**ORIGINAL ARTICLE**

# Metamemory and Metaconcentration Scale (MMS) for Health Professionals: A Psychometric Investigation in Nurses

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## ABSTRACT

**Background:**Metacognitive impairments in nurses including deficits of metamemory and metaconcentration may negatively affect the quality of health care. However, no brief and easily administrable tool to assess metacognitive aspects in health professionals is available.
**Aim**: To evaluate the psychometric validation of the Metamemory and metaconcentration scale (MMS) in nurses.
**Method**: A cross-sectional study with purposive sampling in Saudi nurses (n=134, age=30.7±5.9 years) at Majmaah, Saudi Arabia using the MMS, insomnia severity index (ISI), and a socio-demographic questionnaire was performed. Strobe's guideline and checklist for cross-sectional studies were followed.
**Results**: A 1-Factor model showed best fit (Comparative Fit Index (CFI) and Goodness of fit index > 0.95, Standardized root mean square residual and root mean square error of approximation (RMSEA)< 0.05, $\chi 2$ test (p=.659), $\chi 2/df < 3$, and PClose> 0.5). This 1-factor model showed favorable configural (CFI>.95, RMSEA<.05, $\chi 2/df<3$), metric, and scalar (non-significant $\Delta\chi 2$ and/or and $\Delta CFI \leq .01$) invariance across gender. Internal consistency (Cronbach's alpha=0.90) and item discrimination; item-total correlations (r=.81-.53, p<.01) and the Cronbach's alpha if item-deleted (0.88-0.91) were excellent. Divergent validity was favored by no/weak correlations between the MMS and the ISI scores.
**Conclusions**: The MMS has good psychometric validity for screening metamemory and metaconcentration in health professionals specially nurses. Such screening will help identify one of the important reasons, i.e., deficits of metamemory and metaconcentration that may have a role in the quality of health care.
**Keywords:** Cognition, factor analysis, Metacognition, Surveys and Questionnaires

## INTRODUCTION

Metamemory and metaconcentration are important aspects of the metacognitive attribute that helps to manage the strategy of adaptation in routine activities[1]. Metamemory is awareness and perception about memory which has both a passive and as well an active aspect with a degree of monitoring and controlimplications[2]. Functional neuro-anatomical investigations show that different regions from the prefrontal and parieto-temporal cortices are involved in the metamemorydepending on the nature and type of information on which confidence is based[3]. Self-awareness and cognition about concentration are metaconcentration[1]. Both of these metacognitive characteristics are not just independent predictors but assert an effective synergism in the successful performance of daily activities[1].

Metamemory deficits have been reported in problems of subjective memory[4], cognitive impairments[5], epilepsy[6], insomnia[7], severe pain[8], Alzheimer's disease, schizophrenia, depression, learning disorders, and more importantly even in healthy adults[3,9]. The deficit in metamemory is associated with reduced quality of life in multiple scleroses[10]. Moreover, in general, the metacognitive deficits are also related to common affective disorders like anxiety, depression, stress, andimpaired social functioning[11]. However, some of these risk factors and/or conditions associated with metacognitive impairments including decreased metamemory and metaconcentration are commonly found in nurses. For instance, affective disorders like anxiety, depression, and fatigue are frequently reported in health professionals specially nurses[12]. Similarly, sleep problems like sleepiness and insomnia are commonly prevalent in nurses[12]. Perception of increased responsibility decreases metamemory in certain conditions[13], this has inferential consequences for nurses as well, who may also feel the burden of responsibility for patients' improvement at times. Lower metaconcentration abilities are associated with decreased executive function[14]; such pieces of evidence if substantiated in health professionals as wellmay indicate negative connotations for health administration. Indeed, under simulated clinical settings, factors of time pressure and task difficulty lead to cognitive biases of over/under-confidence in making risk assessment among nurses[15]. It is therefore imperative to explore strategies to develop simple screening procedures for metacognitive deficits of metamemory and metaconcentration in nurses.

Presently, there is no tool to evaluate metamemory and metaconcentration in nurses. This study was undertaken with the purpose to develop a brief questionnaire with adequate psychometric validity to screen metamemory and metaconcentration in health professionals including nurses. There are many valid measures to assess metacognition and its aspects like metamemory but these are exhaustive, often lengthy, and more suitable for administration in psychiatric settings[1]. Besides, with the notable exception of a concise tool developed at the Department of Psychiatry, Charité Universitäts Medizin Berlin, none has items to measure metaconcentration[1]. This brief questionnaire was thoroughly reviewed and used as a template for the adaptation and development of a concise, easily applicable tool for screening purposes even in non-psychiatric set-ups. This modified version was named as Metamemory and metaconcentration scale (MMS) for health professionals. Further, psychometric characteristics like item analysis, factorial validity, measurement invariance,

internal consistency and, divergent validity of this new measure, i.e., the MMS was investigated in SAUDI nurses.

## METHODS

**Participants:** One hundred and thirty-four nurses with an average age of 30.6±5.9 years who were working in different hospitals and health centers located in the Majmaah city in the Riyadh region of Saudi Arabia participated in this study. A total of 150 Saudi nurses were approached, out of which 134 participated in the study with a response rate of 89.33%, data of 4 respondents were removed (from psychometric analysis) for construct-level missing values. Finally, psychometric analysis of a sample of 129 is presented in this study, n/p ratio = 14.33, where n = sample size, and p = number of items in the questionnaire of which psychometric property is being investigated. The inclusion criterion was an active registration of the nurses with the Saudi Commission for Health Specialists. The exclusion criterion was self-reported use of prescribed neuro-psychotic medicines.

**Procedure:** The study design was cross-section involving purposively sampled nursing professionals. The survey methodology involved two ways of administration; an online and a paper-based data collection. The choice of survey administration was decided by participants as per their comfort. All efforts were made to explain the aims and objectives of the study and clarify doubt(s) related to the survey before data collection. For the online study; a participant information sheet was attached. Moreover, online participants were encouraged to contact the researchers with any doubt(s) and/or queries before completing the survey. The study participation was voluntary and without any potential health risks. Participants had complete independence to withdraw at any stage during the study. All the participants gave informed written consent during enrollment. The study was approved by the institutional review board (File number: 18-257E) of Majmaah University, Ministry of Health, Saudi Arabia. The research procedures were in agreement with the institutional guidelines, and the Helsinki declaration, 2002. A brief questionnaire to assess metamemory, and metaconcentration in health professionals, i.e., the MMS, the Insomnia severity index (ISI), and a socio-demographics tool were employed[1,16]. Strobe's guideline and checklist for cross-sectional studies were followed.

**Measures:** (*Metamemory and metaconcentration scale (MMS) for health professionals):* TheMMS is an adapted version of a brief questionnaire tool developed by the team of Verena Klusmann at the Department of Psychiatry, Charité - University Medicine. The original items of the tool developed by this team were adapted to incorporate and reflect the daily activities and responsibilities of health professionals. No modifications were made in the original scoring plan implemented by Klusmann et al[1]. The MMS has two sub-scales; one with 5-items to assess the respondent's perception about his memory, also called as metamemory[1]. The other set of 4-items measure respondent's awareness about his concentration, also known as metaconcentration[1]. All the 9-items of the scale, i.e., 5-items of the metamemory and 4-items of the metaconcentration have an identical scoring pattern, these are graded from 1 to 5, where, 1 stand for poor, 2 for fair, 3 for average, 4 for good and 5 represents very good. The total score of the scale and sub-scales are obtained by adding the scores for all the items comprising the scale/sub-scale. Therefore, the range of total score for the MMS is 9-45, metamemory is 5-25 and,the metaconcentration is 4-20[1]. The original tool which was validated in the German elderly population and was found to have adequate psychometric measures including preliminary item analysis, internal consistency (Cronbach's alpha), divergent validity, and the dimensionality validity[1].

**Insomnia Severity Index (ISI):** TheISI is the most widely used questionnaire tool to screen insomnia. It was developed by Charles M. Morin as a psychological measure of insomnia at the Center for Studies of Sleep Disorders, University Laval, Canada. The ISI has 7-items that are scored as 0, 1, 2, 3, and 4, which represent none, mild, moderate, severe and, very severe status of insomnia-related symptoms of the respondent, respectively. The tool evaluates the respondent's insomnia by assessing sleep problems; related dissatisfaction, quality of life, distress, and disturbances in daily activities. The scores for all the individual 7-items are added to generate a total score, which may be in the range of 0 and 28 with higher scores representing the increasing severity of insomnia. The scale has been shown to have favorable validity like internal consistency, internal homogeneity, test-retest reliability, responsiveness, factorial validity, divergent validity, and convergent validity in various populations including nurses[16,17,18].

**Socio-demographics questionnaire:** A socio-demographic questionnaire requiring the respondent to give information regarding their age, gender, highest educational qualification, experience as nursing professional, area of specialty, and presence of chronic conditions/diseases was used.

**Statistical analysis:** SPSS version 23.0 was used for the statistical analysis. Mean, standard deviation (SD) and the range was used to describe continuous variables, categorical variables have been summarized as percentage and numbers in each group. Item analysis has been presented using measures of the classical theory of item analysis like mean, SD, item-total score correlations, Cronbach's α if Item Deleted, skewness/kurtosis; statistics, and standard error, and percentage distribution of the MMS item scores across all feasible values.

According to the Mahalanobis distance criteria [$X^2(9)=33.72$, $p<.0001$]; one outlier was identified and therefore removed from the factor analysis[19]. None of the MMS item scores in the study population had any major problems of skewness and kurtosis as evidenced by the Z-score value (absolute value less than 3.29) of skewness and kurtosis. Many measures were employed to assess the suitability of the MMS scores in SAUDI nurses for performing factor analysis. A value of $X2(df=36)=694.528$, $p<0.001$ for Bartlett's test showed that the MMS item score correlation matrix among the SAUDI nurses was not degenerate suggesting dataset cannot be replicated as a linear combination of fewer items[20]. A determinant value of 0.005, further endorsed the absence of singularity together with the absence of multicollinearity in the item scores of the MMS[20]. Most of the inter-item correlations, i.e., 31 out

of 36 were between 0.3 and 0.7, satisfying conditions of factorability and providing further support of the absence of multicollinearity between the MMS item scores[21]. The communality scores ranged between 0.56 and 0.76; therefore, all the item scores of the MMS satisfied retention criteria for the factor analysis[22]. A value of 0.89 for the Kaiser-Meyer-Olkin Test of Sampling Adequacy (KMO) indicating a meritorious degree of shared variance among the MMS item scores, thus supported the factorability of the MMS item scores[20]. Moreover, as required for the factor analysis, the diagonal elements of the anti-image correlation matrix were above 0.5 with a range of values between 0.82 and 0.92.

The MMS item scores are ordinal in nature with values in the range of 1 and 5; Maximum likelihood estimator with bootstrapping was used to perform the confirmatory factor analysis (CFA)[23]. The missing value in the MMS item score was imputed before theCFA because AMOS cannot perform bootstrapping with missing data. Four models; A: 2-Factor, B: 2-Factor model with incorporation of modification indices (correlated error terms), C: 1-Factor, D: 1-Factor model with incorporation of modification indices (correlated error terms) were screened by the CFA (Figure 1). According to the recommended practices, fit indices from different classes were used[19,24,25]. For the Comparative Fit Index (CFI) and goodness of fit index (GFI), a value above 0.95 determined model fit[26]. Whereas a non-significant $\chi 2$ test, a $\chi 2/df$ (<3), root mean square error of approximation (RMSEA) less than 0.05, standardized root mean square residual (SRMR) less than 0.05 and p of Close Fit (PClose) more than 0.5 indicated model fit[26]. Measurement invariance (configural, metric, and scalar) of the validated model was evaluated across gender. Internal consistency was evaluated by the Cronbach's alpha test, while, internal homogeneity and divergent validity were assessed by Spearman's correlation test.

## RESULTS

**Participants' characteristics:** The majority of Saudi nurses (62.8%) who participated in the study were aged between 26 and 35 (Table 1). Female participants (65.1%) were more than male nurses. The majority of the participating nurses(51.2%) reported that they have a bachelor'sdegree as their highest level of educational qualification(Table 1). About 1/3$^{rd}$ (28.7%) of the study population reported more than 10 years of experience as nursing professionals (Table 1). Participating nurses reported eight areas of specialty/practice, namely medical wards, surgical wards, emergency, outpatient clinics, Intensive care units, obstetrics-gynecology wards, pediatric wards, and primary healthcare centers. One out of six nurses reported symptoms of moderate to severe insomnia (Table 1).

**Preliminary item analysis:** Table 2 summarizes measures of the preliminary item analysis. There was one item-level missing value for the MMS, which was imputed using expected maximization method[27]. Expected maximization is not affected by data characteristics like the fraction of the missing data, its distribution, and sample size[27]. No problem of skewness or kurtosis (absolute value of the Z-score of the statistic was less than 3.29) was seen for the MMS scores, i.e., subscale scores of the metamemory and metaconcentration and their items (Table 2). No ceiling/floor effect was seen for the subscale scores because the lowest/highest score was observed for less than 15 % of the respondents[28]. No floor effect was seen for any of the item scores of the MMS because the lowest score was observed for less than 15% of the respondents (Table 2)[28]. The marginal problem of ceiling effect was observed for 3-item scores with 15.7%, 16.4%, and 16.4%, respectively reporting the highest score of 5 for them (Table 2)[28]. Responses showed that Saudi nurses selected all the possible scores across the Likert scale for all the items of the MMS. The average scores for the MMS items ranged between 2.82 and 3.43 (Table 2). All the item-total correlations (r=.81-.53, p<.01) for the MMS scores were moderate to strong (Table 2). The value of the item discrimination index of the Cronbach's alpha if item-deleted ranged between 0.88 and 0.91 (Table 2).

Table 1 Participant characteristics

| **Characteristics** | **Mean ± SD/ number (%)** |
|---|---|
| Age (yrs) | |
| 21-25 | 20(14.9) |
| 26-30 | 52(38.8) |
| 31-35 | 29(21.6) |
| 36-40 | 10(7.5) |
| 41-45 | 7(5.2) |
| 46-50 | 3(2.5) |
| Unreported | 13(9.7) |
| Gender | |
| Male | 46(34.3) |
| Female | 88(65.7) |
| Highest qualification | |
| Diploma | 54(40.3) |
| Bachelor | 70(52.2) |
| Master | 10(7.5) |
| Experience as nursing professionals (yrs) | |
| Up to 5 | 54(40.3) |
| 6-10 | 40(29.9) |
| 11-15 | 16(11.9) |
| 16-20 | 7(5.2) |
| 21-25 | 2(1.5) |
| Unreported | 15(11.2) |
| Area of practice/specialty | |
| Medical Wards | 23(17.2) |
| Surgical Wards | 17(12.7) |
| Emergency | 25(18.7) |
| Outpatient Clinics | 11(8.2) |
| Intensive Care Units | 24(17.9) |
| Obstetrics-gynecology Wards | 6(4.5) |
| Pediatric Wards | 13(9.7) |
| Primary Healthcare Centers | 15(11.2) |
| Presence of disease/medical condition | |
| No | 103(76.9) |
| Yes | 31(23.1) |
| Insomnia | |
| No clinical insomnia (0-7 ISI total score) | 56(41.8) |
| Sub-threshold insomnia (8-14 ISI total score) | 57(42.5) |
| Moderate insomnia (15-21 ISI total score) | 20(14.9) |
| Severe insomnia (22-28 ISI total score) | 1(0.7) |

SD: standard deviation; ISI: Insomnia severity index

**Factor analysis:** (*Confirmatory Factor Analysis (CFA):* Two models (model-B and model-D) showed favorable fit with values of CFI and GFI above 0.95, SRMR and RMSEA less than 0.05, non-significant χ2 test, χ2/df less than 3, and PClose above 0.5 (Table 3)[26].

**Model-D: Measurement invariance among gender groups:** Configural invariance was evidenced by a non-significant χ2 test, χ2/df<3, CFI>.95, and RMSEA <.05 for model compared across gender without constraints (Table 4)[29]. Metric invariance was evidenced by a chi-square difference test (p=.229), and ΔCFI <.01, between fully unconstrained and model with equal loadings (Table 4)[29]. Scalar invariance was evidenced by a chi-square difference test (p=.365), and ΔCFI <.01, between models with equal loadings and equal intercepts (Table 4)[29].

**Internal consistency, internal homogeneity, item discrimination:** The Cronbach's alpha for the MMS scale was 0.90. Most of the inter-item correlations (31 out of 36) were significant (p < 0.01) and above 0.3 (Table 5).

**Divergent construct validity:** Weak and negative correlation was seen between the ISI scores and one of the items for the metamemory (r=-.18, p < 0.05), one of the items of the metaconcentration (r=-.28, p < 0.01) and the metaconcentration subscale (r=-.23, p < 0.01) (Table 2).

Table 2 Descriptive statistics and divergent validity of the Metamemory and metaconcentration scale for health professionals in nurses

| Items of the MMS | ISI score | Cronbach's α if Item Deleted | Item-total correlation | Mean±SD | Skewness | | Kurtosis | | Percentage distribution across item scores | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Statistic (SE) | z | Statistic (SE) | z | 1 | 2 | 3 | 4 | 5 | Missing value |
| mmem-1 | .15 | .91 | .53** | 2.82±1.18 | .02(.21) | .08 | -1.04(.42) | -2.51 | 14.9 | 28.4 | 22.4 | 28.4 | 6.0 | 0.0 |
| mmem -2 | -.10 | .89 | .72** | 3.31±1.11 | -.41(.21) | -1.97 | -.73(.42) | -1.75 | 6.0 | 20.9 | 20.1 | 41.8 | 11.2 | 0.0 |
| mmem -3 | -.18* | .89 | .73** | 3.37±1.11 | -.33(.21) | -1.60 | -.59(.42) | -1.43 | 6.0 | 16.4 | 28.4 | 33.6 | 15.7 | 0.0 |
| mmem -4 | -.08 | .88 | .81** | 3.39±1.14 | -.38(.21) | -1.81 | -.72(.42) | -1.74 | 6.0 | 18.7 | 22.4 | 36.6 | 16.4 | 0.0 |
| mmem -5 | -.09 | .88 | .81** | 3.33±1.02 | -.26(.21) | -1.26 | -.50(.42) | -1.21 | 3.7 | 17.9 | 31.3 | 35.8 | 11.2 | 0.0 |
| mconcen-1 | -.13 | .88 | .75** | 3.35±1.00 | -.57(.21) | -2.72 | -.14(.42) | -.34 | 5.2 | 14.2 | 29.1 | 43.3 | 8.2 | 0.7 |
| mconcen-2 | -.15 | .88 | .80** | 3.46±0.99 | -.66(.21) | -3.15 | .08(.42) | .20 | 4.5 | 11.9 | 26.9 | 46.3 | 10.4 | 0.0 |
| mconcen-3 | -.28** | .88 | .80** | 3.40±0.97 | -.48(.21) | -2.30 | -.10(.42) | -.24 | 3.7 | 13.4 | 31.3 | 41.8 | 9.7 | 0.0 |
| mconcen-4 | .15 | .89 | .71** | 3.25±1.22 | -.32(.21) | -1.54 | -.74(.42) | -1.79 | 11.2 | 14.2 | 29.1 | 29.1 | 16.4 | 0.0 |
| Metamemory | -.07 | | | 16.22±4.29 | -.38(.21) | -1.82 | -.13(.42) | -.32 | | | | | | |
| Meta-concentration | -.23** | | | 13.47±3.56 | -.51(.21) | -2.42 | -.23(.42) | -.56 | | | | | | |

SD: Standard deviation; SE: Standard Error, *p<.05, **p<.01
Divergent validity: Correlation of the MMS with the Insomnia severity index (ISI) scores
mmem-1 to mmem-5: items of the MMS measuring metamemory; mconcen-1 to mconcen-4: items of the MMS measuring metaconcentration

Table 3 Fit statistics of the models of the Metamemory and metaconcentration scale(MMS) for health professionalsin nurses

| Models | CFI | GFI | SRMR | RMSEA | $\chi^2$ | df | *p* | $\chi^2$/df | PClose |
|---|---|---|---|---|---|---|---|---|---|
| A | .926 | .894 | 0.068 | .120(.090-.152) | 76.149 | 26 | .000 | 2.929 | .000 |
| B | .996 | .959 | 0.036 | .030(.000-.080) | 25.737 | 23 | .313 | 1.119 | .691 |
| C | .899 | .861 | 0.078 | .138(.109-.169) | 95.625 | 27 | .000 | 3.542 | .000 |
| D | 1.000 | .973 | 0.036 | .000(.000-.062) | 16.905 | 20 | .659 | .845 | .898 |

A: 2-Factor, B: 2-Factor model with incorporation of modification indices (correlated error terms), C: 1-Factor, D: 1-Factor model with incorporation of modification indices (correlated error terms)
CFI: ComparativeFitIndex, GFI: Goodness of fit index, SRMR: Standardizedroot mean square residual, RMSEA: root mean square error of approximation

Table 4 Measurement invariance of the 1-Factor model* of the Metamemory and metaconcentration scale (MMS) for health professionals in nurses across gender groups

| | $\chi^2$ | df | *P*-value | $\chi^2$/df | CFI | RMSEA | $\chi^2$ difference test statistics | | | ΔCFI |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | $\Delta\chi^2$ | Δdf | *P*-value | |
| *1-Factor model: MMS | | | | | | | | | | |
| Configural invariance | 44.174 | 40 | .300 | 1.104 | .994 | .028 (.000-.068) | | | | |
| Weak/Metric Invariance-Equal loadings | 54.711 | 48 | .235 | 1.140 | .991 | .033 (.000-.068) | 10.538 | 8 | .229 | -.003 |
| Strong/Scalar Invariance-Equal intercepts | 64.538 | 57 | .230 | 1.132 | .989 | .032(.000-.065) | 9.826 | 9 | .365 | -.002 |

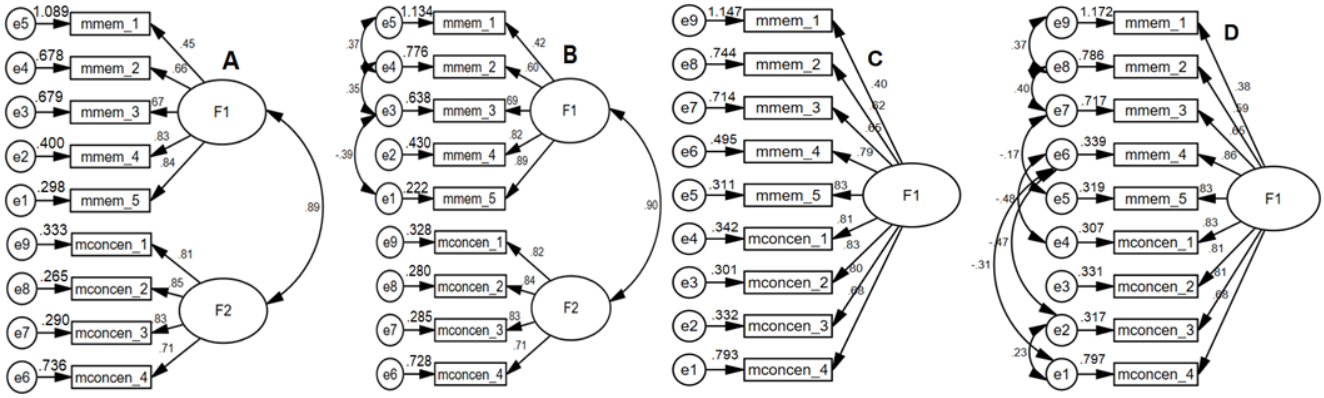
*1-Factor model with incorporation of modification indices (correlated error terms)
CFI: Comparative Fit Index, RMSEA: root mean square error of approximation

Table 5: Inter-item Correlation matrix of the Metamemory and metaconcentration scale for health professionals (MMS) in the nurses

| Items of the MMS | mmem-1 | mmem-2 | mmem-3 | mmem-4 | mmem-5 | mconcen-1 | mconcen-2 | mconcen-3 | mconcen-4 |
|---|---|---|---|---|---|---|---|---|---|
| mmem-1 | | .50* | .26* | .36* | .36* | .24* | .26* | .22* | .16 |
| mmem-2 | | | .62* | .52* | .51* | .49* | .49* | .47* | .34* |
| mmem-3 | | | | .59* | .46* | .52* | .50* | .56* | .42* |
| mmem-4 | | | | | .67* | .54* | .67* | .58* | .49* |
| mmem-5 | | | | | | .68* | .67* | .65* | .59* |
| mconcen-1 | | | | | | | .68* | .64* | .58* |
| mconcen-2 | | | | | | | | .70* | .63* |
| mconcen-3 | | | | | | | | | .66* |
| mconcen-4 | | | | | | | | | |

*$p$< 0.01, mmem-1 to mmem-5: items of the MMS measuring metamemory; mconcen-1 to mconcen-4: items of the MMS measuring metaconcentration

Figure 1: Confirmatory factor analysis models of the Metamemory and metaconcentration scale (MMS) for health professionals in nurses




A: 2-Factor, B: 2-Factor model with incorporation of modification indices (correlated error terms), C: 1-Factor, D: 1-Factor model with incorporation of modification indices (correlated error terms)
mmem-1 to mmem-5: items of the MMS measuring metamemory; mconcen-1 to mconcen-4: items of the MMS measuring metaconcentration.

All coefficients are standardized. *Ovals* latent variables, *rectangles* measured variables, *circles* error terms, *single-headed arrows* between *ovals* and *rectangles* factor loadings, *single-headed arrows* between *circles* and *rectangles* error terms
Amos does not display standardized values of uniqueness on the models;therefore, models were manually edited to put numerical values taken from the Amos text output (Estimates→Scalars→Variances)

## DISCUSSION

To the best of our knowledge, this is the first study on the development of a tool to assess metamemory and metaconcentration specially designed for health professionals including nurses. The psychometric investigations revealed that the MMS has excellent internal consistency, divergent validity, favorable item discrimination, factorial validity, and the factor structure invariance among genders.

**Preliminary item analysis:** Apart from the marginal issues of the ceiling effect for the three-item scores, the overall performance of the MMS as regards to the ceiling/floor effect and score distribution was acceptable. This is because even for those items with minor issues of a ceiling effect, there were no significant violations from normality as implied by the Z-score of their skewness, which were between -1.54 and -1.81. Similar to our findings, some studies also showed that even though item scores may sometime have issues of ceiling/floor effect as determined by the 15% criteria; but the scale and/or subscale scale score does not have major issues of score distribution[28]. The item score distributions were better for the MMS than the parent tool, of which it is an adapted version. Klusmann et al had found that 7 out of 9-items had Z-score values of the skewness index between -3.5 and -9.87 at baseline, while 8 out of the 9-items had Z-score values between -4.88 and -9.88. Though, Klusmann had not reported the Z-score values, these were obtained by dividing the reported values of the skewness statistics with their standard error[1]. Therefore, this suggests that the MMS item score distributions were symmetrical and normal in the Saudi nurses than that reported for its' parent tool in the German elderly population[1]. The values of the item-total score correlations (0.53 and above) as well the Cronbach's alpha if item deleted (0.88 and above) show that the items of the MMS had excellent item discrimination. Klusmann et al had also reported favorable item discrimination as indicated by the Cronbach's alpha if item deleted values, i.e., 0.51 to 0.68 at baseline and 0.47 to 0.63 at follow-up[1]. In brief, the MMS scores had favorable item discrimination, no ceiling/floor effect for scale score and, a symmetrical item score distribution.

**Factor analysis:** (*Confirmatory Factor Analysis (CFA):* Even though the values of the model fit indices supported the validity of a 2-factor (model-B) structure, which was

based on theoretical justification, but the high value of inter-factor correlation (0.90) raised serious doubts about the divergent validity of its two factors[30]. Therefore, the validity of model-D, a 1-Factor model, which has also shown optimum values for the fit indices were favored. The result is contrary to the findings of Klusmann et al, who had found that a 2-Factor structure was valid for their tool in the German elderly[1]. Therefore, future studies are warranted to investigate the measurement invariance of the MMS across different cultures and demographics. Indeed, there are questionnaire tools thathave been shown to have different factor structures in different populations[25,30]. A similar tool adapted for use in the student population was found to have a 2-Factor structure[31]. It is desirable to establish issues of the convergent validity, divergent validity, and reliability/consistency of the factors during factorial investigations. Since the model-D is a unidimensional model; therefore, there was no issue of the divergent validity of the factor involved. The internal consistency or reliability of the 1-Factor structure, i.e., model-D is the same as the reliability of the scale, which was excellent as discussed later. A value of 0.65 for the average variance extracted indicated favorable convergent validity for the 1-Factor structure[26].

**Measurement invariance of Model-D among gender groups:** Multi-group CFA was used to investigate the measurement invariance of the validated model, i.e., model-D among gender groups of Saudi nurses. The evidence for configural, metric and, scalar measurement invariances further supported the factorial validity of the model-D across gender groups of the Saudi nurses[29]. Measurement invariance was not reported for the related tool validated in the German elderly population[1].

**Internal consistency and homogeneity:** Though there is no consensus about the cut-off criteria for the Cronbach's alpha value a practical rule of thumb has been in use in the literature. The value of the Cronbach's alpha for the MMS supported the deduction of an excellent internal consistency according to this rule of thumb[32]. The Cronbach's alpha value of the MMS in our study was much higher than its related measure of metacognition in the German elderly (0.61-0.67)[1]. The evidence for internal consistency of the MMS scores in Saudi nurses is further beefed up by a moderate to a strong level of item-total correlations and the fact that 31 out of 36 inter-item correlations were above 0.3.

**Divergent construct validity:** Recent research shows that metacognitive traits possibly including metamemory characterize brain activities in primary insomnia[33,34], which may have a causal association with two prominent insomnia –related features namely sleep reactivity and sleep-related arousal[35]. Moreover, decreased metamemory satisfaction and ability have been associated with insomnia[7]. All these pieces of evidence indicate a relationship between metamemory and insomnia[7,33,34,35]. Nonetheless, metamemory and insomnia do stand for a different concept, therefore, absence of correlation except for a few weak and negative ones, between the MMS scores and the measure of insomnia, i.e., insomnia severity index in the Saudi nurses plausibly provide support for the divergent validity of the MMS.

**Limitations:** The modest sample size is an important limitation; therefore, future studies on larger samples with random sampling may give more rigorous evidence. Convergent validity and test-retest reliability were not assessed. Longitudinal and cross-cultural CFA needs to be carried out, more importantly, because, a 1-Factor model was found valid even though theoretical considerations supported a 2-Factor construct.

## CONCLUSION

The MMS, which is the first tool to assess metamemory and metaconcentration in health professionals, showed sufficient psychometric validity evident in desirable properties of item analysis, factorial validity, measurement invariance across gender groups for the validated model, excellent internal consistency and divergent validity in the Saudi nurses.

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