothesized that, in people with higher neuroticism, the relationships would be stronger than in people with lower neuroticism, mainly because neuroticism has been negatively associated with episodic and working memory and executive functions (Crow, 2019; Munoz et al., 2013; Robison et al., 2017) and positively associated with SMCs (Könen & Karbach, 2020; Sutin et al., 2020).

Method

Participants

The sample was composed of 80 healthy volunteers (41 men and 39 women) ranging from 18 to 34 years old. Partic-

ipants were recruited from classrooms on different campuses of the University of Valencia (Spain). The recruitment phase was carried out through posters displayed on different campuses at the University and information presented to different classes about the type of data collected, the duration of the session, the location of the lab, and the compensation they would receive if they participated. Interested students were contacted for an initial interview by telephone where the exclusion criteria were evaluated. As compensation, they received a pen drive for participating in the study and a neuropsychological report that contained the results of the neurocognitive tests employed in the study. Exclusion criteria were: not being in an age range from 18 to 35 years old; tobacco, alcohol, or other drug abuse; having a disease or using a medication that can directly affect cognitive functioning (e.g. antidepressants or sleep medications); uncorrected visual or hearing problems. Participants were also asked a question about the presence of a stressful life event or an important change in their habits during the past year, such as becoming independent from their parents, the appearance of a major disease, an accident, or any other event they subjectively felt had significantly affected them. Those who reported any event they subjectively experienced as stressful were excluded from participating in the study, given that stress and stress-related factors have been related to SMCs (Fiocco et al., 2006; Peavy et al., 2013; Zapater-Fajarí et al., 2022). As in other studies with non-clinical samples of young individuals (Loprinzi et al., 2019; Mecacci et al., 2004; Molina-Rodriguez et al., 2016; Montenegro et al., 2013; Pearman, 2009; Pellicer-Porcar et al., 2014), we did not use a cognitive screening measure to determine study inclusion.

Procedure

Participants were contacted by telephone. If they did not meet any of the exclusion criteria, they were summoned to the Laboratory of Social Cognitive Neuroscience at the University of Valencia to carry out the evaluation session. This session lasted approximately one hour, and it was held at 10 am, 12 pm, 4 pm, and 6 pm. Both the schedule and the gender of the participant were counterbalanced. The day before the session, participants were instructed to maintain their general sleep habits. They were also asked to refrain from drinking stimulants, such as caffeinated coffee, cola, tea, or chocolate, at least two hours prior to the appointment. During the session, they filled out psychological questionnaires to assess SMCs, neuroticism, and depression, and a general questionnaire about sociodemographic information, along with a neuropsychological battery to assess working and episodic memory and executive functions. Specifically, the order of test administration was DST, FCSRT, and TMT. The administration and correction of the neurocognitive tests was carried out by two psychologists trained for this purpose who were unaware of the study hypotheses. All participants read and signed a written informed consent to participate in the study, which was written in accordance with the Declaration of Helsinki. The protocol was approved by the Research Ethics Committee of the University of Valencia (1034878). The data collection period was between April 2017 and April 2018.

Measures

Subjective socioeconomic status (SES) was measured using the nine-rung social ladder (Adler & Stewart, 2007). The participants were asked about their place on the ladder, which represents their standing in the society of each country. A score of 1 represented the lowest education and income and the worst jobs or no job, and a score of 10 represented the best education, income, and jobs. There are data suggesting that SES is more consistently and strongly related to overall health than objective indicators of social status (Adler et al., 2000; Operario et al., 2004). In addition, SES has been related to a four-year functional decline (Chen et al., 2012).

Subjective memory complaints (SMCs). To measure SMCs, we used the Spanish version (Lozoya-Delgado, Ruiz-Sánchez de León & Pedrero-Pérez, 2012) of the Memory Failures of Everyday (MFE) (Sunderland, Harris & Gleave, 1984). It is composed of 30 items (e.g., My memory failures cause me problems in everyday life; I forget something that was told to me yesterday or a few days ago) rated on a 5-point Likert scale from 0 (never or almost never) to 4 (always or almost always). Although the concept of SMCs has mainly been attributed to a perception of memory loss, the MFE-30 questionnaire also covers other cognitive processes, such as attention, perceptive recognition, language, and speech planning, among others. Higher scores indicate more SMCs, with a maximum score of 120. In our sample, the Cronbach's alpha was .928.

Neuroticism. We used the Spanish version (Costa & McCrae, 1999) of the NEO-FFI questionnaire (Costa & McCrae, 1992) to measure neuroticism. This subscale consists of 12 items (e.g., I often feel inferior/ to others; Sometimes scary thoughts come to mind; Sometimes things seem bleak and hopeless to me) rated on a 5-point Likert scale from 0 (strongly disagree) to 4 (strongly agree). A maximum score of 48 points can be obtained. In the present study, the Cronbach's alpha was .844.

Depression. We used the Spanish version (Sanz, Perdigón & Vázquez, 2003) of the Beck Depression Inventory-II (BDI-II; Beck, Steer & Brown, 1996) to measure depression. This test evaluates the emotional, cognitive, motivational, and somatic symptoms of depression experienced in the past two weeks. It consists of 21 items (e.g., on Mood; Feelings of failure; Pessimism) with four possible specific answers for each item (e.g. Mood: I do not feel sad; I feel sad most of the time; I am sad all the time; I am so sad and unhappy that I can't stand it), and the total score ranges from 0 to 63, where higher scores indicate higher symptomatology. The Cronbach's alpha in this study was .836.

During the neuropsychological assessment, the following tests were administered to assess different cognitive do-

mains: episodic memory, working memory, and executive functions.

Episodic Memory was assessed with the Spanish version (Peña-Casanova et al., 2009) of the original Free and Cued Selective Reminding Test (FCSRT; Buschke, 1973). The FCSRT includes a list of 16 words, each of which belongs to a different semantic category. First, there is an identification phase in which participants read each word, relating it to its category. Next, an interference task is carried out (counting backward by threes) for 20 seconds. Afterwards, free recall is performed (90 seconds), and all the previously read words have to be recalled. Immediately after that, only for the elements not retrieved, a cued recall takes place by providing the categories. These trials (free and cued recall) are repeated three times. After a 30-minute delay, the same procedure is used to test delayed recall. Two scores are calculated: (i) FCSRT-Immediate Total Recall (the number of words remembered freely plus the number of words remembered with a cue on the first three trials); and (ii) FCSRT-Delayed Total Recall (the number of words remembered in free retrieval plus the number of words remembered in delayed retrieval with a cue).

Working Memory was assessed with the Spanish version of the Digit Span Test (DST) (Pereña et al., 2004), a subtest of the Wechsler Memory Scale III (Wechsler, 1997). Participants listen to a sequence of digits (from 0 to 9) at a rhythm of one per second. The participant has to write the numbers on the computer when the sequence ends, first in the same order (DST-Forward) and then in reverse order (DST-Backward). The first sequence had two digits, and this length was increased by one after two trials if at least one of these trials was recalled correctly. If the participant answered two trials of the same length incorrectly, the task ended. We obtained two scores: (i) DST-Forward (the total number of attempts correctly remembered in the same order); and (ii) DST-Backward (the total number of attempts correctly remembered in the reverse order).

Executive Functions were assessed with the Trail Making Test (Reitan, 1992). This task has two trials, A and B, each consisting of 25 circles distributed on a white sheet of din A-4 dimensions. On trial A, the circles were numbered from 1 to 25, and the participant was instructed to trace a line connecting the circles in ascending numerical order as quickly as possible. On trial B, the circles contained numbers from 1 to 13 and letters from A to L, and the participant was asked to alternate numbers and letters in ascending and alphabetical order. The examiner indicated the errors instantly (during the performance of the task) and contributed to the score because the additional time needed for corrections was included in the final score, which was calculated in seconds. Two scores were obtained: (i) TMT-A (the seconds used to successfully finish trial A); and (ii) TMT-B (the seconds used to successfully finish trial B). Thus, higher scores indicate worse performance.

Statistical Analyses

Linear regression analyses were performed to investigate the relationship between SMCs and cognitive domains. First, four simple separate regression analyses were performed with each cognitive index as the independent variable and SMCs as the dependent variable. Second, four separate stepwise regressions were performed for adjusted analyses. To do this, we included the covariates (detailed below) in Step 1 and each cognitive index in Step 2. Covariates included in the adjusted analyses were: (i) depression, due to its relationship with SMCs (Schweizer et al., 2018); (ii) educational level; and (iii) socioeconomic status (only for analyses with FCSRT Immediate and DST-Backward), based on the significant relationships found in Pearson's correlations between sociodemographic factors, SMCs, cognitive indexes, and neuroticism (Table 2). In addition, for analyses with DST-Backward and TMT-B, we included the DST-Forward and TMT-A, respectively, as covariates to control the attentional component in each task. When sex and age were added as covariates, the conclusions of the statistical results did not change, and so these analyses were not included.

To investigate the moderating role of neuroticism in the relationship between cognitive performance and SMCs, we performed moderation analyses. These analyses make it possible to estimate the interaction effect of cognitive domains on SMCs depending on the neuroticism scores. To determine the significance of the interaction effect, bootstrapped bias-corrected 95% confidence intervals (CI %) were used (Hayes, 2017) with 5000 bootstrapped samples. We interpreted that a significant interaction effect exists when this confidence interval does not contain zero. For unadjusted analyses, separate moderation analyses were conducted for each cognitive index. The cognitive index was the independent variable, SMCs were the dependent variable, and neuroticism was the moderator. For adjusted analyses, we repeated these analyses, including the covariates described above.

Outliers were detected as values that deviated from the mean (± 3 SD). There was one outlier in the adjusted regression analyses, one in the (unadjusted and adjusted) moderation analyses between FCSRT Immediate and Delayed Total Recall and SMCs, and one in the unadjusted moderation analyses between TMT-B and SMCs. In the regression analyses, there were no collinearity issues for the factors included in the model, based on tolerance values >0.1 and variance inflation (VIF) values <10. Specifically, in our adjusted moderation analyses, tolerance and VIF values indicated no collinearity between cognitive tests and neuroticism (FCSRT-Immediate Total Recall: Tolerance = .929, VIF =1.077; FCSRT-Delayed Total Recall: Tolerance = .976, VIF = 1.025; DST-Backward: Tolerance = .773, VIF =1.294; TMT-B: Tolerance = .619, VIF = 1.617; Neuroticism: Tolerance = .556, VIF = 1.797).

Four participants had missing data for depression, and, therefore, 76 participants were included in the regression and moderation analyses controlling for covariates.

To obtain a medium effect size for the regression analyses (f ²= .15, α = .05 and power = .80), we estimated a sample size of N = 55 using the G power software. We recruited more participants because the effect size of the relationship between SMCs and cognition has not been well established in young people. In addition, the bootstrapping approach used in the moderation analysis views the original sample size as a miniature representation and randomly resamples it with replacements. This approach increases the statistical power, and the use of bootstrap-corrected confidence intervals solves the issues related to the relatively small sample size (Hayes, 2017).

To perform these statistical analyses, SPSS version 25.0 was used. All *p* values were two-tailed, and the level of significance was considered $p < .05$. Z scores were used in the moderation analyses. We used PROCESS 3.4 for SPSS (Model 1) to test moderated regression effects.

Results

Participants' characteristics (described using means and standard deviations) are shown in Table 1. Pearson's correlations showed that SMCs were negatively related to educational level ($r(78) = -.323$, $p = .003$) and positively related to neuroticism ($r(78) = .378$, $p = .001$) and depression ($r(74) = .473$, $p < .001$). Regarding the cognitive indexes, FCSRT-Immediate Total Recall was positively related to SES ($r(78) = .220$, $p = .050$) and negatively related to SMCs ($r(78) = -.254$, $p = .023$). DST-Backward was negatively associated with SES ($r(78) = -.247$, $p = .027$), and TMT-B was positively related to neuroticism ($r(78) = .237$, $p = .035$). Finally, neuroticism and depression were positively associated ($r(74) = .659$, $p < .001$) (Table 2).

Table 1
Characteristics of the study population for the total sample.

	Mean (SD)/N	Range	Min-max/ %	Kurtosis g_2
1. Age (years)	22.313 (3.757)	-	18-34	1.324
2. Educational level		-		.082
Secondary school	53		66.3	-
College degree	17		21.3	-
Master's degree	10		12.5	-
3. SES	5.925 (1.167)	0-10	3-9	-.190
4. BMI (kg/m²)	22.689 (3.657)	-	16.6-33.1	.842
5. SMC	23.275 (14.896)	0-120	0-60	-.767
6. Neuroticism	19.463 (8.519)	0-48	5-44	-.304
7. Depression	7.316 (6.261)	0-63	0-28	1.015
8. FCSRT ITR	45.950 (3.089)	0-48	33-48	6.040
9. FCSRT DTR	15.725 (.551)	0-16	13-16	7.142
10. DST Forward	6.875 (.919)	0-8	5-8	-.242
11. DST Backward	5.750 (1.119)	0-8	3-8	-.177
12. TMT A	34.250 (12.061)	-	14-84	3.063
13. TMT B	65.573 (22.626)	-	22-137	.816

Note. SES = Subjective socioeconomic status; BMI = body mass index; SMC = subjective memory complaints; FCSRT = Free and Cued Selective Reminding Test; DST = Digit Span Test; TMT = Trail Making Test; SD = standard deviation

Table 2
Participants' characteristics and Pearson's correlations between the study variables.

	2	3	4	5	6	7	8	9	10	11	12	13
1. Age (years)	.666**	−.029	.274*	−.210	−.102	−.073	.036	−.056	.008	−.050	−.293**	−.115
2. Educational level		−.141	.207	−.323**	−.021	−.013	−.007	.070	.128	.020	−.203	−.184
Secondary school												
College degree												
Master's degree												
3. SES			−.051	−.125	−.086	−.027	.220*	.145	−.044	−.247*	.067	.108
4. BMI (kg/m²)				−.060	.016	.139	−.100	.046	−.019	−.113	−.138	−.107
5. SMC					.378**	.473**	−.254*	−.170	−.078	.104	.017	.073
6. Neuroticism						.659*	−.177	−.129	−.190	.045	.135	.237*
7. Depression							−.119	−.078	−166	−.007	−.036	.075
8. FCSRT ITR								.267*	.149	.117	.052	−.005
9. FCSRT DTR									.281*	.092	−.140	−.171
10. DST Forward										.326**	−.092	−.358**
11. DST Backward											−.171	−.260*
12. TMT A												.545**
13. TMT B												

Note. SES = Subjective socioeconomic status; BMI = body mass index; SMC = subjective memory complaints; FCSRT = Free and Cued Selective Reminding Test; DST = Digit Span Test; TMT = Trail Making Test; SD = standard deviation.

Regression analyses of cognitive function and SMCs

Unadjusted regression showed a negative association between SMCs and FCSRT-Immediate Total Recall (p = .023). However, SMCs were not significantly related to the other cognitive indexes assessed: FCSRT-Delayed Total Recall (p = .132), DST-Backward (p = .357), and TMT-B (p = .520) (Appendix: Table 1). The adjusted regression analyses confirmed that SMCs were negatively related to FCSRT-Immediate Total Recall (p = .033), but they were not significantly related to the other cognitive indexes assessed (FCSRT-Delayed Total Recall (p = .151), DST-Backward (p = .387), and TMT-B (p = .956)) (Table 3).

Table 3
Adjusted regression analyses with SMCs as dependent variable and cognitive domains as predictors.

	R^2	Adj. R^2	R^2 change	Standard error	β	p
Step 1: Covariates	.355	.328	.355	11.891		<.001
Depression					.480	<.001
Educational level					-.299	.002
SES					-.080	.410
Step 2: FCSRT-Immediate Total Recall	.396	.361	.041	11.593	-.209	.033
	R^2	Adj. R^2	R^2 change	Standard error	β	p
Step 1: Covariates	.339	.321	.339	11.954		<.001
Depression					.497	<.001
Educational level					-.267	.007
Step 2: FCSRT-Delayed Total Recall	.358	.331	.019	11.863	-.139	.151
	R^2	Adj. R^2	R^2 change	Standard error	β	p
Step 1: Covariates	.331	.293	.331	12.619		<.001
Depression					.466	<.001
Educational level					-.302	.004
SES					-.004	.973
DST-Forward					-.128	.209
Step 2: DST-Backward	.338	.291	.007	12.641	.095	.387
	R^2	Adj. R^2	R^2 change	Standard error	β	p
Step 1: Covariates	.309	.280	.309	12.739		<.001
Depression					.469	<.001
Educational level					-.296	.005
TMT-A					-.036	.766
Step 2: TMT-B	.309	.270	.000	12.828	- .007	.956

Note. FCSRT = Free and Cued Selective Reminding Test; DST = Digit Span Test; TMT = Trail Making Test, SES = Subjective socioeconomic status.

Moderation analyses of cognitive function and SMCs with neuroticism as moderator

Unadjusted analyses showed a significant negative interaction term between FCSRT-Immediate Total Recall and neuroticism in an SMC model (Est. = −.258; CI% [−.515, −.002]). In addition, there was a significant negative relationship between FCSRT-Immediate Total Recall and SMCs in participants with high neuroticism (Est. = −.381, CI 95% [−.637, −.125]). This relationship was no longer significant in participants with medium and low neuroticism (Est. = −.121; CI 95% [−.349, .107] and Est. = .140; CI 95% [−.275, .554], respectively). No significant interaction terms were observed for FCSRT-Delayed Total Recall (Est. = −.144; CI% [−.332, .043]), DST-Backward (Est. = .037; CI% [−.179, .252]), and TMT-B (Est. = .064; CI% [−.116, .245]) (Figure 1) (Appendix: Table 2).

Table 4 shows the results of adjusted moderation analyses. After controlling for covariates, the results of the moderation analyses showed a significant negative interaction term between FCSRT-Immediate Total Recall and neuroticism in an SMC model (Est. = −.255; CI% [−.491, −.018]).

Figure 1
Moderation analysis of immediate episodic memory and SMCs moderated by neuroticism (trends are differentiated in M±1SD units).

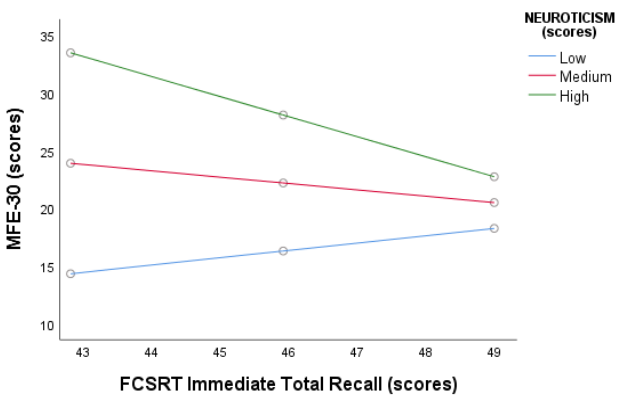

Table 4

Conditional effects of independent variables on SMCs at different values of neuroticism.

Adjusted moderation analyses						
Independent variable: FCSRT-Immediate Total Recall						
Covariates: educational level, SES, and depression						
ΔR2 interaction = .038		*F* = 4.625, df(1, 2) = 1.68		*p* = .035		
Neuroticism	Effect	SE	*t*	*p*	LLCI	ULCI
−.990	.158	.195	.810	.421	−.232	.548
.031	−.102	.108	−.940	.351	−.317	.114
1.052	−.362	.120	−3.011	.004	−.601	−.122
Independent variable: FCSRT-Delayed Total Recall						
Covariates: educational level and depression						
ΔR2 interaction = .026		*F* = 2.893, df(1, 2) = 1.69		*p* = .094		
Neuroticism	Effect	SE	*t*	*p*	LLCI	ULCI
−.990	.082	.145	.564	.575	−.207	.371
.031	−.069	.091	−.760	.450	−.250	.112
1.052	−.220	.105	−2.081	.041	−.430	−.009
Independent variable: DST-Backward						
Covariates: educational level, SES, depression, and DST-Forward						
ΔR2 interaction = .001		F = .050 df(1,2) = 1.68		*p* = .823		
Neuroticism	Effect	SE	*t*	*p*	LLCI	ULCI
−1.000	.105	.145	.722	.473	−.184	.394
.019	.081	.114	.714	.478	−.146	.308
1.039	.058	.164	.352	.726	−.269	.384
Independent variable: TMT-B						
Covariates: educational level, depression, and TMT-A						
ΔR2 interaction = .014		F = 1.429, df(1, 2) = 1.69		*p* = .236		
Neuroticism	Effect	SE	*t*	*p*	LLCI	ULCI
−1.000	−.161	.170	−.946	.348	−.500	.179
.019	−.051	.132	−.390	.698	−.315	.212
1.039	.058	.151	.386	.701	−.242	.358

Note. FCSRT = Free and Cued Selective Reminding Test; DST = Digit Span Test; TMT = Trail Making Test; SES = Subjective socioeconomic status. Values for quantitative moderators are the mean and plus/minus one SD from the mean.

Discussion

The aims of this study were to investigate whether SMCs and objective cognitive performance were related in young people, and the possible moderating role of neuroticism in this association. Overall, we found that SMCs were only negatively related to immediate episodic memory. In addition, neuroticism moderated the association between SMCs and immediate episodic memory, but not the rest of the associations. Our results showed that individuals who expressed more SMCs showed worse immediate episodic memory performance, suggesting that young people who reported SMCs actually had worse cognitive performance, specifically immediate episodic memory.

In our study, bivariate correlations first showed a positive association between SMCs and neuroticism and depressive symptomatology, which is in line with other studies relating SMCs with these psychological traits in young individuals (Könen & Karbach, 2020; Rowell et al., 2016; Sutin et al., 2020). Moreover, SMCs were also correlated with a lower educational level and lower immediate episodic memory. The latter association was also corroborated in our regression models.

The association between SMCs and immediate episodic memory performance found in the present study is in line with previous studies with mixed-age samples (Montenegro et al., 2013; Ruiz-Sánchez et al., 2010, 2014; Söğütlü & Alaca, 2019), but it is not consistent with Pearman (2009), who included only young people, as in this study. This mixed finding could be due to the task used to evaluate episodic memory. The relationship between SMCs and episodic memory was observed when episodic memory was evaluated using tasks consisting of list of words, similar to the FCSRT, such as the list of words from the Wechsler Memory Scale III (Wechsler et al., 1997), used in Montenegro et al. (2013) and Ruiz-Sánchez et al. (2010, 2014), or the Verbal Memory Process Test by Öktem (2011), used in Söğütlü & Alaca, (2019). However, Pearman (2009) failed to find an association between SMCs and episodic memory evaluated with a Logical Memory Test from the Wechsler Memory Scale III (Wechsler et al., 1997), a task that consists of remembering a short story. This suggests that tasks that consist of lists of words could be more sensitive to detecting this subtle deficit than tasks that use stories. Supporting this, it has been reported that the FCSRT presents high specificity in detecting variations in cognition in other types of populations, such as individuals in the predementia phase of Alzheimer's Disease (Grande et al., 2018; Teichmann et al., 2017). Some studies have even found that the FCSRT has higher discriminant validity than magnetic resonance imaging volumes in detecting

differences between individuals with unaltered cognitive performance and patients with Alzheimer's disease (Sánchez-Benavides et al., 2014). Therefore, our results provide support for this sensitivity of the FCSRT, especially on the immediate trial, in a young sample.

The lack of statistically significant associations between SMCs and the other cognitive domains evaluated in this study is consistent with previous studies with mixed-age samples that did not find a relationship between SMCs and delayed episodic memory (Montenegro et al., 2013; Mendes et al., 2008) or between working memory and executive functions such as processing speed or inhibition tasks (Könen & Karbach, 2020). However, other studies found an association between SMCs and cognition state (i.e., working, prospective, and retrospective memory and attention control) (Unsworth et al., 2012) in young people, and between working memory and executive functions (Ruiz-Sánchez et al., 2010, 2014; Söğütlü & Alaca, 2019) and visual memory and attention (Ruiz-Sánchez et al., 2010, 2014; Söğütlü & Alaca, 2019) in mixed-age samples.

A possible explanation for these inconsistent results would be the different ways of measuring SMCs. For example, Unsworth et al. (2012) assessed SMCs three times a day using a diary, thus providing more ecological information about them, whereas in the present study, SMCs were measured with the MFE-30 questionnaire. Therefore, in examining the relationship between SMCs and these cognitive domains, the way SMCs are evaluated would be important. It should also be mentioned that studies evaluating cognitive complaints generally found that they were related to executive functions in mixed-age samples (Stenfors et al., 2013), but not to working memory in young people (Wright & Osborne, 2005). These results might suggest that cognitive complaints measured in general may not be sensitive to assessing memory performance, but they are sensitive to measuring other domains, such as executive functions, although more research is needed. In the relationship between neuroticism and subjective complaints, both memory and cognitive complaints have been positively related to neuroticism (Colvin et al., 2018; Mecacci et al., 2004; Pearman, 2009; Sutin et al., 2020).

Another explanation for these inconsistent results could be that our participants did not present enough memory difficulties to express high SMCs, compared to participants in other studies that observed a relationship between SMCs and most of the assessed cognitive domains. The samples in these studies, in addition to including a broader age range, consisted of participants who came to the expert with complaints, even though they did not present any neurological conditions (Ruiz-Sánchez et al., 2010; Söğütlü & Alaca, 2019). However, this latter condition is not met in all the studies that found a relationship (Ruiz-Sánchez et al., 2014), and so more investigation is needed to fully address this issue. In addition to immediate episodic memory, SMCs could also be motivated by other cognition problems related to disruptions in concentrating on the present moment. This type of disruption, called mind-wandering, which has been related to neuroticism (Kane et al., 2017; Robison et al., 2017), was observed in about half the sample in a study with young people (Killingsworth & Gilbert, 2010).

In the current study, we found a direct relationship between immediate episodic memory and SMCs, although the moderating role of neuroticism in this association gives us more information about the conditions where this relationship occurs. Thus, in people with higher neuroticism scores, there is a negative relationship between immediate episodic memory and SMCs. This result could indicate that, among individuals with the same performance on immediate episodic memory, only those who score high on neuroticism will report memory complaints. In contrast, people who obtain medium to low neuroticism scores, even with the same performance on immediate episodic memory as people with high neuroticism, will not complain about their memory. We also found a trend in the association between delayed episodic memory and SMCs in individuals with high neuroticism, although the interaction between neuroticism and delayed episodic memory did not reach statistical significance. These results are consistent with other recent studies that found that neuroticism was related to poor episodic memory performance (Munoz et al., 2013) and more SMCs (Sutin et al., 2020).

Different interpretations of the way neuroticism could affect the relationship between objective and subjective cognition can be considered. One possibility is that people with high neuroticism report their daily memory function more accurately. Another interpretation could be that people with high neuroticism tend to ruminate, worry, and report more somatic complaints (Denovan, Dagnall & Lofthouse, 2019). Moreover, in recent studies, this trait has been related to perfectionism (Smith et al., 2019), based on early authors who conceived perfectionism as a neurotic search for the idealized self, along with the feeling that "it's never enough" (Adler, 1938; Ellis, 1958; Horney, 1950). Thus, people with high neuroticism could have higher expectations about what their cognitive performance should be, leading them to have a biased underestimation of their memory abilities and report more SMCs (Colvin et al., 2018; Matthews, 2004).

Despite the contributions of this study, it has several limitations that will have to be considered in future studies to advance the field of SMCs in young people. First, our findings should be replicated, administering more tests in each domain and focusing on healthy young people with moderate-severe levels of SMCs, such as young patients who consult a specialist about these complaints. Second, due to the uncertain effect sizes in young people, despite the medium effect size expected in our sample, the relationships found should be confirmed in studies with a larger number of participants. Nevertheless, it is worth noting that our main moderation findings are supported by the bootstrap technique, which reduced the standard error and increased the statistical power. Further work should also confirm the trend we found between delayed episodic memory and

SMCs in individuals with high neuroticism. Third, we have to consider that the comparison of a statistically significant relationship and a non-significant one is not in itself statistically significant (Gelman & Stern, 2006). Despite this, the use of confidence intervals and statistical significance allows us to assess the reliability of the results. We hypothesized that SMCs could be explained by subtle cognitive deficits mainly in immediate episodic memory, as hypothesized previously (Ruiz-Sanchez de León et al., 2010; 2014; Montenegro et al., 2013; Pearman, 2009). However, due to the cross-sectional nature of the study, we could not establish causation. Finally, in the current study, we only evaluated neuroticism, and it might be valuable to include other personality traits that have previously been related to SMCs, such as extraversion or responsibility (Sutin et al., 2020). Thus, future research should evaluate objective and subjective cognition in a more ecological way in the participants' daily environment and increase the number of participants. Moreover, further research could include other personality traits and test their moderating role in the relationship between objective cognition and SMCs.

In conclusion, we found that the presence of SMCs appears to only be related to immediate episodic memory, and higher levels of neuroticism affect this relationship. Furthermore, it is worth mentioning that, despite the association between depression and SMCs and neuroticism, the inclusion of depression in the analyses does not change the statistical conclusions, which adds robustness to the relationships observed in the current study. Thus, healthy young people who express subjective memory complaints could be reporting immediate episodic memory deficits related to stress and emotions associated with neuroticism. The current findings suggest that both specific memory failures and a negative personality dimension such as neuroticism could contribute to SMCs in a non-clinical young population.

Complementary information

Competing interests.- The authors have no relevant financial interests to disclose and no conflicts of interest, affiliations, financial or proprietary interests to declare that are relevant to the content of this article.

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Appendix

Table 1

Unadjusted regression analyses with SMCs as dependent variable and cognitive domains as predictors.

Unadjusted regression analyses						
Subjective memory complaints						
	R^2	Adj. R^2	R^2 change	Standard error	β	*p*
Cognitive domains						
FCSRT-Immediate Total Recall	.064	.052	.064	14.501	-.254	.023
FCSRT-Delayed Total Recall	.029	.016	.029	14.774	-.170	.132
DST-Backward	.011	−.002	.011	14.910	.104	.357
TMT-B	.005	−.007	.005	14.951	.073	.520

Note. FCSRT = Free and Cued Selective Reminding Test; DST = Digit Span Test; TMT = Trail Making Test, SES = Subjective socioeconomic status.

Table 2

Conditional effects of independent variables on SMCs at different values of neuroticism.

Independent variable: FCSRT-Immediate Total Recall						
ΔR2 interaction = .040		*F* = 4.036, df(1, 2) = 1.75		*p* = .048		
Neuroticism	Effect	SE	*t*	*P*	LLCI	ULCI
−.999	.140	.208	.670	.505	−.275	.554
−.009	−.121	.115	−1.056	.295	−.349	.107
1.017	−.381	.129	−2.967	.004	−.637	−.125
Independent variable: FCSRT-Delayed Total Recall						
ΔR2 interaction = .024		F = 2.343, df(1, 2) = 1.75		*p* = .130		
Neuroticism	Effect	SE	*t*	*p*	LLCI	ULCI
−.999	.060	.155	.386	.700	−.250	.369
−.009	−.085	.098	−.871	.387	−.280	.110
1.017	−.230	.114	−2.021	.047	−.457	−.003
Independent variable: DST-Backward						
ΔR2 interaction = .001		F = .116, df(1, 2) = 1.76		*p* = .735		
Neuroticism	Effect	SE	*t*	*p*	LLCI	ULCI
−1.008	.052	.144	.359	.720	−.235	.338
−.002	.089	.104	.853	.397	−.119	.296
1.004	.126	.157	.801	.426	−.187	.439
Independent variable: TMT-B						
ΔR2 interaction = .006		F = .503, df(1,2) = 1,75		*p* = .481		
Neuroticism	Effect	SE	*t*	*p*	LLCI	ULCI
−.999	−.047	.155	−.303	.763	−.355	.261
−.009	.018	.111	.161	.873	−.204	.239
1.017	.083	.132	.625	.534	−.181	.346

Note. FCSRT = Free and Cued Selective Reminding Test; DST = Digit Span Test; TMT = Trail Making Test; SES = Subjective socioeconomic status. Values for quantitative moderators are the mean and plus/minus one SD from the mean.