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REVIEW ARTICLE

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Investigating the relationship between negative symptoms and metacognitive functioning in psychosis: An individual participant data meta-analysis

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Abstract

Purpose: Negative symptoms are a persistent, yet under-explored problem in psychosis. Disturbances in metacognition are a potential causal factor in negative symptom development and maintenance. This meta-analysis uses individual participant data (IPD) from existing research to assess the relationship between negative symptoms and metacognition treated as summed scores and domains.

Methods: Data sets containing individuals with negative symptoms and metacognition data, aged 16+ with psychosis, were identified according to pre-specific parameters. IPD integrity and completeness were checked and data were synthesized in two-stage meta-analyses of each negative symptoms cluster compared with metacognition in seemingly unrelated regression using restricted maximum likelihood estimation. Planned and exploratory sensitivity analyses were also conducted.

Results: Thirty-three eligible data sets were identified with 21 with sufficient similarity and availability to be included in meta-analyses, corresponding to 1301 participants. The strongest relationships observed were between summed scores of negative symptoms and metacognition. Metacognitive domains of self-reflectivity and understanding others' minds, and expressive negative symptoms emerged as significant in some meta-analyses. The uncertainty of several effect estimates increased significantly when controlling for covariates.

Conclusions: This robust meta-analysis highlights the impact of using summed versus domain-specific scores of metacognition and negative symptoms, and relationships are not as clear-cut as once believed. Findings support arguments for further differentiation of negative symptom profiles and continued granular exploration of the relationship between metacognition and negative symptoms.

KEYWORDS
anhedonia, apathy, metacognition, psychosis, schizophrenia

Practitioner points

- There is sufficient evidence of a general relationship between composite negative symptom scores and metacognition to warrant further development of treatments targeting metacognitive difficulties in people with problematic negative symptoms.
- Impaired metacognitive capacity for understanding the self and others is most strongly associated with negative symptoms.
- Duration of illness and the presence or absence of disorganization symptoms do not override the impact of metacognitive problems on negative symptoms.

INTRODUCTION

Negative symptoms can be a persistent clinical problem for people experiencing psychosis (Sauvé et al., 2019) but treatment development has been hampered by viewing negative symptoms as an undifferentiated group of experiences. More recently, new studies have added a mechanistic understanding of distinct correlates of different negative symptom domains (Kaiser et al., 2017; Marder & Galderisi, 2017). Two clusters have been identified: *experiential deficits* (including low motivation, reduced pleasure and social withdrawal) and *expressive deficits* (including reduced speech and emotional expression; Strauss et al., 2013).

One candidate theoretical mechanism implicated in negative symptoms is metacognition – the ability to understand our own and others' thoughts, feelings and intentions and to use these to make sense of the world and solve problems (Lysaker, Minor, et al., 2020). Disturbed metacognition may influence the development and maintenance of negative symptoms by inducing a fragmented understanding of one's own and others' beliefs, desires and intentions and this can result in reduced motivation due to the loss of the capacity to reflect on what is personally important and worth pursuing. For example, tasks requiring sustained effort will be hampered when representation of the goal state is degraded due to low levels of metacognition, and this may be reflected in common correlates of negative symptoms such as low expectancies for pleasure, and reduced use of social and affective components of communication (Faith et al., 2020; Garcia-Mieres et al., 2020).

The literature exploring links between metacognition and negative symptoms offers mixed results (McGuire et al., in review). Based on current evidence, impaired overall metacognitive functioning is the most consistent correlate of negative symptoms, while no single sub-domain of metacognitive functioning is consistently associated with negative symptoms. However, it is difficult to estimate a precise relationship between negative symptoms and metacognition based on aggregate data due to problems with reporting quality. At least 86% of the reports in the systematic review by McGuire et al. (in review) mentioned data already published elsewhere, and their analyses treat metacognition and negative symptoms as summed scores as opposed to investigating their components. Additionally, participants are often grouped based on their scores in other domains (such as total schizophrenia symptoms and metacognition levels; see Naggara et al., 2011). Hence, isolating the impact of metacognition on negative symptoms independent of other variables cannot be confidently determined from currently published papers. Theoretical and practical treatment advances could be made with further analyses to determine whether elements of metacognitive capacity predict *distinct* relationships with individual negative symptoms or symptoms grouped into experiential and expressive clusters.

Given the quantity of negative symptom and metacognition data already available, a meta-analysis of existing data appears appropriate to explore these issues. However, given the participant overlap from previously published reports and a lack of relevant analyses for several data sets (McGuire et al., in review), an Individual Participant Data Meta-Analysis (IPDMA) would give a better estimate of the relationship between these variables and would allow comparisons which would not be possible when compared with a traditional meta-analyses (Riley et al., 2010).

The aim of this study was to conduct an IPDMA of the relationship between specific negative symptoms and dimensions of metacognition in people who experience psychosis. Differences between these results and aggregated data reported in a previous systematic review (McGuire et al., in review) will be explored to determine whether any specific study and participant-level factors (such as demographic or diagnostic differences between participants) are likely to affect any observed relationships between metacognition and negative symptoms as a means of further understanding the variance between these constructs. Given the lack of analyses exploring a relationship between domains of metacognition and individual negative symptoms or clusters, no predictions were made around which metacognitive domains would be associated with negative symptom clusters or individual symptoms.

METHODS

Protocol and registration

Methods were developed according to a protocol, available on PROSPERO (registration number CRD42019130678).

Eligibility criteria

Data sets were eligible if they contained participants aged 16+ who experienced psychosis and reported both negative symptoms and metacognition using reliable and valid measures. Data sets identified in McGuire et al. (in review) were considered eligible for inclusion in the meta-analysis, including any data sets which were not eligible for inclusion in the systematic review due to not being published in English. No data sets created after the conclusion of the systematic search conducted for the systematic review (30th April 2019) were included in the IPDMA.

The main data of interest included the Metacognition Assessment Scale – Abbreviated (MAS-A) subscales and Positive and Negative Symptoms Scale (PANSS) negative symptoms subscale data, as these were the most common measures used as identified in the systematic review. The MAS-A rates narrative responses in terms of increasingly complex reflections across four metacognitive domains: self-reflectivity, understanding others' minds, decentration (the ability to make sense of experiences independent to the self) and mastery (the ability to respond to psychological problems).

Treatment of PANSS scale items

Through factor analyses, individual PANSS items (measuring symptoms of psychosis) have been categorized into subdomains. It is contested as to whether some items on the original negative symptom subscale (PANSS-ONS) are better conceptualized as other symptom types, such as disorganization. There is little consensus on which factor structure of the PANSS gives the most accurate representation of distinct symptom clusters (Wallwork et al., 2012); therefore, we compiled data for all PANSS items which have ever been included under the negative symptoms subscale in any factor analyses. These factor analyses and the corresponding items are listed in Table 1.

It was pre-specified that data sets using alternatives to MAS-A and PANSS negative symptoms would be assessed for their similarity and what proportion of the overall data they represent to determine the potential benefit of including them in any meta-analyses. Demographic variables were sourced for all included data sets, and we created one variable (whether participants experienced first or multiple episode psychosis) from study reports and author contact where this information was not reported. For longitudinal data with repeated measures, only the first epoch data were selected. Of the reports where IPD was not obtained, there were no comparable published analyses which could contribute to our meta-analyses.

Individual participant data (IPD) integrity

The primary reviewer quantified the volume of missing data and checked IPD for any noticeable errors (e.g. metacognition or negative symptom scores higher than the maximum possible score), and re-calculated for meta-analyses where errors were identified (errors will be described in Results section). Reviewers and original authors discussed reasons for missing data and made judgements regarding whether data were likely to be missing at random or associated with dropout or other factors.

TABLE 1 Negative symptom items identified by confirmatory factor analysis.

Confirmatory factor analysis study	Negative symptom items															
	N							G								P
	1	2	3	4	5	6	7	5	7	8	11	13	14	15	16	2[a]
Kay et al. (1987)	X	X	X	X	X	X	X									
Kay and Sevy (1990)	X	X	X	X		X		X	X		X	X			X	
Bell, Lysaker, Milstein, et al. (1994)	X	X	X	X		X			X			X		X		
White et al. (1997)	X	X	X	X		X		X	X	X		X	X			
Marder et al. (1997)	X	X	X	X		X			X						X	
van der Gaag et al. (2006)	X	X	X	X		X			X	X		X			X	X
Citrome et al. (2011)	X	X	X	X		X			X						X	
Wallwork et al. (2012)	X	X	X	X		X			X							
Reininghaus et al. (2013)	X	X	X	X		X			X			X			X	
Kelley et al. (2013)	X	X	X	X		X			X			X			X	X
Total (out of 9)	9	9	9	9		9		2	9	2	1	6	1	1	6	2

Code	Negative symptom item
N1	Blunted affect
N2	Emotional withdrawal
N3	Poor rapport
N4	Passive/apathetic social withdrawal
N5	Difficulty in abstract thinking
N6	Lack of spontaneity and flow of conversation
N7	Stereotyped thinking
G5	Mannerisms and posturing
G7	Motor retardation
G8	Uncooperativeness
G11	Poor attention
G13	Disturbance of volition
G14	Poor impulse control
G15	Preoccupation
G16	Active social avoidance
P2(−)	Conceptual disorganization

[a]This item is not analysed individually as found by van der van der Gaag et al. (2006) to be negatively correlated with negative symptom items.

Synthesis methods

Meta-analyses were conducted in a two-stage approach using R version 3.6.1 (code and packages used described: https://osf.io/ub3aj/). To deal with the computational complexity of the meta-analytic models used, we conducted individual meta-analyses for each of the 16 specific negative symptoms identified in Table 1 to estimate the predictive value of each subcomponent of the MAS-A (self-reflectivity; understanding others' minds; decentration and mastery). We used seemingly unrelated regression (SUR), which helps to account for the correlation between these different metacognitive capacities (Zellner, 1962) (previous analyses show that these subcomponents are highly correlated; Bonfils et al., 2016). The four obtained beta coefficients from each SUR analysis (describing the degree of change in a specific negative symptom given a 1-unit change in each metacognitive domain) were then combined in a multivariate meta-analyses which, unlike a univariate approach, provides some control for the relationship between metacognitive domains. A random-effects model was used and was estimated using REstricted Maximum Likelihood (REML) to reduce downward bias in between-study variance estimates.

We conducted several planned sensitivity analyses at each stage, including checking assumptions for regression analyses, comparison between SUR outcomes and those which would be observed by multiple regression and a comparison of univariate versus multivariate meta-analyses. Additionally, IPD for individual negative symptoms were not available in all cases, but across several data sets summed symptom scores were available. These were examined post hoc using the original version of the subscale (PANSS-ONS) and the (Bell, Lysaker, Beam-Goulet, et al., 1994; van der Gaag et al., 2006) negative symptom factor structures (PANSS-BNS and PANSS-VDGNS) to examine both the possibility that the summed score was more strongly associated with metacognition, the impact of each summed including different items. As it is also recognized that negative symptoms can be separated into experiential and expressive negative symptoms, and these were, therefore, also compared using the (Harvey et al., 2017) factor structure. Similarly, the total metacognition score was compared to explore whether this was more strongly associated with negative symptoms than individual metacognitive domains.

Post hoc, the Bell, Lysaker, Beam-Goulet, et al. (1994) cognitive subscale and the van der Gaag et al. (2006) disorganization subscale (which both measure cognitive disorganization) were examined to establish whether these accounted for some findings. A large proportion of the studies included multiple episode psychosis (MEP) groups. The inclusion of MEP populations alone was also compared to the original results. We also investigated the impact of the configuration of the data on the results by investigating the differences in results when data were clustered by levels of metacognition and negative symptoms, and where data were scaled to standardize unit differences across scales (using both min–max normalization and z-score standardization).

For all meta-analyses, between-study heterogeneity was quantified by the I^2 statistic and observed using forest plots (in the case of meta-analyses exploring metacognitive subdomains, forest plots were derived from the univariate analyses due to these being unavailable in the package for multivariate models). We used two-sided p values and 95% confidence intervals (CIs) of the estimated effect to determine the statistical significance of results and small study effects were assessed using funnel plots and influence of outliers was checked through visual inspection and influence diagnostic computations (Viechtbauer & Cheung, 2010). For any meta-analyses with significant results, subsequent tests were performed to determine whether age and education affected the results.

RESULTS

The 33 eligible data sets identified are described in Item 1 of the Appendix S1. This includes all data sets included in the McGuire et al. (in review) systematic review and an additional data set identified in review procedures but not included because it was not reported in English. Of these, 12 data sets were not included in meta-analyses detailed in Figure 1. Broadly, an estimated 276 individuals' data were excluded because of the use of different measures (e.g. the Metacognitive Assessment Interview [MAI], the MAS Revised [MAS-R] and the Brief Psychiatric Rating Scale [BPRS]) which prevented the data from being compared meaningfully in meta-analyses, and an estimated 152 individuals' data were not included because data were unavailable. One sample (i.e. Kukla et al., 2013), where participants were estimated to overlap substantially with other USA data sets, was not independently included in analyses; however, the estimated unique participants (less than 5% of the sample, i.e., four participants) were relatively low. Thirty-two participants were excluded from another sample (MacBeth et al., 2014), as their data were only available as MAS-R ratings.

The final number of unique participants contributing to analyses was 1270. The unique individual participant data were greater than the 1241 participants estimated based on the sum of the samples included in published reports. Supplement Item 2 shows that raw IPD mostly matched

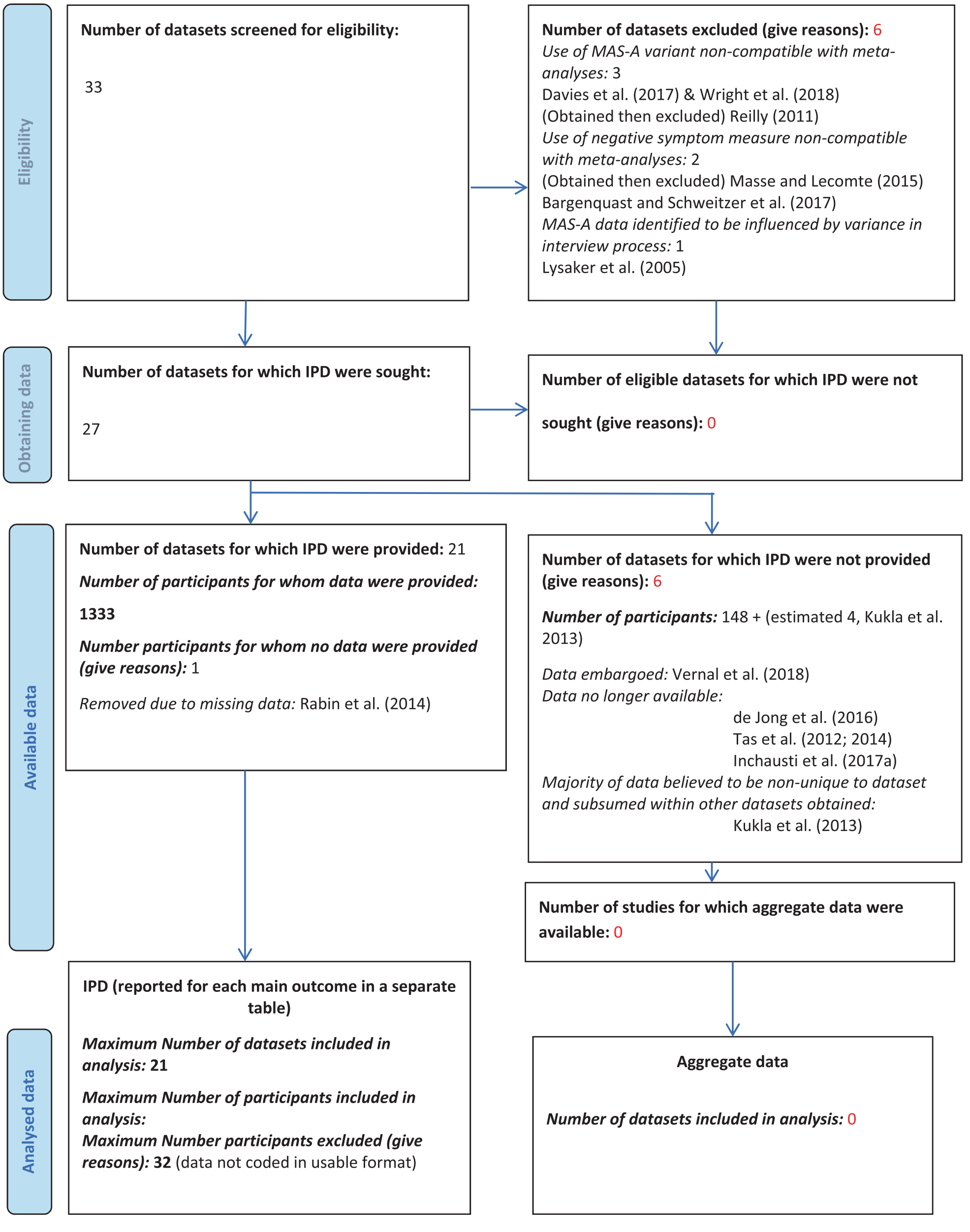

FIGURE 1 Prisma flow diagram.

published reports. Where IPD was greater, this may be due to published analyses only including participants with available data for variables of interest. In cases where the IPD obtained was lower than the expected sample size based on publication, this is due to overlapping subsamples where the other participants are accounted for elsewhere. One data set (Bonfils et al., 2016) had much greater IPD than the aggregate data estimate. These additional participants were only reported in publications which included data from other overlapping samples (e.g. Gagen et al., 2019), which explains why it was not attributed to another data set (Bonfils et al., 2016) when estimating the aggregate data sample size. In this sense, the overall IPD obtained was estimated to represent 87.14% of the published data, which is in line with recommended guidelines (Tierney et al., 2015), but contains more participants than the published data.

Description of IPD obtained

Data were obtained in an anonymized and otherwise unaltered form (excluding one participant who was removed due to missing data from one sample; Rabin et al., 2014). Data were cleaned, and co-authors assisted with translation of databases where necessary. There were a few minor errors apparent in data entry and coding (i.e. some sum scores had been computed incorrectly), and these were identified through checking procedures using components of these scores where these were available (see Supplement Item 3 in Appendix S1). Data sets were collated in the same format in Excel for the purposes of analyses, and only included data which were necessary for each meta-analysis, including negative symptoms and metacognition item level, subscale and summed scores as appropriate and covariates such as age, gender and education.

Item 3 of the supplement shows that all recruited participants provided at least some data (assuming no further cleaning of the data set by the original authors had occurred). Nine data sets reported data on the 35 variables of interest. Education was the most common variable which was systematically unsuitable or unavailable across a total of nine data sets, with the primary reason that data were unsuitable for comparison being that data were collected as a categorical variable around the level of education rather than years of education. This slightly impacts covariate analyses but not the main analyses. Four data sets only included the PANSS-ONS total and two data sets (Abu-Akel & Bo, 2013; Luther et al., 2019) only collected specific individual PANSS items. Computation of summed scores was computed where required. The Bell, Lysaker, Beam-Goulet, et al. (1994) cognitive and van der Gaag et al. (2006) disorganization subscale data for one sample (Rabin et al., 2014) were not requested as analyses involving these variables were conducted post hoc; however, these data were available in other samples. Overall data were comparable for meta-analyses with most data available for analyses.

Given that samples vary greatly in their size and demographic characteristics (i.e. sample ranges of 11–181 participants across data sets and first episode psychosis (FEP) and MEP samples with a range of ages), we meta-analysed the age, gender and education of participants across data sets, allowing comparisons which provide equal weighting to participants in each study. These are described in Table 2.

Meta-analysis of individual participant data

Table 3 represents results of IPDMAs for the relationship between metacognition and each negative symptom subscale, and summed score variation. They are grouped by the metacognition subscale or total score which was being examined as a potential predictor. Fifteen data sets contributed to each IPDMA (apart from the PANSS-ONS meta-analyses where 19 data sets contributed) based on available data. All significant results indicate a negative relationship between metacognition and negative symptoms, indicating that deficits in metacognition are likely to result in higher levels of negative symptoms. Supplement item 4 in Appendix S1 reports results for individual negative symptoms.

The effect size was largest for comparisons between total MAS-A and negative symptoms, regardless of which factor structure was used (i.e. PANSS-ONS, $\beta = -.688$). There were small and significant relationships between the PANSS-ONS and self-reflectivity, understanding others' minds, with the latter showing the strongest association ($\beta = -.410$, CI = −0.775 to −0.045). Expressive negative symptoms were also associated with self-reflectivity, although the strength of relationship was much lower ($\beta = -.032$, CI = −0.063 to −0.001). Of these results, heterogeneity was highest for PANSS-ONS ($I^2 = 85.9\%$ for the multivariate meta-analysis comparing this subscale with all domains of metacognition) and lowest for expressive negative symptoms compared with self-reflectivity ($I^2 < 0.1\%$). Further

TABLE 2 IPDMA estimates of the demographic and clinical profile across data sets.

Demographic and clinical variables	Weighted average (standard error)
Age	36.97 (2.029)
Proportion of males	71%
Years of education[a]	11.54 (0.672)
Negative symptom scores	
Experiential negative symptoms[b]	8.279 (0.459)
Expressive negative symptoms[b]	9.238 (0.499)
PANSS-ONS[c]	18.165 (0.683)
PANSS-BNS[c]	18.949 (0.808)
PANSS-VDGNS[c]	18.858 (0.757)
Metacognition scores	
SR: Self-reflectivity[d]	4.178 (0.249)
UOM: Understanding others' minds[d]	2.983 (0.215)
D: Decentration[d]	0.816 (0.169)
M: Mastery[d]	3.377 (0.262)
Total metacognition[d]	11.505 (0.520)

[a]Nine data sets did not contribute to this figure.

[b]Only 15 of the 21 data sets contributed to these figures with scores of a possible 3–21 for Experiential negative symptoms (NS) and 4–28 for expressive NS.

[c]Possible scores range from 7 to 49 (PANSS-ONS), 8 to 56 (PANSS-BNS) and 2 to 62 (PANSS-VDGNS).

[d]Possible score ranges for each scale are 0–9 (SR/M), 0–7 (UOM), 0–3 (D) and 0–28 (Total metacognition).

examination of heterogeneity included reflections on Forest and Funnel Plots of the preceding univariate analyses (reported in Supplement item 5 in Appendix S1).

Across all models, right skew was present in many regression models. It was too computationally complex to transform these analyses within the final meta-analytic models used; however, using REML to estimate the meta-analyses may have helped correct for this. Some regression models also appeared non-linear, and this may have influenced the significance of some results, for example, both the experiential and PANSS-VDGNS models appeared non-linear across several data sets when plotted against total metacognition (examples given in Supplement Item 6 in Appendix S1). Alternatively, studies with small samples may have contributed to the differences in the patterns of these relationships across data sets (IntHout et al., 2015). Again, by analysing data on aggregate through meta-analysis, and using REML, many of these issues were minimized.

All individual negative symptom items apart from G14 and G16 (poor impulse control and active social avoidance respectively), were significantly associated with total metacognition (β range: −.029 to −.101). In comparison, in analyses of individual negative symptoms, N6 (lack of spontaneity and flow of conversation) was the only item which showed a significant association with any subdomain of the MAS-A (mastery), and the relationship was extremely small ($\beta = -.007$). However, the heterogeneity for these analyses appeared much higher (e.g. I^2 for original negative symptoms subscale compared with total MAS-A = 90.7%).

Sensitivity analyses

Given that the original negative symptom subscale was most strongly associated with metacognition across all analyses, it seemed appropriate to consider whether this may have been due to disorganization

TABLE 3 IPDMA estimates of the relationship between metacognition and negative symptoms.

Negative symptom item(s)	Comparison with self-reflectivity (Beta, 95% CI)	Comparison with understanding other's minds (Beta, 95% CI)	Comparison with decentration (Beta, 95% CI)	Comparison with mastery (Beta, 95% CI)	Comparison with total metacognition (Beta, 95% CI)
PANSS-ONS	−0.281 (−0.560 to −0.003)[†]	−0.410 (−0.775 to −0.045)[§]	−0.377 (−0.760 to 0.005)	−0.447 (−0.987 to 0.093)	−0.688 (−0.855 to −0.521)[¶]
PANSS-VDGNS	−0.015 (−0.051 to 0.021)	−0.034 (−0.099 to 0.030)	−0.022 (−0.084 to 0.040)	−0.009 (−0.032 to 0.015)	−0.475 (−0.614 to −0.335)[¶]
PANSS-BNS	−0.033 (−0.077 to 0.010)	−0.065 (−0.141 to 0.010)	−0.057 (−0.158 to 0.045)	−0.029 (−0.0.69 to 0.011)	−0.512 (−0.636 to −0.389)[¶]
Experiential negative symptoms	−0.001 (−0.006 to 0.005)	−0.003 (−0.019 to 0.014)	−0.001 (−0.018 to 0.018)	−0.001 (−0.004 to 0.003)	−0.114 (−0.171 to −0.056)[¶]
Expressive negative symptoms	−0.032 (−0.063 to −0.001)[‡]	−0.053 (−0.107 to 0.001)	−0.043 (−0.112 to 0.025)	−0.018 (−0.041 to 0.004)	−0.323 (−0.397 to −0.249)[¶]

[†]$p = .048$; [‡]$p = .049$; [§]$p = .028$; [¶]$p < .001$.

items (which were removed from the negative symptom subscale in subsequent factor analytic solutions) contributing significantly to the relationships observed. Therefore, *post-hoc* IPDMA were conducted using the Bell, Lysaker, Beam-Goulet, et al. (1994) cognitive and van der Gaag et al. (2006) disorganization subscales from each factor structure compared with levels of metacognition (described further in Item 7 of the Supplement in Appendix S1). Mastery was the only domain significantly related to cognitive disorganization items using both factor structures (Bell: $\beta = -.071$, 95% CI = −0.126 to −0.016; van der Gaag (VDG): $\beta = -.098$, 95% CI = −0.179 to −0.017). The VDG and Bell factor structures had a moderate relationship with total metacognition ($\beta = -.589$, CI = −0.714 to −0.465 and $\beta = -.445$, CI = −0.528 to −0.361 respectively). Heterogeneity was low for both analyses ($I^2 = 6.8\%$ and 0.1% respectively). The effect sizes shown for total metacognition associations are similar to the PANSS-VDGNS and PANSS-BNS (i.e. all moderate) with considerably overlapping confidence intervals.

Taking these findings together, it was also considered that differences between first- and multi-episode samples may have been a cause for heterogeneity amongst the findings. Analyses were repeated removing the first-episode sample data sets (MacBeth et al., 2014; McLeod et al., 2014; Trauelsen et al., 2016; Vohs et al., 2014). Relationships between total metacognition and all negative symptoms and cognitive disorganization items remained statistically significant. The significant relationships between self-reflectivity and understanding others' minds and PANSS-ONS were not retained after removing FEP samples due to increased uncertainty of estimate. The significant relationship between expressive negative symptoms and self-reflectivity, or between mastery and N6, and the VDG and Bell cognitive disorganization subscales were also not retained for the same reason. The MEP only analyses did not show any stronger or more precise estimates compared with analyses using all data sets (summarized in Supplement item 8 in Appendix S1). There were not enough data sets for it to be deemed feasible to conduct the same analyses on the FEP samples alone.

Sensitivity analyses involving investigating differing configurations of the data are also described in Supplement item 9 of the Appendix S1. These results indicate similar findings to those reported above.

Covariate analyses

Those analyses which were statistically significant were examined in meta-analyses that included covariates which were commonly reported across most studies (age, gender and education), again using seemingly unrelated regression (SUR) to account for the existing correlation between these variables (described in full in Supplement item 10 in Appendix S1). All summed score relationships with MAS-A components remained significant after controlling for these variables, except the relationship between total metacognition and experiential negative symptoms and PANSS-VDGNS. Interestingly, of the relationships between the total MAS-A scores and individual negative symptoms, only poor rapport, lack of spontaneity and flow of conversation and stereotyped thinking (N3, N6 and N7 respectively) remained significant when controlling for covariates.

Some beta coefficients in the covariate analyses were larger than in the original meta-analyses (i.e. the relationship between self-reflectivity and PANSS-ONS was −0.389 in the covariate analyses vs. −0.281 in the original meta-analyses). This may be because the original meta-analyses used SUR to include all metacognitive subscales, which may have driven down the association between any one subscale and negative symptoms. Consistent with this, covariate analyses with total metacognition (where the original meta-analyses did not use SUR) showed smaller beta coefficients than the original meta-analyses (i.e. −0.211 when covariates are included vs. −0.688 in the original meta-analyses). This indicates that covariates may explain some of the relationships between negative symptoms and metacognition, but perhaps not as much as the other correlated domains of metacognition.

The heterogeneity for these analyses was in most cases smaller than the heterogeneity shown in analyses not controlling for covariates (reductions range from 4.6% to 68.2% decrease in heterogeneity), with only the relationship between mastery and N6 showing an increase by 15.8% in heterogeneity when controlling for covariates, although this relationship was no longer statistically significant.

DISCUSSION

Previous attempts to improve negative symptom treatments have been hampered by incomplete understanding of mechanisms of their aetiology and maintenance. This individual participant data meta-analysis offers a more precise and thorough evaluation of the contribution of disturbed metacognition. Of the 33 data sets considered for inclusion, six were excluded due to using unsuitable metacognition measures and six were unavailable (a proportion of participants were also excluded from one data set for using a different metacognition measure). The remaining 21 data sets all measured negative symptoms using the Positive and Negative Syndrome Scale and metacognition using the Metacognition Assessment Scale (Abbreviated). The final sample of 1301 participants (1119 of which had 100% complete or only systematically missing data) is the most comprehensive data set used to analyse the association between metacognition and negative symptoms to date. Even with the limitation that the data set was compiled from studies published up to 2019, this study provides an important test of the theory that metacognitive processes play a role in the development of specific sub-types of negative symptoms and overall negative symptom burden.

Associations between negative symptoms (across all stratifications) were most consistently related to metacognition when measured as an aggregate construct. Strongest associations at the aggregate level could perhaps reflect that the greatest impact of metacognition on negative symptoms is the *degree* of global metacognitive deficits over and above deficits in specific areas. Nonetheless, self-reflectivity and understanding others' minds were also found to be independently associated with total negative symptoms, for PANSS-ONS only, and expressive negative symptoms were associated with self-reflectivity. These associations support the theory that degradation of a person's ability to make sense of complex self- and socially referential information increases the likelihood of difficulties engaging in socially motivated behaviour and the affective elements of communication.

This link between metacognition and expressive functioning was also seen in our analyses of experiential and expressive deficits. There was a slightly stronger relationship between expressive deficits and metacognition and expressive deficits was the only negative symptom subtype which was associated with a specific domain of metacognition (self-reflectivity). Also, individual expressive deficits were the only PANSS items robust to the impact of including covariates in analyses. One interpretation is that problems with expressivity are more persistent deficits that are closely linked to poor metacognition. In particular with lesser abilities to synthesize and integrate information into an evolving sense of oneself and others, persons increasingly struggle to express themselves in ways which allow others to grasp what they are thinking and feeling. This is consistent with existing theoretical models about expressivity (Garcia-Mieres et al., 2020). In comparison, the factors involved in experiential deficits may extend beyond metacognitive problems and may require other elements such as cognitive distortions and neurocognitive deficits (Faith et al., 2020).

There was high heterogeneity across analyses. In the case of the PANSS-ONS, this may be partially explained by the contribution of cognitive disorganization items in this subscale, which were shown in sensitivity analyses to have a similar small-to-moderate association with metacognition, but with a different profile of associations at the subscale level (with cognitive disorganization more strongly related to mastery). Further sensitivity analyses suggest the inclusion of FEP samples, or the configuration of data are not key drivers of heterogeneity, given that they show largely overlapping results with the original IPDMAs. The heterogeneity found may, therefore, reflect the variance in individual differences in these associations, although other variables which may contribute to these associations (e.g. cognitive distortions, neurocognitive deficits) merit further investigation.

An important interpretative point for this study is whether restricted variation in negative symptom profiles or lack of severe cases of negative symptoms present in the participants studied here might have affected the observed results. Taking the two key measures (MAS-A and PANSS negative symptoms), the weighted average in the overall sample for total metacognition was 11.51 (maximum possible = 30) and 18.2 (maximum possible = 49) for negative symptoms. Only 10 participants scored higher than 33 on any PANSS subscale, which suggests that people with more severe negative symptoms were under-represented in this sample. Other areas of psychology are impacted by sample invariance, and obfuscation of differences between individuals experiencing symptoms clustered under the same subgroup may limit treatment efficacy (Agelink van Rentergem et al., 2021; Harald & Gordon, 2012). Future research should explore stratified negative symptom samples using agreed recommendations to differentiate negative symptom experiences (Galderisi et al., 2021). If these relationships can be better modelled in samples with more severe negative symptoms, the symptom profiles best suited to metacognitive treatments, such as metacognitive and reflective insight therapy (Lysaker, Gagen, et al., 2020), metacognitive interpersonal therapy (Inchausti et al., 2023) or metacognitive oriented social skills training (Inchausti et al., 2019), may be better identified.

Limitations

Although IPDMA is generally recognized to be a highly powered analytical method (Belias et al., 2019), several data sets contained small samples which may have impacted heterogeneity statistics (IntHout et al., 2015). Given that most samples were below 100 participants, data loss would have been too great to have constrained analyses by data set sample size. Additionally, the use of multivariate analysis somewhat mitigated the impact of alpha inflation, but as multivariate analyses of all individual negative symptom items were too computationally complex, the type I error rate is likely increased. As analyses were exploratory and subject to power constraints, post-hoc probability adjustments (i.e. Bonferroni correction) were judged too restrictive and likely to have increased the possibility of type II error. Analyses should be investigated in novel data sets to confirm whether these results can be replicated. Also, searches for the corresponding literature review for this IPDMA were last conducted in 2019. There is likely to have been a small number of data sets which have been published since then, which this study does not address.

The study of negative symptoms is also affected by methodological and measurement issues. In particular, while the PANSS was the only negative symptom measure that afforded enough data to permit the analyses being undertaken, it is recognized that the subjective components of negative symptom experience are more effectively measured by more modern and focused tools (Galderisi et al., 2021; Marder & Galderisi, 2017). Using single-scale and single-item analyses more generally also minimizes the capacity to explain the variance in the relationship between negative symptoms and metacognition across individuals compared with multimodal assessment. Taken together, these limitations indicate that the relationship between negative symptoms and metacognition may be more multifaceted than currently pictured and so purpose-built data sets should be compiled to more comprehensively explore these relationships.

CONCLUSIONS

This IPDMA provides the most robust and comprehensive exploration to date of the relationship between metacognition and negative symptoms. It is clear that this relationship is more complex than is evident from the individual study findings and there also seem to be sampling and measurement issues that may contribute to the patterns seen. The results do suggest that metacognitive functioning may be a relevant treatment target in supporting recovery from negative symptoms overall and, possibly, expressive deficits in particular. It is possible that treatments which have successfully targeted metacognition, such as metacognitive reflection and insight therapy (Lysaker, Gagen, et al., 2020), may lead to improvements in negative symptoms. Studies with more diverse samples that use updated symptom measures are warranted to support improved understanding of tractable treatment targets.

AUTHOR CONTRIBUTIONS

Nicola McGuire: Conceptualization; writing – original draft; methodology; writing – review and editing; formal analysis; data curation. **Andrew Gumley:** Conceptualization; writing – review and editing; supervision; data curation. **Ilanit Hasson-Ohayon:** Writing – review and editing; data curation. **Stephanie Allan:** Writing – review and editing. **Warut Aunjitsakul:** Writing – review and editing. **Orkun Aydin:** Writing – review and editing; data curation. **Sune Bo:** Writing – review and editing; data curation. **Kelsey A. Bonfils:** Writing – review and editing; data curation. **Anna-Lena Bröcker:** Writing – review and editing; data curation. **Steven de Jong:** Writing – review and editing; data curation. **Giancarlo Dimaggio:** Writing – review and editing; data curation. **Felix Inchausti:** Writing – review and editing; data curation. **Jens Einar Jansen:** Writing – review and editing; data curation. **Tania Lecomte:** Writing – review and editing; data curation. **Lauren Luther:** Writing – review and editing; data curation. **Angus MacBeth:** Writing – review and editing; data curation. **Christiane Montag:** Writing – review and editing; data curation. **Marlene Buch Pedersen:** Writing – review and editing; data curation. **Gerdina Henrika Maria Pijnenborg:** Writing – review and editing; data curation. **Raffaele Popolo:** Writing – review and editing; data curation. **Matthias Schwannauer:** Writing – review and editing; data curation. **Anne-Marie Trauelsen:** Writing – review and editing; data curation. **Rozanne van Donkersgoed:** Data curation; writing – review and editing. **Weiming Wu:** Data curation; writing – review and editing. **Kai Wang:** Data curation; writing – review and editing. **Paul H. Lysaker:** Writing – review and editing; data curation. **Hamish McLeod:** Writing – review and editing; data curation; supervision; conceptualization.

CONFLICT OF INTEREST STATEMENT

The authors attributed to this manuscript declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are provided by the co-authors listed here. Restrictions apply to the availability and retention of these data, which were used under licence for this study. Data are available from the authors upon reasonable request at the discretion of co-authors and subject to retention agreements.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1

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