


## SHORT REPORT

# Conversion between the Modified Mini-Mental State Examination (3MSE) and the Mini-Mental State Examination (MMSE)

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## Funding information

National Institutes of Health, Grant/Award Numbers: 5U01AT000162, DK57136, DK57149, DK56990, DK57177, DK57171, DK57151, DK57182, DK57131, DK57002, DK57078, DK57154, DK57178, DK57219, DK57008, DK57135, DK56992; National Institute on Aging, Grant/Award Numbers: P30-AG21332, U24 AG059624, 1UL1TR001420-01

## Abstract

**Background:** The Modified Mini-Mental State Examination (3MSE) and the Mini-Mental State Examination (MMSE) are two commonly used instruments for assessing cognitive function. Although conversion between 3MSE and MMSE is useful in applications such as integrative data analysis, there are limited published reports on the topic. Our objective is to provide a dual tool: (1) an item-level conversion tool to score responses for deriving both 3MSE and MMSE measures, and (2) cross-walk tables to facilitate quick conversion between 3MSE and MMSE.

**Methods:** An SAS program tool allows scoring of 3MSE item-level responses into MMSE score. Using integrated data sets ( $n = 8346$ ), actual 3MSE and MMSE scores obtained from the same individuals were linked to form cross-walk tables.

**Results:** An SAS conversion program was made available. Cross-walk tables were derived. Validation sample shows bias is  $-0.11$  (standard deviation = 1.02) in 3MSE→MMSE; the converse had substantially large bias.

**Discussion:** The 3MSE→MMSE conversion table can be used in clinical practice and legacy system data.

## KEYWORDS

cognitive assessment, cross-walk table, integrated data

## 1 | INTRODUCTION

Both the Mini-Mental State Examination (MMSE)<sup>1</sup> and the Modified MMSE (3MSE)<sup>2</sup> are commonly used examinations for assessing

global cognitive function. In many clinical studies, these tests serve as screening instruments for identifying mild cognitive impairment (MCI) and probable dementia (PD). The MMSE is an 11-item instrument that takes 5 to 10 minutes to administer. A recent review showed

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that the MMSE remains the most frequently used cognitive screening instrument.<sup>3</sup> Its brevity has likely contributed to its widespread use.<sup>4</sup> While evidence of the test's reliability and validity have been reported in the literature,<sup>5,6</sup> the MMSE has reported limitations including deficits in content validity, ceiling and floor effects, and insensitivity to conditions such as preclinical dementia and early-stage dementia.<sup>7-9</sup> Designed to overcome these deficits, the 3MSE modifies some MMSE items and adds new items. As a result, the scoring range is extended from 0 to 30 in the MMSE to 0 to 100 in the 3MSE. The extended range allows for more variability across individuals and improves discrimination among test takers with smaller and more nuanced differences in cognitive function. While the 3MSE does require more time to complete, it has shown superior psychometric properties compared to the MMSE, as well as enhanced sensitivity and specificity.<sup>9-11</sup>

When a 3MSE is collected from a test taker, the items are manually scored and recorded.<sup>12</sup> As an example, in one of the 3MSE items, the test taker is asked to repeat three words the interviewer has said. The number of words the test taker correctly repeats in whatever order after the first presentation is the score for this item. Because the 3MSE is an extended version of the MMSE, it is possible to simultaneously score the 3MSE items to generate an MMSE score.<sup>9</sup> For example, in the recall item, the MMSE scoring scheme is identical to that of the 3MSE.

As far as we know, there is only a limited number of published direct conversion tools between 3MSE and MMSE scores. Conversion can occur at two levels—when item-level responses are available (Item Level) and when only summary (total) scores are available (Total Only).

Conversion between the two measures is important for several reasons. First, there are situations in which the MMSE score is required for a completed study but only a 3MSE score is recorded. Consider the case of a secondary data analysis for which a researcher wants to compare MCI patients across two completed studies. One study uses the 3MSE while the other uses the MMSE, with corresponding cutoffs for MCI classification. To render the classification criteria comparable, the researcher would have to retrieve item-level responses from the 3MSE study and manually rescore them to generate the MMSE score for comparison. As the 3MSE study has been completed, using a scorer to rescore the test could be costly and time consuming. An Item Level conversion that uses a software program, which we provide in this article, is more efficient. The need for efficient Item Level conversion 3MSE→MMSE is especially pronounced when multiple data sets are involved, such as in data harmonization within integrative data analysis (IDA).<sup>13</sup>

Total Only conversion, or *direct* conversions between 3MSE and MMSE summary scores using cross-walk tables, is useful in comparative studies such as those involving legacy data that only contain summary 3MSE scores but not item-level scores. One example is a meta-analysis, an approach of data analysis in which summary scores from multiple studies are synthesized. Additionally, in some legacy data systems, granular item-level data may not be always available and direct conversion may be the only way.

This article has two goals. First, we provide an efficient software tool for deriving both 3MSE and MMSE scores using item-level data collected from the 3MSE instrument. Second, we provide cross-walk con-

## RESEARCH IN CONTEXT

1. **Systematic review:** The authors identified and reviewed the original articles for the Modified Mini-Mental State Examination (3MSE) and Mini-Mental State Examination (MMSE) and their scoring algorithms.
2. **Interpretation:** The findings, in the form of a conversion program and conversion tables allow practitioners and researchers to efficiently convert scores between 3MSE and MMSE.
3. **Future direction:** Samples that contain measures from more cognitively impaired individuals should be analyzed to strengthen the cross-walk tables between 3MSE and MMSE.

version tables for both 3MSE→MMSE and MMSE→3MSE based on a sample of  $n = 8346$  participants from an integrated data set. The software tool and cross-walk tables are respectively called Item Level conversion tool and Total Only conversion tool.

## 2 | METHODS

### 2.1 | Item level conversion tool

We created an SAS macro using SAS version 9.4 (SAS Institute, Inc.) for scoring 3MSE response data into respective 3MSE and MMSE scores. The program included several design features: (1) uniform variable naming format for 3MSE items, (2) derived 3MSE and MMSE scores that follow standard scoring protocols, and (3) an indicator of the presence of missing values in 3MSE-item response.

### 2.2 | Total only conversion tool

#### 2.2.1 | Data

Multiple data sets that contained 3MSE data were first integrated. The data sets can be categorized into three groups: (1) small study (normal cognition); (2) large study (normal cognition); and (3) large study (with MCI/PD participants). Category 1 consisted of two data sets extracted from aging studies archived at the Pepper Older Americans Independence Centers (OAIC) Coordinating Center at the Wake Forest School of Medicine. Out of a total of 52 archived studies, only two—the Acute Myeloid Leukemia (AML) Study<sup>13</sup> and the Intensive Diet and Exercise for Arthritis (IDEA) Study<sup>14</sup>—included 3MSE data, and both were added to the integrated analysis. Category 2 consisted of two large randomized trials, the LIFE (Lifestyle Interventions and Independence for Elders) Study,<sup>15</sup> the Look AHEAD (Action for Health in Diabetes) Continuation Study,<sup>16</sup> and the third category consisted of the Ginkgo

Evaluation of Memory (GEM) study,<sup>17</sup> which consisted of 15% MCI participants out of total  $n = 3063$ . Sample characteristics of individual studies are reported elsewhere.<sup>13,18,14–17</sup>

### 2.3 | Statistical analysis

A random sample of 20% of the data in the data set were drawn and set aside as a validation sample while the remaining 80% of data were used to calibrate the cross-walk table. The calibration procedure used equipercenile equating with smoothing<sup>19</sup> to derive mapped scores in the cross-walk table. To objectively assess the accuracy of the mapped score, derived scores were read from the cross-walk table and then compared to the corresponding observed scores in the *validation sample*. Several measures, including bias, variance, and Pearson correlation were used for accuracy assessment.

## 3 | RESULTS

In the supporting information, we provide instruction for accessing and using the SAS program codes and test data set.

Table 1 shows sample characteristics of complete 3MSE cases ( $n = 8346$ ) for the cross-walk analysis. The range of 3MSE scores in the calibration and validation data sets were [47,100] and [64,100], respectively. Table 2 shows the 3MSE→MMSE and MMSE→3MSE conversion tables.

There were substantial ceiling effects for both the 3MSE and MMSE measures. In the calibration sample ( $n = 6677$ ), for example, 45% of individuals scored 95 or more on the 3MSE scale, and 44% scored 29 or 30 on the MMSE scale. Substantial variations also exist among mapped values for a given 3MSE score. From the validation data set ( $n = 1669$ ), we obtained the following assessment results of validation. In the 3MSE→MMSE, (average) bias =  $-0.11$ , standard deviation [SD] =  $1.02$ ; and for MMSE→3MSE, bias =  $5.3$ , SD =  $3.3$ . The biases and SDs tended to be higher toward the lower end of the score range. The correlation between the 3MSE and MMSE scores was  $0.80$  for the calibration data and  $0.79$  for the validation data.

## 4 | DISCUSSION

In this article we report on tools for mapping the 3MSE to the MMSE and vice versa. The 3MSE→MMSE conversion is almost unbiased, with an average value of negative a tenth of a point on the MMSE scale. For a given 3MSE score of 90, the derived MMSE score is 27 and the 95% confidence limit is (25, 29). The width in the confidence interval implies that although the conversion is useful for activities such as IDA, it needs to be used with caution for other purposes when a higher precision is required, such as diagnostic classification. Not surprisingly, the conversion of MMSE→3MSE was not as reliable as 3MSE→MMSE. The positive average bias of 5.3 points on the 3MSE scale is substantial and indicates a general pattern of overestimation of 3MSE score

**TABLE 1** Sample characteristics of the integrated data set (total  $n = 8346$ )

	N (%)	Mean (SD)
Study		
WF OAIC	536 (6.4)	
LIFE	1506 (18.0)	
LAC	3482 (41.7)	
GEM	2822 (33.8)	
Sex		
Male	3466 (41.5)	
Female	4880 (58.5)	
Race		
White	6461 (77.6)	
African American	1001 (12.0)	
Hispanic	494 (5.9)	
Other	370 (4.4)	
Education		
< 13 years	2125 (26.2)	
13–16 years	4069 (49.6)	
>16 years	1980 (24.2)	
Age		74.3 (7.1)
3MSE		92.7 (5.7)
MMSE (derived)		27.8 (1.8)

Abbreviations: 3MSE, Modified Mini-Mental State Examination; GEM, Ginkgo Evaluation of Memory; LAC, Look AHEAD (Action for Health in Diabetes) Continuation; LIFE, Lifestyle Interventions and Independence for Elders; MMSE, Mini-Mental State Examination; WF OAIC, Wake Forest Older Americans Independence Center.

when one starts with an MMSE score. The bias increases with lower values of MMSE, which is perhaps somewhat expected, as the MMSE is not known to be sensitive for discriminating MCI from healthy individuals. Variation in the derived 3MSE score for a given MMSE score is also quite large— $\approx 6.6$  points in both directions at the 95% confidence level. Care needs to be exercised when applying the MMSE→3MSE.

Our conversion tables differ substantially from the 3MSE/MMSE conversion table published in Crane et al.,<sup>20</sup> which unlike our approach, used anchor-set-based linking. For example, a 3MSE score of 69 mapped to an MMSE score of 25 on Crane et al. but to 20 in our conversion. We applied the Crane conversion to the validation sample for 3MSE→MMSE and found bias =  $-1.82$  (SD =  $1.44$ ), which were both substantially higher than the conversion reported in this paper (bias =  $-0.11$ , SD =  $1.02$ ). As individuals' *actual* MMSE scores were directly derived from 3MSE item-level responses in our study, we found the discrepancy puzzling. A possible explanation is heterogeneity in study population. Further investigation is required.

### ACKNOWLEDGMENT

This study acknowledges support from the following National Institutes of Health grants: 5U01AT000162 (GEMS), DK57136,

**TABLE 2** Conversion tables<sup>a</sup> 3MSE → MMSE and MMSE → 3MSE

3MSE→	MMSE	MMSE→	3MSE
69	20	20	90
70	21	21	90
71	21	22	93
72	21	23	93
73	22	24	94
74	22	25	96
75	22	26	97
76	23	27	97
77	23	28	97
78	23	29	100
79	23	30	100
80	24		
81	24		
82	24		
83	25		
84	25		
85	25		
86	26		
87	26		
88	26		
89	27		
90	27		
91	27		
92	27		
93	28		
94	28		
95	28		
96	29		
97	29		
98	29		
99	30		
100	30		

<sup>a</sup>Sample size of a pair of mapped values needs to be at least five to be reported.

Abbreviations: 3MSE, Modified Mini-Mental State Examination; MMSE, Mini-Mental State Examination.

DK57149, DK56990, DK57177, DK57171, DK57151, DK57182, DK57131, DK57002, DK57078, DK57154, DK57178, DK57219, DK57008, DK57135, and DK56992 (LA-C), and #UO1 AG22376, 3U01AG022376-05A2S (LIFE). This work was supported by the National Institute on Aging under grants and P30-AG21332, and U24 AG059624 (Pepper studies), and 1UL1TR001420-01.

## CONFLICTS OF INTEREST

The authors have no conflicts to report.

## AUTHOR CONTRIBUTIONS

Edward H. Ip contributed to the design of the study, analysis of data, and wrote the first draft of the article. June Pierce created the SAS programs and macros for 3MSE/MMSE conversion and extraction of data. Shyh-Huei Chen contributed to data analysis especially equating and conversion table. James Lovato extracted and preprocessed data. Kathleen M. Hayden, Christina Hugenschmidt, Suzanne Craft all made contributions to interpretation of data and revising the draft. Dalane Kitzman was instrumental in overseeing the study and is PI of the primary grant (U24) that supported the initiative. Steve Rapp provided guidance for analysis of 3MSE and MMSE data. All authors were involved in reviewing the manuscript and editing the document.

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#### SUPPORTING INFORMATION

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

**How to cite this article:** Ip EH, Pierce J, Chen S-H, et al. Conversion between the Modified Mini-Mental State Examination (3MSE) and the Mini-Mental State Examination (MMSE). *Alzheimer's Dement*. 2021;13:e12161. <https://doi.org/10.1002/dad2.12161>