Correction to: The Toronto cognitive assessment (TorCA): normative data and validation to detect amnestic mild cognitive impairment

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Erratum

Upon publication of this article [1], it was brought to our attention that one of the 303 participants in the normative study should have been deleted from the database. Therefore, we reanalyzed the data with this individual removed. This resulted in minor numerical changes affecting tables, figures, and text. In addition, we added IQ data that were omitted in seven participants with normal cognition. This resulted in minor changes affecting Table 9. There were also minor typographical corrections made in the tables.

There was no significant impact on the analyses or findings reported in the paper from any of the revisions. The changes are as follows:

Table 2

- Due to deletion of the single participant who should have been omitted from the database, the sample size was changed from 303 to 302 in the 50–89 year old group and from 76 to 75 in the 50–59 year old group. The number of males in each group was reduced by 1. The Mean (SD) TorCA Sum scores were revised in the 50–89 and 50–59 year old groups.
- The cut-off scores for the impaired, borderline, and normal limits ratings for the Sum Index were revised in the 50–59 year old group.
- The cut-off scores for the impaired and borderline ratings for the Delayed Memory Recognition Index were revised in the 70–79 year old group.
- The cut-off scores for the impaired and borderline ratings for the Visuospatial Index were revised in the 70–79 and 80–89 year old groups.

Table 4

- The cut-off scores for the below normal and borderline ratings for Clock Drawing were revised in the 50–89 year old group.

Table 5

- The cut-off score for the borderline rating for Digit Span Backwards was revised for the 70–79 year old group.
- The cut-off scores for the borderline and normal limits ratings for Digit Span Backwards were revised for the 80–89 year old group.

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Table 6
- The cut-off score for the borderline rating for Repetition was revised for the 50–89 year old group.

Table 7
- The Test2-Test1 Mean Difference was revised from 2.8 to 2.4 for the Memory – Immediate Recall Index.

Table 9
- There was a revision to the demographic information in which IQ data for seven participants with normal cognition were omitted. With the addition of these seven participants, there was a change in the Mean IQ (SD). The t-test comparing the IQ of participants with aMCI to those with normal cognition was recalculated with these seven individuals included. There was a minor change in the degrees of freedom and the p-value.
- One participant with aMCI was not given the verbal component of the IQ estimate due to non-exclusionary English as a second language considerations. However, a comparable estimate of IQ was within the range exhibited by the remaining aMCI participants. This was added in a footnote.

Figure 1
- The sample size was changed from 303 to 302

Figure 4
Due to a change in cut-off scores:
- The rating for MDRec in the 70–79 year old group was changed from an orange triangle to a blue dot, i.e., from below normal limits to borderline.
- The rating for MDRec in the Index Plot was changed from an orange triangle to a blue dot, i.e., from below normal limits to borderline.

Text (page 5, column 2, paragraph 2)
Due to the change in sample size from 303 to 302, there was a change in the degrees of freedom, F values, Cohen’s d, and number of points higher on Sum Index in women than men. The revised text is:

The Sum Index was significantly affected by age (F(3,298) = 7.27, p = 0.001) (Table 2). There was a significant but small effect size (Cohen’s d = 0.29) [20] for gender. Women scored a mean of 5.5 (SED = 2.2) points higher than men (F(1,300) = 6.24, p = 0.013). Age and education were weakly, but significantly, correlated with Sum Index (r = 0.24 and 0.23, both p < 0.001), each accounting for approximately 5% of the variance.

The revised tables and figures are shown on the following pages
The revised tables are:

**Table 2** Toronto Cognitive Assessment (TorCA) group profiles and normative data

| Group profile | Age group | 50–89 years | 50–59 years | 60–69 years | 70–79 years | 80–89 years |
|---------------|-----------|-------------|-------------|-------------|-------------|-------------|
| N             | 302       | 75          | 77          | 75          | 75          |             |
| Male/female   | 103/199   | 28/47       | 22/55       | 20/55       | 33/42       |             |
| Years of education, median (range) | 16 (8–20) | 16 (12–20) | 16 (11–20) | 16 (9–20) | 14 (8–20)   |             |
| TorCA Sum Index, mean (standard deviation) | 292.8 (18.4) | 297.6 (18.6) | 296.9 (16.7) | 290.5 (16.6) | 286.0 (19.4) |             |
| TorCA Sum Index, median | 295 | 301 | 298 | 291 | 289 |             |

**Normative Data**

| Normative Data | Percentile range | Rating | 50–89 years | 50–59 years | 60–69 years | 70–79 years | 80–89 years |
|----------------|------------------|--------|-------------|-------------|-------------|-------------|-------------|
| Sum Index      | ≤ 5 Impaired     | < 261  | < 266       | < 272       | < 262       | < 257       |             |
|                | 6–24 Borderline  | 261–281| 266–287     | 272–287     | 262–280     | 257–272     |             |
|                | ≥ 25 Normal limits | > 281 | > 287       | > 287       | > 280       | > 272       |             |
| Orientation    | ≤ 5 Impaired     | < 10   | < 10        | < 10        | < 10        | < 10        |             |
|                | 6–24 Borderline  | 10     | 10          | 10          | 10          | 10          |             |
|                | ≥ 25 Normal limits | > 10  | > 10        | > 10        | > 10        | > 10        |             |
| Immediate Memory Recall | ≤ 5 Impaired | < 15  | < 17        | < 16        | < 15        | < 14        |             |
|                | 6–24 Borderline  | 15–18  | 17–20       | 16–18       | 15–17       | 14–16       |             |
|                | ≥ 25 Normal limits | > 18  | > 20        | > 18        | > 17        | > 16        |             |
| Delayed Memory Recall | ≤ 5 Impaired | < 10  | < 14        | < 12        | < 8         | < 6         |             |
|                | 6–24 Borderline  | 10–14  | 14–16       | 12–15       | 8–12        | 6–12        |             |
|                | ≥ 25 Normal limits | > 14  | > 16        | > 15        | > 12        | > 12        |             |
| Delayed Memory Recognition | ≤ 5 Impaired | < 19  | < 20        | < 19        | < 18        | < 18        |             |
|                | 6–24 Borderline  | 19     | 20          | 19          | 18–19       | 18          |             |
|                | ≥ 25 Normal limits | > 19  | > 21        | > 19        | > 19        | > 18        |             |
| Visuospatial   | ≤ 5 Impaired     | < 25   | < 27        | < 25        | < 24        | < 24        |             |
|                | 6–24 Borderline  | 25–27  | 27–28       | 25–27       | 24–27       | 24–27       |             |
|                | ≥ 25 Normal limits | > 27  | > 28        | > 27        | > 27        | > 27        |             |
| Working Memory/Attention/Executive Control | ≤ 5 Impaired | < 99  | < 98        | < 102       | < 99        | < 98        |             |
|                | 6–24 Borderline  | 99–106 | 98–105      | 102–107     | 99–106      | 98–105      |             |
|                | ≥ 25 Normal limits | > 106 | > 105       | > 107       | > 106       | > 105       |             |
| Language       | ≤ 5 Impaired     | < 71   | < 63        | < 74        | < 74        | < 66        |             |
|                | 6–24 Borderline  | 71–78  | 63–78       | 74–80       | 74–78       | 66–76       |             |
|                | ≥ 25 Normal limits | > 78  | > 80        | > 78        | > 78        | > 76        |             |
### Table 4  Normative data for subtests within domains: Visuospatial

| Percentile | Rating                  | Toronto Cognitive Assessment Visuospatial test ratings |
|------------|-------------------------|-------------------------------------------------------|
|            |                         | Benson Figure Copy | Clock Drawing |
| Ages 50–89 years |                   |                                                          |
| ≤ 5        | Below normal            | < 14              | < 10         |
| 6–24       | Borderline              | 14                | 10–12        |
| ≥ 25       | Within normal limits    | > 14              | > 12         |
| Ages 50–59 years |                   |                                                          |
| ≤ 5        | Below normal            | < 15              | < 11         |
| 6–24       | Borderline              | 15                | 11–12        |
| ≥ 25       | Within normal limits    | > 15              | > 12         |
| Ages 60–69 years |                   |                                                          |
| ≤ 5        | Below normal            | < 14              | < 10         |
| 6–24       | Borderline              | 14                | 10–12        |
| ≥ 25       | Within normal limits    | > 14              | > 12         |
| Ages 70–79 years |                   |                                                          |
| ≤ 5        | Below normal            | < 14              | < 10         |
| 6–24       | Borderline              | 14                | 10–12        |
| ≥ 25       | Within normal limits    | > 14              | > 12         |
| Ages 80–89 years |                   |                                                          |
| ≤ 5        | Below normal            | < 13              | < 9          |
| 6–24       | Borderline              | 13–14             | 9–12         |
| ≥ 25       | Within normal limits    | > 14              | > 12         |
# Table 5: Normative data for subtests within domains: Working Memory/Attention/Executive Control

| Percentile Rating | Serial Subtractions 7 s | Serial Subtractions 3 s | Total | Digit Span Forwards | Digit Span Backwards | Total | Trails A Time | Trails A Score | Trails B Time | Trails B Score | Trails B Time Difference | Alternating Sequences | Similarities |
|--------------------|-------------------------|-------------------------|-------|---------------------|---------------------|-------|---------------|---------------|---------------|---------------|------------------------|------------------------|--------------|
| Ages 50–89 years   |                         |                         |       |                     |                     |       |               |               |               |               |                        |                        |              |
| ≤ 5                | Below normal            | < 9                     | < 11  | < 21                | < 5                 | < 4   | < 10          | > 67          | < 24          | > 163         | < 22                   | > 107                  | < 2           | < 7           |
| 6–24               | Borderline              | 9–10                    | 11–12 | 21–23               | 5                   | 4     | 10            | 67–47         | –             | 163–107      | 22                      | 107–63                | –             | 7–8           |
| ≥ 25               | Within normal limits    | > 10                    | > 12  | > 23                | > 5                 | > 4   | > 10          | < 47          | 24            | < 107         | > 22                   | < 63                    | 2             | > 8           |
| Ages 50–59 years   |                         |                         |       |                     |                     |       |               |               |               |               |                        |                        |              |
| ≤ 5                | Below normal            | < 9                     | < 11  | < 21                | < 5                 | < 4   | < 10          | > 67          | < 24          | > 163         | < 22                   | > 107                  | < 2           | < 7           |
| 6–24               | Borderline              | 9–10                    | 11–12 | 21–23               | 5                   | 4     | 10            | 67–47         | –             | 163–107      | 22                      | 107–63                | –             | 7–8           |
| ≥ 25               | Within normal limits    | > 10                    | > 12  | > 23                | > 5                 | > 4   | > 10          | < 47          | 24            | < 107         | > 22                   | < 63                    | 2             | > 8           |
| Ages 60–69 years   |                         |                         |       |                     |                     |       |               |               |               |               |                        |                        |              |
| ≤ 5                | Below normal            | < 10                    | < 11  | < 21                | < 5                 | < 4   | < 9           | > 59          | < 24          | > 146         | < 24                   | > 100                  | < 2           | < 9           |
| 6–24               | Borderline              | 10                      | 11–12 | 21–23               | 5                   | 4     | 9–10          | 59–43         | –             | 146–91       | –                        | 100–53                | –             | 9             |
| ≥ 25               | Within normal limits    | > 10                    | > 12  | > 23                | > 5                 | > 4   | > 10          | < 43          | 24            | < 91          | 24                      | < 53                    | 2             | > 9           |
| Ages 70–79 years   |                         |                         |       |                     |                     |       |               |               |               |               |                        |                        |              |
| ≤ 5                | Below normal            | < 9                     | < 11  | < 20                | < 5                 | < 4   | < 10          | > 86          | < 24          | > 196         | < 23                   | > 137                  | 0             | < 8           |
| 6–24               | Borderline              | 9–11                    | 11    | 20–23               | 5                   | 4     | 10            | 86–49         | –             | 196–111      | 23                      | 137–65                | 1             | 8             |
| ≥ 25               | Within normal limits    | > 11                    | > 11  | > 23                | > 5                 | > 4   | > 10          | < 49          | 24            | < 111         | 24                      | < 65                    | 2             | > 8           |
| Ages 80–89 years   |                         |                         |       |                     |                     |       |               |               |               |               |                        |                        |              |
| ≤ 5                | Below normal            | < 9                     | < 11  | < 22                | < 5                 | < 4   | < 9           | > 73          | < 24          | > 198         | < 21                   | > 159                  | 0             | < 7           |
| 6–24               | Borderline              | 9–10                    | 11–12 | 22–23               | 5                   | 4     | 9            | 73–53         | –             | 198–120      | 21–22                   | 159–85                 | 1             | 7–8           |
| ≥ 25               | Within normal limits    | > 10                    | > 12  | > 23                | > 5                 | > 4   | > 9           | < 53          | 24            | < 120         | > 22                   | < 85                    | 2             | > 8           |
Table 6 Normative data for subtests within domains: Language

| Percentile | Rating           | Ages 50–89 years | Ages 50–59 years | Ages 60–69 years | Ages 70–79 years | Ages 80–89 years |
|------------|------------------|------------------|------------------|------------------|------------------|------------------|
|            |                  | F-words | Animal names | Naming | Repetition | Single word comprehension | Reading single word comprehension | Sentence comprehension | Single word reading | Semantic knowledge |
| ≤ 5        | Below normal limits | <10     | <14          | <13     | <8         | <8                  | <2                   | <5                  | <11               | <9               |
| 6–24       | Borderline       | 10–12   | 14–16        | 13      | 8          | –                   | –                    | 5–6                 | 11                | 9                |
| ≥ 25       | Normal limits    | >12     | >16          | >13     | >8         | 8                   | 2                    | >6                  | 12                | >9               |
| ≤ 5        | Below normal limits | <8      | <13          | <9      | <5         | <8                  | <2                   | <5                  | <9                | <9               |
| 6–24       | Borderline       | 8–11    | 13–18        | 9–13    | 5–7        | –                   | –                    | 5–6                 | 9–11              | 9                |
| ≥ 25       | Normal limits    | >11     | >18          | >13     | >7         | 8                   | 2                    | >6                  | 12                | 10               |
| ≤ 5        | Below normal limits | <10     | <14          | <13     | <8         | <8                  | <2                   | <6                  | <12               | <9               |
| 6–24       | Borderline       | 10–12   | 14–17        | 13      | 8          | –                   | –                    | 6–7                 | –                 | 9                |
| ≥ 25       | Normal limits    | >12     | >17          | >13     | >8         | 8                   | 2                    | 8                   | 12                | 10               |
| ≤ 5        | Below normal limits | <11     | <11          | <12     | <8         | <8                  | <2                   | <4                  | <11               | <9               |
| 6–24       | Borderline       | 11–12   | 11–15        | 12      | 8          | –                   | –                    | 4–5                 | 11                | 9                |
| ≥ 25       | Normal limits    | >12     | >15          | >12     | >8         | 8                   | 2                    | >5                  | 12                | 10               |
Table 9 Normal cognition and aMCI group demographics and TorCA indices comparisons

| Group demographics          | NC | aMCI |
|-----------------------------|----|------|
| N                           | 57 | 50   |
| Male/female                 | 19/38 | 27/23 |
| Age, mean (SD)              | 75.3 (7.9) | 77.7 (6.5) |
| Years of education, mean (SD) | 15.02 (3.2) | 15.5 (3.4) |
| IQ, mean (SD)               | 122.81 (13.54)* | 121.33 (13.98) |

Table 7 Toronto Cognitive Assessment (TorCA) Test–Retest Results

| TorCA index                  | Test 1 mean (SE) | Test 2 mean (SE) | Test 2–Test 1 mean difference (SED) | t(27) (p value) | Stability (p value) | % change |
|------------------------------|------------------|------------------|-------------------------------------|----------------|---------------------|----------|
| Orientation                  | 11.2 ± 0.2       | 11.3 ± 0.2       | 0.1 ± 0.2                           | 0.5 (0.631)    | 0.10 (0.007)        | 0.1      |
| Memory—Immediate Recall      | 19.5 ± 0.7       | 21.9 ± 0.7       | 2.4 ± 0.5                           | 4.6 (0.0001)   | 0.73 (0.0001)       | 14.3     |
| Memory—Delayed Recall        | 15.8 ± 0.9       | 17.5 ± 0.8       | 1.7 ± 0.5                           | 3.4 (0.002)    | 0.83 (0.0001)       | 10.7     |
| Memory—Delayed Recognition   | 20.2 ± 0.2       | 20.4 ± 0.2       | 0.2 ± 0.2                           | 0.9 (0.363)    | 0.57 (0.001)        | 1.0      |
| Visuospatial                 | 28.6 ± 0.4       | 28.4 ± 0.4       | −0.2 ± 0.3                          | −0.7 (0.5)     | 0.68 (0.0001)       | 0.7      |
| Executive Control*           | 111.0 ± 1.2      | 112.0 ± 1.3      | 1.0 ± 1.3                           | 0.9 (0.4)      | 0.52 (0.004)        | 1.0      |
| Language                     | 84.4 ± 1.3       | 83.1 ± 1.3       | −1.3 ± 0.9                          | −1.4 (0.2)     | 0.75 (0.0001)       | 1.5      |
| Sum                          | 290.7 ± 3.2      | 294.0 ± 3.4      | 3.3 ± 1.4                           | 2.4 (0.023)    | 0.92 (0.0001)       | 1.1      |

Test 1 and Test 2 mean indices and test–retest correlations (test stability) expressed as Pearson r
Interpretation of stability coefficients (Pearson r): very good, ≥ 0.90; good, 0.80–0.89; acceptable, 0.70–0.79; low, < 0.70
SE standard error, SED standard error of the difference
*Working Memory/Attention/Executive Control

**Table 9** Normal cognition and aMCI group demographics and TorCA indices comparisons

| TorCA index group comparisons | NC (SD) | aMCI (SD) | t(105) (p value)** | Effect size, Hedge’s g (95% CI) |
|-------------------------------|---------|----------|--------------------|--------------------------------|
| Orientation                  | 11.58 (0.76) | 10.38 (1.69) | 4.84 (0.0001) | −0.93 (−1.33, −0.53) |
| Memory—Immediate Recall      | 20.77 (4.45) | 14.18 (3.29) | 8.62 (0.0001) | −1.66 (−2.10, −1.22) |
| Memory—Delayed Recall        | 16.86 (4.85) | 6.66 (4.65) | 11.07 (0.0001) | −2.13 (−2.60, −1.65) |
| Memory—Delayed Recognition   | 20.19 (1.33) | 17.42 (2.42) | 7.45 (0.0001) | −1.43 (−1.86, −1.01) |
| Visuospatial                 | 29.79 (1.80) | 30.02 (2.16) | 0.602 (0.549) | 0.12 (−0.26, 0.50) |
| Executive Control*           | 108.47 (10.30) | 107.34 (8.17) | 0.625 (0.534) | −0.12 (−0.50, 0.26) |
| Language                     | 80.16 (8.34) | 76.90 (6.23) | 2.26 (0.026) | −0.42 (−0.81, −0.04) |
| Sum                          | 287.82 (23.92) | 262.86 (17.63) | 6.07 (0.0001) | −1.17 (−1.58, −0.76) |

aMCI amnestic mild cognitive impairment, CI confidence interval, NC normal cognition, SD standard deviation, TorCA Toronto Cognitive Assessment
*One participant with aMCI was not given the verbal component of the IQ estimate due to non-exclusionary English as a second language considerations. A comparable estimate of IQ was within the range exhibited by the remaining aMCI participants
**Significance tests corrected for multiple comparisons using Bonferroni correction at p ≤ 0.05/7 (0.007)
The revised figures are:

![Flow chart of participants for normative study](image1)

**Fig. 1** Flow chart of participants for normative study

![iPad summary score sheet showing domain scores and numerical and graphic percentile ratings. Probability of aMCI shown as 93.7%. aMCI amnestic mild cognitive impairment](image2)

**Fig. 4** iPad summary score sheet showing domain scores and numerical and graphic percentile ratings. Probability of aMCI shown as 93.7%. aMCI amnestic mild cognitive impairment
In addition to the above, we have provided an annotated pdf as a Additional file 1 documenting the changes. The original article can be found online at https://doi.org/10.1186/s13195-018-0382-y

Additional file

Additional file 1: Annotated pdf documenting changes to original article. (PDF 1130 kb)

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