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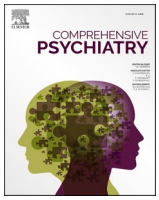

Flowers for Algernon: How metacognition affects quality of life in schizophrenia. Structural equation modeling with the FACE-SZ cohort

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ABSTRACT

Background and hypothesis: We examined the association between metacognitive performance, functioning, and quality of life (QoL) in schizophrenia using structural equation model analyses.
Study design: A sample of 249 participants was assessed for symptoms, functioning, QoL, and both objective and subjective cognitive performance. Metacognitive performance was defined as the adequation between objective and subjective measures of cognitive performance.
Study results: Our model showed an excellent fit (CFI = 0.981; RMSEA = 0.014–0.081) and explained 53.3 % of the variance in functioning and 50.3 % in QoL. Metacognitive performance was not significantly associated with functioning but showed a negative association with QoL ($\beta = -0.383$, $p < 0.001$). Thus, a greater underestimation of one's cognitive abilities was linked with lower QoL, potentially reflecting heightened awareness of deficits that affect well-being. Depression, also negatively associated with QoL ($\beta = -0.359$, $p < 0.001$), was linked to the underestimation of cognitive abilities, whereas symptom severity was associated with their overestimation ($\beta = -0.296$, $p < 0.001$). Complementary analyses suggest that the subjective cognition model closely mirrors that of metacognitive performance, questioning the distinctiveness of metacognition as an explanatory factor in schizophrenia outcomes.
Conclusion: Our findings imply that interventions that boost confidence in cognitive abilities, such as cognitive remediation, may improve QoL. Future research should investigate the causal pathways between these factors and explore the role of social cognition, often impaired in schizophrenia, as another mediator. Comprehensive treatment that addresses clinical symptoms, depression, and subjective cognition challenges appear essential to improve outcomes in schizophrenia.

"*I don't know what's worse: to not know what you are and be happy, or to become what you've always wanted to be, and feel alone.*"
— Daniel Keyes, Flowers for Algernon.

1. Introduction

Schizophrenia is a complex and multi-dimensional psychiatric disorder associated with a wide spectrum of cognitive impairment that has a significant impact on the daily lives of patients [1]. Cognitive dysfunction stands out as a strong predictor of social and occupational functioning in schizophrenia [2–4]. Several studies have also identified neuropsychological performance as a determinant of quality of life (QoL) in this pathology [5–7]. Therefore, accurate assessment and an understanding of cognitive deficits are critical to ensure effective management and intervention strategies in schizophrenia [8].

Individuals with schizophrenia also exhibit deficits in awareness of their own cognitive impairment concerning reasoning, beliefs, and memory [8–10]. These deficits are also referred to as deficits in "metacognitive performance", defined as "the correlation between metacognitive judgments and actual task performance" [11]. Such deficits have crucial clinical implications, as a misappraisal of one's deficiencies may lead to underestimating the need for treatment, a lack of motivation for cognitive remediation, and poor adherence [12]. Higher levels of cognitive complaints have been shown to be associated with better occupational outcomes, suggesting a link between self-awareness of cognitive deficits and functional improvement in individuals with schizophrenia [13]. By contrast, being aware of one's impairment has also been shown to be associated with self-stigma, restrictions, and depression [14].

In a recent meta-analysis, patients with schizophrenia were found to have a lower QoL in physical, psychological, social, and environmental domains than healthy controls [15]. However, how the distinct dimensions of schizophrenia symptoms and cognitive aspects contribute to QoL is still poorly understood. This study aimed to investigate the aspects that contribute to functioning and QoL in schizophrenia, with a particular focus on metacognition, using structural equation modeling (SEM). To better understand these discrepancies in quality of life, it

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seems essential to consider both objective and subjective cognition, and how their interplay—especially via metacognitive processes—may shape real-world outcomes.

Objective cognition refers to measurable cognitive performance assessed through standardized tasks, including memory, attention, and executive functions, independent of personal perception [16]. Subjective cognition refers to an individual's self-reported perception of their cognitive abilities, such as memory and attention, which may not always align with objective measures [16]. Several studies have reported that patients' subjective experiences of cognitive functioning sometimes fail to accurately reflect assessed cognitive performance [17–20]. This mismatch between perceived and actual cognitive performance raises questions about how each dimension independently contributes to functioning and quality of life.

Although both subjective and objective cognition have been associated with functioning and QoL in schizophrenia [21,22], their respective relationships with these outcomes differ markedly. Objective cognition is consistently linked to better psychosocial functioning, which itself is a key determinant of QoL. However, direct associations between objective cognition and QoL are often weak [23] or even negative [22,24]. Conversely, subjective cognition is positively associated with QoL, but its relationship to functioning is less clear and may, in some cases, be negative [13].

To clarify how these differing associations relate to metacognitive performance, we tested two structural equation models (SEMs) separately: one in which subjective and objective cognition were treated as separate predictors, and another in which metacognitive performance was modeled as a latent variable representing the discrepancy between subjective and objective cognition. This approach allowed us to test whether metacognitive performance could provide a distinct explanatory account of functioning and QoL. Specifically, we hypothesized that metacognitive performance, as an emergent property of the subjective–objective gap, would be positively associated with both functioning and QoL, potentially capturing variance not explained by subjective and objective measures separately. We hypothesized that metacognitive performance might influence quality of life either directly—by enabling individuals to more accurately assess their own cognitive abilities, thereby fostering better self-awareness and adaptive functioning—or indirectly, through its positive impact on psychosocial functioning, which in turn would contribute to improved quality of life.

We controlled for depressive symptoms and core schizophrenia symptoms. Notably, previous findings have demonstrated an association between cognitive complaints and depressive symptoms in schizophrenia, underscoring the influence of depression on negative subjective cognitive judgments [19]. Furthermore, prior research has identified positive correlations between psychotic symptoms and self-reported cognitive deficits while highlighting the detrimental effects of psychotic symptoms on QoL in schizophrenia [25–28]. Recent network analyses further revealed that functioning in schizophrenia is shaped by a complex interplay of factors, including positive, negative, and depressive symptoms and disorganization, as well as deficits in neurocognition, social cognition, and metacognition [29]. In particular, functioning was found to be closely interconnected with negative symptoms, disorganization, and metacognitive impairment.

Despite advances in this field, a comprehensive understanding of the determinants that influence functioning and QoL in schizophrenia remains elusive [29]. Notably, few studies in this field have used SEM. This approach allows for the examination of latent variables (a variable that cannot be directly observed or measured, but is inferred from observable variables), such as metacognitive performance [30,31]. SEM enables the simultaneous estimation of multiple relationships, allowing for a comprehensive view of the interactions between metacognitive performance, symptoms severity, depression, functioning, and QoL [32]. Finally, it makes it possible to assess how well theoretical models fit the data, ensuring that the proposed relationships reflect the true dynamics between the variables [33].

Through this study, we aimed to bridge this gap by providing deeper insights into these determinants, ultimately contributing to the development of targeted interventions designed to enhance the functioning and overall well-being of individuals with schizophrenia.

2. Methods

2.1. Study design and characteristics of the recruiting network

This multicenter, cross-sectional study included patients recruited into the FACE-SZ (FondaMental Advanced Centers of Expertise for Schizophrenia) cohort within a French national network of nine centers (Bordeaux, Clermont-Ferrand, Colombes, Créteil, Grenoble, Lyon, Marseille, Strasbourg, and Versailles).

This network was set up by the Fondation FondaMental (www.fondation-fondamental.org), which has created an infrastructure and has provided resources to follow clinical cohorts and conduct research on patients with schizophrenia. The ethical standards of the relevant national and institutional committees on human experimentation and the Helsinki Declaration of 1975, as revised in 2008, were followed by the authors in all procedures involved in this study. The local ethics committee (Comité de Protection des Personnes Ile de France IX), under French law for non-interventional studies (observational studies without any risk, constraint, or supplementary or unusual procedure concerning diagnosis, treatment, or monitoring), approved all procedures involving human patients on 18 January 2010. Although an informational letter was required for all patients, the board waived the need for written informed consent. However, verbal consent was witnessed and formally recorded.

2.2. Participants

All participants were referred by their respective psychiatrists. The criteria for diagnosing schizophrenia were based on the Structured Clinical Interview for the DSM-5 (SCID). The study included patients with clinically stable schizophrenia, defined as no admission or treatment change in the past four weeks. The patients were between 18 and 65 years of age. To eliminate the possibility of confounding effects on objective cognitive performance, individuals with a history of substance abuse within a month prior to assessment, those with a coexisting neurological disorder, such as multiple sclerosis, epilepsy, meningitis, traumatic brain injury, stroke, or another significant neurological condition, those who had undergone electroconvulsive therapy within the last six months, those with dysthyroidism or significant sensory impairment were excluded.

2.3. Assessment tools

2.3.1. Clinical evaluation

The severity of schizophrenic symptoms was measured using the total score of the positive and negative syndrome scale [34] (PANSS).

Depression was assessed using the total score of the Calgary Depression Scale (CDS), a nine-item structured interview scale that has been validated for schizophrenia [35]. Higher scores indicate worse depression.

2.3.2. Subjective cognition

Subjective cognition was measured using the Subjective Scale To Investigate Cognition in Schizophrenia (SSTICS). This self-report questionnaire consists of 21 items, each designed to target specific domains of cognitive impairment [36]. Respondents quantify the frequency of their cognitive complaints on a five-point scale, ranging from "very often" (0) to "never" (4). The original scoring was reversed to reflect perceived cognitive performance rather than perceived cognitive impairment, ensuring consistency with the direction of the objective cognitive measures. These items cover working memory, explicit

memory, attention, executive functions, language, and praxis [37]. The SSTICS scale presents both good internal consistency (α = 0.88) and stability over time [36,37].

Based on previous factor analyses conducted in the literature, we opted for a five-factor structure [37–40] with memory (items 1 to 11), attention (items 12 to 16), executive functions (items 17 to 19), language (item 20), and praxis (item 21). We did not include the 21st item related to the praxis factor in the analyses, as this dimension was not assessed in the neuropsychological battery.

Based on the structure of the scale, we computed mean scores for the four remaining dimensions by averaging the relevant item responses: Memory, Attention, Executive Functions, and Language. As normative data are lacking for the SSTICS, domain scores were standardized within the clinical sample and reverse-coded so that higher values reflect better subjective cognition, in line with the directionality of objective cognition scores. This allowed for consistent interpretation across variables in the structural equation models.

2.3.3. Objective cognition

A comprehensive battery of cognitive tests was administered to the cohort by experienced neuropsychologists. It included 10 tests, among which four were subtests from the WAIS version IV [41], as the French version of the WAIS-IV was progressively introduced during the course of data collection.

Objective cognition was modeled as a latent variable reflected by four domain-specific indicators: Objective Memory, Objective Attention, Objective Executive Functions, and Objective Language. These domains were selected to mirror the four-domain structure of the SSTICS scale (subjective cognition), in order to ensure conceptual alignment between subjective and objective cognition and facilitate meaningful comparison within the structural model.

Each domain indicator was computed as the mean of standardized scores from a subset of cognitive tests selected for their theoretical and empirical relevance to the target domain:

- *Objective Memory*: WAIS Digit Symbol Coding, WAIS Arithmetic, four measures of the California Verbal Learning Test [42] (Immediate Recall, Short Delay Free Recall, Long Delay Free Recall, and Long Delay Recognition).

WAIS Coding and WAIS Arithmetic were included in the Objective Memory domain to ensure consistency with the SSTICS memory subscale, which encompasses both short-term and working memory.

Although these subtests are commonly associated with processing speed and numerical reasoning, they also engage memory-related processes. WAIS Coding involves learning and recalling symbol-digit pairings under time pressure, which recruits both working memory and incidental learning mechanisms. Prior studies have shown that performance on this subtest is influenced not only by speed, but also by associative memory and cognitive flexibility [43,44].

WAIS Arithmetic was included in the Objective Memory domain due to its reliance on working memory, specifically the mental manipulation of numerical information without external aids. Prior studies have shown that arithmetic performance in schizophrenia is strongly influenced by working memory capacity rather than arithmetic skills [45,46], supporting its classification within a memory-related construct.

- *Objective Attention*: Continuous Performance Test - Identical Pairs (CPT-IP) (mean discrimination capacity) [47], time to complete part A of the Trail Making Test [48] (TMT), and WAIS Digit Span (forward).
- *Objective Executive functions*: Modified Six Elements Test [49,50] (error score), time to complete part B of the TMT, and WAIS Digit Span (backward).
- *Objective Language*: WAIS similitudes, Verbal Fluency (semantic and phonemic) [51], and fNART [52].

Higher scores reflect better performance. Raw scores for each cognitive test were first converted into norm-corrected standardized scores based on published norms, adjusting for age and education where applicable [41,53–57]. Composite scores for each objective domain (Memory, Attention, Executive Functions, Language) were then computed by averaging the corresponding normed scores. Because normative data are not available for the subjective cognition measure (SSTICS), SSTICS domain scores were standardized within the clinical sample. To allow subtraction objective and subjective cognition, we applied the same within-sample z-score transformation to all objective domain scores. This harmonization ensured that both constructs were placed on a common scale centered on the clinical sample.

2.3.4. Metacognitive performance

Metacognitive performance, refers to an individual's ability to accurately assess their own cognitive performance [58,59]. It can be seen as a component of metacognition [60]. There are several theories concerning the best way to operationalize metacognition [61]. We selected our measure based on the recent research of Torres et al. on metacognitive knowledge in bipolar disorders [62]. In this study, the participant's actual test performance z-score was subtracted from their prediction rating. Similar measures have been used before [63–65].

Metacognitive performance was defined as the discrepancy between objective and subjective cognition in each domain (Memory, Attention, Executive Functions, and Language). Objective cognition scores were first norm-corrected using published standards, then averaged by domain and standardized within the clinical sample. Subjective cognition scores were computed by averaging the relevant SSTICS items for each domain, standardized within the clinical sample, and reverse-coded so that higher scores indicate better perceived cognition. For each domain, metacognitive performance was calculated as the difference between those objective and subjective standardized scores. These four discrepancy scores served as indicators of a latent metacognitive performance construct in the structural equation model. In this convention, positive values indicate underestimation of one's abilities (objective > subjective), negative values reflect overestimation (subjective > objective), and values near zero suggest accurate self-assessment. Thus, higher metacognitive performance scores correspond to greater underestimation, while lower scores indicate greater overestimation of one's cognitive functioning.

2.3.5. Functioning

We investigated two types of functioning. First, domain-based psychosocial functioning was assessed using the Personal and Social Performance (PSP) scale, which evaluates an individual's ability to perform social activities, maintain personal relationships, take care of themself, and control violent behavior [66]. Second, global functioning was evaluated using the Global Assessment of Functioning (GAF), a numerical scale ranging from 0 to 100 [67].

2.3.6. Quality of life

Two distinct dimensions of QoL were considered. The first was the schizophrenia-specific QoL, measured using the SQOL scale. This scale was developed from the point of view of individuals with schizophrenia [68]. It encompasses psychological well-being, self-esteem, family relationships, relationships with friends, resilience, physical well-being, autonomy, and sentimental life. Higher scores on this scale indicate better QoL.

The second dimension consisted of global health-related QoL, measured using the European Quality of Life 5 Dimensions and 3 Lines (EQ-5D-3L) value index. It is a generic preference-based measure developed to describe and value health across various disease areas [69]. The scale evaluates five aspects of health: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has three levels: no, some, and extreme problems. The respondents are asked to indicate their health state for the five aspects. EQ-5D health states

were converted into a single summary number, the index value. The EQ-5D-3L index is calculated by subtracting the values of the descriptive EQ-5D system obtained using a time trade-off valuation technique [70]. A value of 1 corresponds to the best possible health state according to the scores of the general population of a country/region, whereas an index value <0 represents a worse possible health state.

2.4. Statistical analysis

2.4.1. Rationale for the specifications of the structural equation model (SEM)

2.4.1.1. Rationale to map the latent variables with their indicators. The metacognitive z-scores for the four cognitive domains were included in the SEM as indicators of metacognitive performance. They all corresponded to theoretically separated, albeit partially overlapping, cognitive functions. There is high variability in factorial solutions found in the literature for objective and subjective cognition in schizophrenia. Factorial solutions refer to the patterns discovered through factor analysis, a method used to reveal underlying structures, or "factors," within complex datasets. Previous studies identified memory [45,71], attention [45,72,73], executive functions [45,74,75], and language [73,76] as autonomous objective cognitive dimensions in schizophrenia. The same structure was found for subjective cognitive dimensions [37,40,77,78]. The factorial solution for metacognition is still largely ignored in schizophrenia. For healthy subjects, the domain-specific or domain-general nature of metacognition is a matter of debate [79–82]. We assumed domain-specificity for metacognition, with a similar factorial structure as for objective and subjective cognition, with memory, attention, executive functions, and language as separate, albeit partially overlapping, dimensions.

Two measures were included in the SEM as indicators for the latent variable of functioning: the total PSP and GAF scores. They were chosen because they measure different aspects of functioning. The PSP total score combines specific domains of psychosocial functioning, irrespective of the levels of symptoms, evaluated over a long time frame of 30 days. By contrast, GAF assesses how much a person's symptoms affect day-to-day life, with a global appraisal focusing solely on the time of evaluation. Several studies have reported that these two types of functioning assessments are closely associated in schizophrenia, suggesting that they may serve as complementary measures of functioning [83–86].

Two measures were included in the SEM as indicators for the latent variable of QoL: SQOL & EQ-5D-3L. They were chosen because they measure different aspects of QoL. The SQOL scale was specifically developed for schizophrenia, based on patients' perspectives of psychosocial well-being [87]. By contrast, the EQ-5D-3L measures QoL dimensions related to functional abilities or physical health, and was not specifically designed for any patient group or health condition [69]. These two scales capture complementary aspects of QoL, and several studies have advocated for their combined use in schizophrenia [68,88–90].

2.4.1.2. Rationale for linking the latent variables with each other. As suggested by previous studies, the model included associations between metacognitive performance and functioning [91], as well as between metacognitive performance and QoL [92,93]. The model also assumed an association between functioning and QoL, as suggested by previous studies [94].

2.4.1.3. Rationale for covariate selection. We selected depression, measured using the Calgary Depression Scale total score, because it has been shown to be associated with metacognition [29,95], functioning [96,97], and QoL [98,99] in schizophrenia.

We also included symptoms of schizophrenia as covariates in our model, as they are known to be associated with functioning [100,101] and QoL [102,103]. This approach also allowed us to discriminate the effects of additional depression from the impact of schizophrenia symptoms themselves on functioning and QoL.

2.4.2. Model estimation and testing

Zero-order correlations between each measure were calculated using Pearson's correlation coefficients.

We performed Structural Equation Modeling using the lavaan package [104] in the R environment (version 4.2.1). The minimum sample size was estimated to be 156 using the following formula to calculate sample size: $\boldsymbol{n \geq 50r^2 - 450r + 1100}$ - where r is the ratio of indicators per latent variable [105].

We used Maximum Likelihood with Robust (MLR) standard errors as the estimator for parameter estimation, and the Full Information Maximum Likelihood (FIML) method for handling missing data in the analysis [104]. The MLR estimator is robust to non-normality, making it suitable for datasets with non-normally distributed variables. The FIML method is advantageous in structural equation modeling as it leverages all available information, even when data are missing, to provide accurate parameter estimates and standard errors [106].

We examined consensual fit indices using recommended cutoff criteria for a good fit [33]: the Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) should be >0.95, the Root Mean Square Error of Approximation (RMSEA) $\leq$ 0.05 (p of close-fit >0.05, and 90 % confidence intervals), and the Standardized Root Mean Residual <0.08.

We declared residual correlations between the objective attention dimension and objective executive functions because TMT (A and B) and digit span (forward and backward) measures were distributed across these two dimensions.

Due to ethical and legal restrictions, data involving clinical participants cannot be made publicly available. All relevant data are available upon request to the Fondation FondaMental for researchers who meet the criteria for access to confidential data. This work was not preregistered.

3. Results

The sample included 249 participants who were recruited from 2013 to 2018.

Clinical and socio-demographic data are presented in Table 1.

The participants were mostly men. The average total PANSS score indicated minimal to mild symptoms of schizophrenia. The average score on the Calgary Depression Scale suggested a level of depression between absent and mild. The average EGF score indicated symptoms of significant impairment in social, professional, or academic functioning. The average PSP score indicated marked to severe difficulties in psychosocial functioning. The average SQOL score suggested a QoL slightly lower than that expected by the participants. Finally, the average EQ5D score was below those reported for age classes below 65 in the general French population [107].

In terms of objective cognition, patients exhibited the greatest deficit in objective memory (mean = −0.95, SD = 0.85), whereas language was the domain with the smallest deficit (mean = −0.22, SD = 0.73) (Table 2).

Within subjective cognition, patients reported the highest cognitive complaints for attention, corresponding to periodically encountered difficulties. The domain for which there were the fewest cognitive complaints was memory, corresponding to rarely encountered difficulties (see Table 3).

The average scores for each metacognitive dimension are presented in Supplementary Table 1. The zero-order correlations between the variables included in this model are presented on a heatmap (Supplementary Fig. 1).

Overall, 6.3 % of observations were missing, and the Metacognitive Performance model had 26 different patterns of missingness. A pattern of missingness describes those observations that are missing in a dataset

and how such absences are structured, with each unique combination of missing data across variables representing a distinct pattern. The covariance coverage matrix of missing data is reported in Supplementary Table 2.

This model including metacognitive performance as the exogenous latent variable showed an excellent fit [CFI = 0.981, RMSEA 90 % CI (0.014–0.081), SRMR = 0.037] and explained 53.3 % of the variance in functioning and 50.3 % of the variance in QoL. The results of the model are reported in Fig. 1 and Table 4. Indicator variables were reliable and valid measures of the latent variables, as supported by significant moderate to high factor loadings (absolute values of standardized factor loadings ≥ 0.5, $p < 0.001$).

Metacognitive performance was not significantly associated with functioning ($\beta = 0.049$, $z = 0.767$, $p = 0.44$). However, it was negatively associated with QoL ($\beta = -0.383$, $z = -4.021$, $p < 0.001$), meaning that a greater underestimation (or lower overestimation) of neuropsychological performance was associated with lower QoL.

Based on the scheme in Supplementary Fig. 4, which provides a visualization of the negative correlation between metacognitive performance and QoL, a slightly negative metacognitive performance score might be the best balance to achieve the best quality of life.

Depression was not significantly associated with functioning ($\beta = -0.082$, $z = -1.379$, $p = 0.168$) and was negatively associated with QoL ($\beta = -0.359$, $z = -4.743$, $p < 0.001$). Schizophrenia symptoms (PANSS) were strongly and negatively associated with functioning ($\beta = -0.694$, $z = -12.297$, $p < 0.001$) and not significantly associated with QoL ($\beta = -0.148$, $z = -1.319$, $p = 0.187$).

Finally, depression was positively associated with metacognitive performance ($\beta = 0.439$, $z = 5.336$, $p < 0.001$), meaning that greater depression was associated with greater underestimation. By contrast, schizophrenia symptoms were negatively associated with metacognitive performance ($\beta = -0.296$, $z = -3.815$, $p < 0.001$), meaning that higher levels of symptoms were associated with greater overestimation.

We ran a complementary analysis by replacing metacognitive performance with objective and subjective cognition simultaneously, keeping the same remaining endogenous variables and covariates. This additional analysis, detailed in Supplementary Information 1, examined whether the relationships identified between metacognitive performance, functioning, and QoL aligned with those observed between objective cognition, functioning, and QoL or subjective cognition, functioning, and QoL or whether they differed from both. We found that the pattern of associations between metacognitive performance, functioning, QoL, and depression was similar to the pattern of associations between subjective cognition, functioning and QoL but differed from those involving objective cognition. The only difference between the models for metacognitive performance and subjective cognition was the significant negative association observed between metacognitive performance and PANSS scores, which was absent in the subjective cognition model ($\beta = 0.393$, $z = -0.854$, $p = 0.39$). This suggests that schizophrenia symptoms have a negative impact on objective cognition ($\beta = -0.51$, $z = -6.4$, $p = 0.001$) rather than subjective cognition.

4. Discussion

Our study aimed to investigate the cross-sectional relationship between metacognitive performance, functioning, and QoL in individuals with schizophrenia.

4.1. Implications of the results on quality of life

The results demonstrate that metacognition, as measured by metacognitive performance, has a significant negative association with QoL. Patients who did not underestimate their cognitive capacities tended to report a higher QoL. Higher metacognitive performance may imply that individuals become more acutely aware of their cognitive deficits or other limitations, which could contribute to a more negative self-assessment and, therefore, a decreased QoL due to feelings of inadequacy or frustration, for example in areas in which patients feel they fall short of their expectations or societal norms [108]. Thus, psychoeducation concerning cognitive deficits in schizophrenia should be provided with caution to avoid contributing to an underestimation of one's cognitive abilities. Given that stronger under-estimation in our sample predicted lower QoL, a mildly optimistic bias—shown elsewhere to foster resilience and wellbeing [109,110] - may be more adaptive than perfect calibration.

By contrast, interventions that limit the underestimation of one's cognitive ability may contribute to improving QoL in schizophrenia.

One approach to enhancing confidence in one's cognitive abilities is through cognitive remediation, which has been linked to increased self-confidence for individuals with schizophrenia [111]. This can be attributed to the fact that patients who recognize their capacity to improve their cognitive performance are able to apply these gains to their everyday lives. In addition, self-efficacy training has proven to be beneficial for individuals with schizophrenia, as it helps boost overall competency [112,113]. Furthermore, psychological interventions that focus on enhancing self-esteem, increasing self-confidence, and fostering a more meaningful self-narrative have shown significant positive effects on QoL [114–116]. However, a meta-analysis of randomized controlled trials (RCTs) by Petkari et al. that assessed the effectiveness of

Table 1
Clinical and sociodemographic data of the sample ($n = 249$).

Variable	Mean (OR %)	S.D. (OR N)	Missing data (%)
Age (years)	30.77	8.78	0 %
Sex (%M)	71.00		0 %
Education level (years)	12.51	2.26	0 %
PANSS - Total	68.44	19.56	5 %
PANSS-Positive Symptoms	14.98	6.24	5 %
PANSS-Negative Symptoms	19.00	7.17	4 %
PANSS-General Psychopathology	34.44	10.02	4 %
Calgary Depression Scale	3.80	3.75	4 %
Global Assessment of Functioning	49.64	13.63	6 %
Personal and Social Performance Scale	54.16	14.57	29 %
Subjective Quality of Life (SQOL)	50.73	18.10	5 %
EuroQOL-5D (EQ5D)	0.70	0.24	10 %
Treatment (chlorpromazine equivalents mg/24 h)	482.43	468.07	2 %

Table 2
Summary of objective cognitive dimensions and neuropsychological variables. Standardized scores based on normative data are presented, before within sample scaling.

Objective Cognition	Mean	S.D.	Missing Data (%)
Memory	−0.95	0.85	2
Code	−1.19	0.99	11
Arithmetic	−0.60	1.01	13
CVLT Immediate recall	−1.49	1.25	9
CVLT Short-term Total recall	−1.03	1.08	9
CVLT Long-term Total recall	−1.03	1.14	9
CVLT Recognition	−0.37	1.25	10
Attention	−0.61	0.76	0.01
TMT part A Time	−0.62	1.14	1
Continuous Performance Test (CPTIP)	−1.06	0.98	29.7
Digit Span (forward)	−0.27	0.88	3
Executive Function	−0.81	0.81	0.01
TMT part B Time	−1.13	1.25	2
Six Elements Test	−0.86	1.03	24
Digit Span (backward)	−0.38	0.86	3
Language	−0.22	0.73	1
Similitudes	0.20	1.16	16
Verbal Fluency (P letter)	−0.59	0.97	13
Verbal Fluency (Animals)	−0.92	0.92	13
fNART (Verbal IQ)	0.16	0.64	15

Table 3
Summary of subjective cognitive dimensions. Raw scores are presented. For each subjective dimension, we calculated the average of the items allocated to that dimension. SSTICS Items scale: [min 0 - max 4]. A maximum score of 4 for an item indicates the highest level of subjective cognitive complaints.

Subjective Cognition	Mean	S.D.	Missing Data (%)
Memory	1.29	0.64	0
Attention	1.89	0.90	0
Executive Function	1.59	1.03	0
Language	1.49	1.18	0

psychological interventions to improve the QoL of individuals with schizophrenia revealed that only four of the 60 trials addressed this type of intervention [117]. Moreover, there was no specific cognitive component in the interventions aiming to improve self-esteem in schizophrenia, and incorporating such a component could be beneficial.

Destigmatization could be another option to increase confidence in cognitive performance. Interventions aimed at reducing stigma have been shown to indirectly improve self-esteem [118]. Internalized stigma (or self-stigma) were shown to partially mediate the relationship between self-perceived cognitive deficits and QoL [28]. Recently, stigma related to cognitive impairment in schizophrenia was found to positively correlate with internalized stigma and self-perceived cognitive impairment, but negatively with the motivation to engage in goal-directed behavior and daily activities [119]. Finally, metacognitive training (focusing on self-esteem and stigma) led to fewer depressive symptoms in a schizophrenia sample with up to one year of follow-up than psychoeducation [120]. Only a few psychological interventions target stigma in schizophrenia, even though they may be associated with an improvement in health-related QoL [121]. Interventions to reduce stigma do not specifically address cognition. Thus, it would be beneficial to specifically target cognition in interventions focused on internalized stigma, self-esteem, and empowerment.

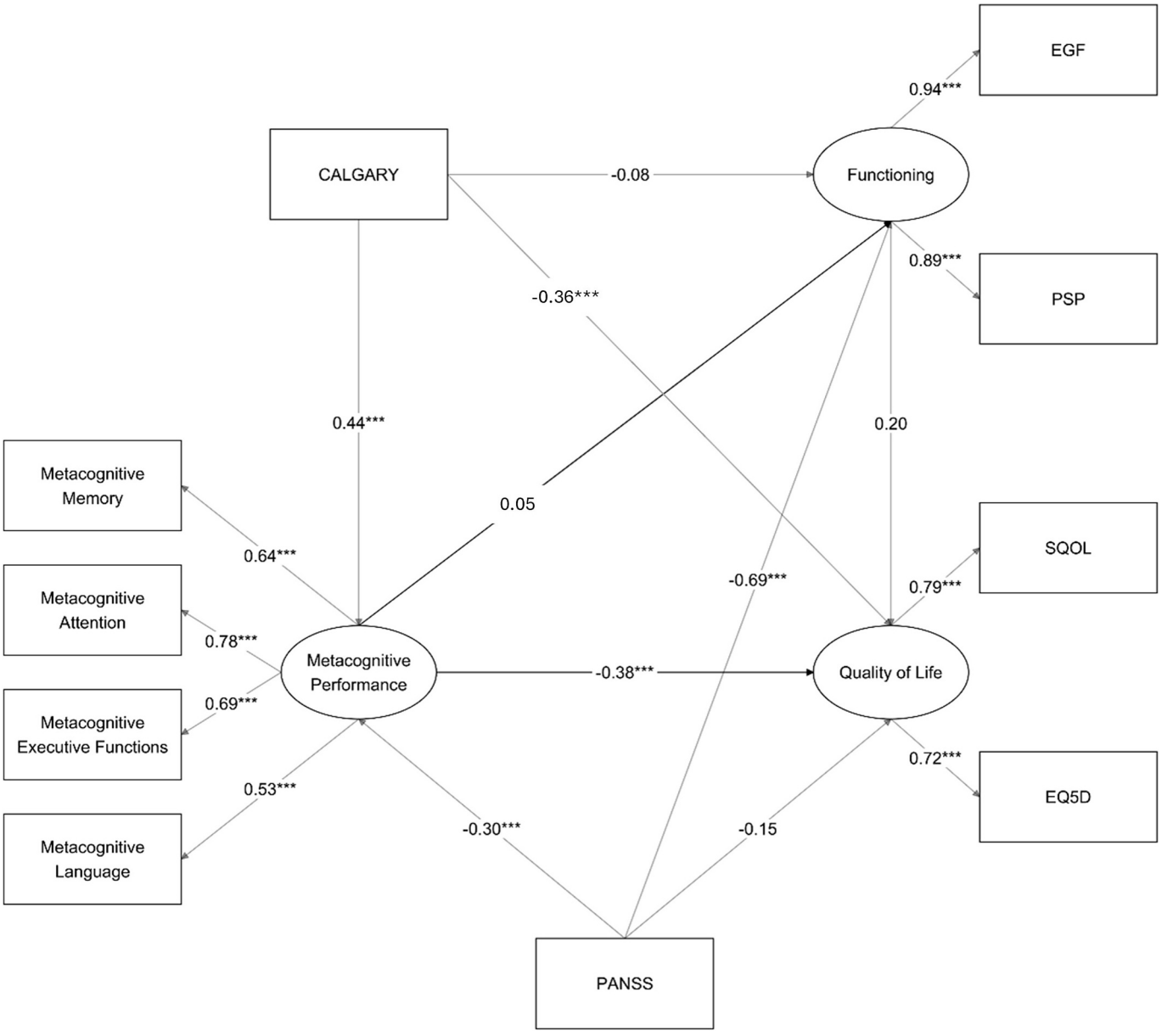

Fig. 1. Simplified diagram of the model. Rectangles indicate the observed variables, ovals the latent variables, single-headed arrows the regressions (freely estimated regression weight), and double-headed arrows the covariances. Path coefficients were standardized. The levels of significance are as follows: ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$.)

Table 4
Statistical outcomes of the model, detailing the relationships between latent variables and observed variables through regression analysis. The columns represent the estimated coefficients (β), standard error (Std.Err), z-values (z), *p*-values (p), standardized estimate on the latent variable scale (Std.lv), and fully standardized estimate, standardized across all variables (latent and observed), allowing a comparison of the effect sizes (Std.all).

Latent Variables	Estimate	Std. Err	z-value	p	Std.lv	Std. all
Metacognitive Accuracy	=~					
Metacognitive Memory	1.000				0.872	0.636
Metacognitive Attention	1.220	0.155	7.853	0.000	1.065	0.785
Metacognitive Language	0.873	0.114	7.666	0.000	0.762	0.531
Metacognitive Executive Functions	1.075	0.153	7.018	0.000	0.938	0.692
Functioning	=~					
EGF	1.000				0.937	0.937
PSP	1.023	0.072	14.136	0.000	0.958	0.889
Quality of Life	=~					
SQOL	1.000				0.786	0.787
EQ5D	0.918	0.122	7.502	0.000	0.721	0.718

Regressions	Estimate	Std. Err	z-value	p	Std.lv	Std.all
Quality of Life	~					
Functioning	0.165	0.097	1.696	0.090	0.196	0.196
Metacognitive Accuracy	-0.345	0.086	-4.021	0.000	-0.383	-0.383
Functioning	~					
Metacognitive Accuracy	0.053	0.068	0.767	0.443	0.049	0.049
Symptoms	-0.033	0.003	-12.297	0.000	-0.036	-0.694
Quality of Life	~					
Symptoms	-0.006	0.005	-1.319	0.187	-0.008	-0.148
Metacognitive Accuracy	~					
Symptoms	-0.013	0.003	-3.815	0.000	-0.015	-0.296
Functioning	~					
Depression	-0.077	0.056	-1.379	0.168	-0.082	-0.082
Quality of Life	~					
Depression	-0.283	0.060	-4.743	0.000	-0.360	-0.359
Metacognitive Accuracy	~					
Depression	0.384	0.072	5.336	0.000	0.440	0.439

4.2. Functioning and metacognitive performance

Metacognitive performance was not associated with functioning in our study. Despite expectations that higher metacognitive awareness would lead to better functioning by allowing individuals to overcompensate for cognitive deficits, our results did not support this association. This absence of a link suggests that metacognitive performance as measured in this study did not translate into improved day-to-day functioning.

This result differs from those of previous studies showing that impaired metacognitive abilities are associated with poorer social and working functioning [93,122–124]. In a systematic review, decreased metacognition was associated with social difficulties and contributed to decreased professional performance for individuals with schizophrenia [125,126]. Furthermore, metacognition was found to partially mediate the relationship between neurocognition and functional capacity and to fully mediate the relationship between functional capacity and social and occupational functioning [127]. The difference observed between our study and previous reports may be explained by how metacognition was measured. Synthetic metacognition, defined as "integrative and contextualizing processes of discrete reflexive moments" [128], is usually measured through structured interviews that evaluate multiple processes, such as emotion recognition, theory of mind, and verbal ability [129,130]. For example the Metacognitive Assessment Scale encompasses a wide range of processes, including social, executive, linguistic, and metacognitive functions [95,131]. It assesses four subscales of metacognition, including Self-reflectivity (understanding one's own mental states) and Mastery (the ability to use knowledge about the mental state of self and others to identify and cope with psychological problems) [132]. It focuses on the integration of information and the integrated sense of self and others, dimensions that we did not measure with the SSTICS, which is a more specific scale, focusing on precise cognitive functions [133].

The difference in results may also stem from the absence of a control for the duration of the illness. A previous study reported that associations between metacognition and disorganization was significant only for subjects with a longer duration of illness [29]. The lack of an association between metacognitive performance and functioning finally suggests that other factors that we did not measure, such as coping mechanisms, support systems, or motivational elements, may be influential in determining functional outcomes. It is also possible that metacognitive performance relates to functioning in a non-linear, U-shaped fashion, such that both underestimation and overestimation of one's cognitive abilities are associated with poorer outcomes. In this view, the degree of miscalibration—regardless of its direction—may be more relevant than the directionality itself. Although our analyses focused on signed difference scores, future studies should investigate the absolute deviation from perfect calibration as a potentially more sensitive predictor of real-world functioning.

Functioning was mainly influenced by schizophrenia symptoms in our study, consistent with previous research showing that poor functioning is associated with positive, negative, and disorganization symptoms [29].

4.3. Covariates and metacognitive performance

Our results show metacognitive performance to be significantly associated with symptom severity: individuals with severe symptoms were also those who overestimated their cognitive abilities. While symptom reduction may lead to functional improvement in schizophrenia, it is unlikely that this enhances QoL, given the expected decline in metacognitive performance. However, complementary analysis (see Supplementary Results) indicates that symptom reduction could potentially have a positive impact solely on objective cognitive function. This complementary analysis consisted of replacing metacognitive performance with objective and subjective cognition simultaneously, keeping the same remaining endogenous variables and covariates.

Previous studies reported positive associations between metacognitive deficits and symptom severity, in particular negative symptoms [134,135]. A recent study exploring the relationship between metacognitive biases and schizophrenic symptoms also identified a strong positive association between overconfidence errors and positive symptoms [136]. Focusing on verbal memory and metamemory, the authors observed that overconfidence in errors was the only significant predictor of positive symptoms. Thus, targeting overconfidence in memory could be relevant in the context of future interventions focusing on positive symptoms.

However, mixed results on associations between metacognition and psychotic symptoms have also been described [137]. Research on various models of metacognitive interventions has led to inconsistent findings in terms of their impact on symptoms [138]. Although some studies reported a specific reduction in positive symptoms [8], others highlighted improvements in specific aspects, such as insight [139], or indicated no significant symptom improvement [140]. Further research on these associations is needed.

In our sample, metacognitive performance was also significantly

associated with depression, but in the opposite direction than schizophrenia symptoms: individuals with more severe depression were also those who underestimated their cognitive abilities the most. This finding echoes the results of a recent network study that described the interrelationships between psychopathological, cognitive, and functioning variables in schizophrenia. Depression scores, as measured using the CDSS, were positively associated with the Metacognition Assessment Scale total score [29]. This association was also identified for subjective cognition in our complementary analysis. A significant correlation between depression and the Executive Function Score of the SSTICS was also measured in the study in which the SSTICS was developed [36] and later studies uncovered strong correlations between the SSTICS total score and levels of depression or dysphoria [40,141,142]. Again, depression may affect metacognition in schizophrenia rather than the reverse, which supports the argument for using SEM over multiple regression. Our results suggest that treating depression in schizophrenia is particularly important, as it can improve QoL, both directly and indirectly, by reducing underestimation of one's cognitive performance. Indeed, depression negatively correlated with QoL, underscoring the impact of depressive symptoms on the subjective well-being of individuals with schizophrenia. Depression remains under-assessed and undertreated in schizophrenia, despite high comorbidity between those two conditions and the availability of medication and psychotherapy [143–146].

4.4. Complementary analysis

The complementary analysis showed that metacognition in our model presented the same pattern of association with depression, functioning, and QoL as subjective cognition. This suggests that subtracting subjective cognition from objective cognition does not explain schizophrenia outcomes better than subjective cognition alone. This does not support the relevance of the concept of metacognition to explain the functional consequences of schizophrenia. A recent series of studies has indeed raised doubts about the existence of an intrinsically metacognitive deficit in schizophrenia [147–149]. Indeed, keeping objective and subjective cognition separate in the model even allows us to better understand the relationship between metacognition and symptoms. The double influence of both schizophrenia and depressive symptoms on metacognition can in fact be broken down into two double dissociations; subjective cognition is influenced by depression but not by schizophrenia symptoms, whereas objective cognition is influenced by schizophrenia symptoms but not by depression.

4.5. Limitations

Our study had several methodological limitations. First, the cross-sectional nature of this study prevents any conclusions about causal relationships among the variables. The sample size was modest but sufficient, based on our sample size calculations. Although our sample was clinically stable and free of major comorbidities, and thus may reflect a profile with limited symptom severity, both cognitive and metacognitive scores showed levels of impairment and variability consistent with prior large-scale or meta-analytic findings in schizophrenia. Objective cognitive z-scores ranged from approximately −0.6 to −1.5 across domains, aligning with established effect sizes [150–153], and were robustly associated with symptom severity. Similarly, subjective cognitive complaints fell within or slightly above the expected range for non-acute samples [37] and showed a strong association with depressive symptoms. Nonetheless, the relative clinical stability and low depressive symptom burden in our sample might help explain the absence of a direct depression-to-functioning link. In more symptomatic or cognitively impaired populations, different association patterns might emerge—potentially revealing stronger direct links between metacognition, depression, and functioning. There was a lack of symmetry between objective and subjective cognition measures. Indeed, the SSTICS measures the perception of a cognitive deficit with a lower boundary set to 0, i.e., a lack of cognitive deficit (an upper boundary in our model as we reversed scores). On the other hand, objective cognition can exceed 0 (corresponding to performance exceeding that of the standard). However, we controlled for this discrepancy between the two metrics by score normalization within the sample.

Subjective cognition lacked an important dimension: processing speed. This domain is considered to be a core cognitive deficit for patients with schizophrenia [154,155] and predicts worse psychosocial functioning [156].

In addition, we did not measure objective or subjective social cognition. Most patients with schizophrenia experience impairment in social cognition, which may mediate the relationship between neurocognition and functioning [157]. Developing measures of social metacognition may be particularly important for understanding important clinical dimensions of schizophrenia, such as functioning [158] and compliance [159]. Without accounting for this aspect of cognition, our model might have overlooked an important factor that could bridge the gap between metacognition and functional outcomes.

The lack of association between metacognitive performance and functioning may partly reflect limitations of the clinician-rated tools used (PSP and GAF), which offer limited granularity, may show ceiling effects in stable samples, and are strongly tied to symptom severity. Future studies should incorporate finer-grained, performance-based or ecologically valid measures — such as the Specific Level of Functioning Scale [160] or the UCSD Performance Based Skills Assessment [161] — to better capture subtle functional impairments related to metacognitive accuracy.

The observed association between metacognitive performance or subjective cognition and quality of life may partly reflect shared method variance, as both QoL and subjective cognition were assessed via self-report. While this bias should be acknowledged, it is also inherent to the nature of these constructs, which can only be meaningfully assessed subjectively.

Finally, due to the cross-sectional design of this study, it was not possible to infer the direction of causality between variables. Future research should consider longitudinal designs to explore the causal relationships between metacognition, functioning, and QoL.

5. Conclusion

Overall, these findings highlight the complexity of factors that influence QoL and functioning in schizophrenia, emphasizing the need for comprehensive interventions that target clinical symptoms, depression, and metacognition to improve patient outcomes. Interventions that increase confidence in one's cognitive abilities may be particularly beneficial for enhancing QoL, while symptom reduction may have a positive impact on objective neuropsychological performance. The complex interplay between metacognition and functional outcomes warrants further investigation.

CRediT authorship contribution statement

Solène Frileux: Writing – original draft, Investigation, Visualization, Formal analysis, Methodology, Conceptualization. **Nathan Faivre:** Writing – review & editing, Investigation, Conceptualization. **Mathieu Urbach:** Writing – review & editing, Investigation, Conceptualization. **Nathan Vidal:** Writing – review & editing, Conceptualization. **Hugo Bottemanne:** Writing – review & editing, Conceptualization. **Fabrice Berna:** Writing – review & editing, Investigation, Data curation. **Cristobal Belmonte:** Writing – review & editing, Investigation, Data curation. **Laurent Boyer:** Writing – review & editing, Investigation, Data curation. **Delphine Capdevielle:** Writing – review & editing, Investigation, Data curation. **Julie Clauss:** Writing – review & editing, Investigation, Data curation. **Isabelle Chéreau:** Writing – review & editing, Investigation, Data curation. **Thierry D'Amato:** Writing – review &

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Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.comppsych.2025.152622.

Data availability

Due to ethical and legal restrictions, data involving clinical participants cannot be made publicly available. All relevant data are available upon request to the Fondation FondaMental for researchers who meet the criteria for access to confidential data.

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