



Correction to: Spatial navigation in early multiple sclerosis: a neglected cognitive marker of the disease?

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Correction to: Journal of Neurology <https://doi.org/10.1007/s00415-020-10079-z>

The original version of this article unfortunately contained a mistake. The correct information is given below.

The given names and family names were interchanged.

The names should be:

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Figure 1 caption should read:

Fig. 1 Human analogue of the Morris Water Maze task. **a** The real-space navigation setting. **b** The scheme of the task

showing an aerial view of the arena (large white circle) with starting point (red filled circle), orientation cues (red and green lines), and goal (purple circle).

Figure 2 caption should read:

Fig. 2 Voxels with significant ($p < 0.05$) grey matter volume reduction in the early MS group compared to controls in rendered brains projected to show: A) left side, B) right side, C) front, D) back, E) top and F) bottom.

Figure 3 caption should read:

Fig. 3 Voxels with significant ($p < 0.05$) grey matter volume reduction in controls compared to the early MS group in rendered brains projected to show: A) left side, B) right side, C) front, D) back, E) top and F) bottom.

Table 1 should be:

The original article can be found online at <https://doi.org/10.1007/s00415-020-10079-z>.

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Table 1 Characteristics of the study participants

	Controls (<i>n</i> = 41)	Early MS (<i>n</i> = 52)	<i>p</i> values	Effect sizes
Demographic characteristics				
Age (years)	29.02 (7.50)	31.29 (6.98)	0.135	0.32 ^a
Women, <i>n</i> (%)	23 (54.80)	28 (54.90)	0.989	0.00 ^b
Education (years)	16.02 (2.58)	15.06 (2.87)	0.095	0.35 ^a
EDSS (score)	NA	1.67 (0.58)	NA	NA
Neuropsychological characteristics^c				
BDI (score)	4.74 (4.94)	8.49 (10.17)	0.047	0.05 ^d
BAI (score)	5.14 (5.07)	9.67 (10.07)	0.013	0.08 ^d
MSNQ (score)	15.98 (11.36)	13.71 (10.02)	0.747	0.00 ^d
NART (score)	118.60 (18.88)	116.06 (8.78)	0.490	0.01 ^d
RAVLT 1–5 (score)	58.74 (7.69)	52.51 (9.29)	0.003	0.10^d
RAVLT delayed (score)	12.60 (2.06)	10.67 (2.78)	0.002	0.11^d
BVMT-R 1–3 (score)	30.31 (4.00)	26.41 (4.80)	< 0.001	0.16^d
BVMT-R delayed (score)	11.10 (1.12)	10.24 (1.62)	0.009	0.08 ^d
SDMT (score)	64.29 (11.17)	56.14 (10.52)	0.004	0.10^d
PASAT (score)	51.57 (7.23)	44.80 (11.32)	0.003	0.10^d
Digit span forward (score)	10.24 (2.01)	8.98 (2.00)	0.007	0.09 ^d
Digit span backward (score)	8.00 (2.93)	6.92 (2.40)	0.099	0.03 ^d
TMT A (time in s)	27.40 (20.92)	31.92 (9.22)	0.208	0.02 ^d
TMT B (time in s)	53.07 (13.30)	71.37(25.43)	< 0.001	0.16^d
COWAT (score)	48.67 (13.60)	39.33 (11.43)	0.001	0.13^d
JLO (score)	27.52 (3.39)	25.67 (4.42)	0.028	0.06 ^d
CFT animals (score)	26.81 (5.63)	24.45 (6.43)	0.056	0.05 ^d
CFT shopping (score)	26.79 (8.18)	25.55 (7.72)	0.312	0.01 ^d
Navigational characteristics^c				
Egocentric navigation (distance, cm)	18.64 (7.39)	31.82 (27.76)	0.010^e	0.07^d
Allocentric navigation (distance, cm)	22.60 (8.22)	38.21 (23.69)	0.004^e	0.09^d
Allocentric delayed navigation (distance, cm)	24.57 (12.21)	34.45 (27.74)	0.038^e	0.05^d
MRI volumetric characteristics^c				
nBP (volume, cm ³)	1507.75 (49.64) ^f	1464.89 (71.09)	0.005	0.10 ^d
nWM (volume, cm ³)	703.40 (34.09) ^f	677.87 (38.06)	0.007	0.10 ^d
nGM (volume, cm ³)	804.34 (35.64) ^f	787.01 (53.31)	0.064	0.05 ^d
npGM (volume, cm ³)	638.76 (33.02) ^f	618.16 (42.36)	0.009	0.09 ^d
Amygdala left (volume, mm ³)	1668.41 (249.56) ^f	1426.00 (236.57)	< 0.001	0.18^d
Amygdala right (volume, mm ³)	1447.44 (213.50) ^f	1505.38 (270.33)	0.127	0.03 ^d
Caudate nucleus left (volume, mm ³)	3689.21 (401.20) ^f	3427.88 (519.02)	0.041	0.06 ^d
Caudate nucleus right (volume, mm ³)	3590.62 (498.15) ^f	3595.89 (565.43)	0.687	0.00 ^d
Hippocampus left (volume, mm ³)	4146.49 (550.70) ^f	3851.45 (584.50)	0.025	0.07 ^d
Hippocampus right (volume, mm ³)	4174.19 (488.38) ^f	3931.15 (562.88)	0.085	0.04 ^d
Globus pallidus left (volume, mm ³)	1937.87 (226.96) ^f	1816.70 (231.26)	0.037	0.06 ^d
Globus pallidus right (volume, mm ³)	1972.83 (275.16) ^f	1854.15 (239.10)	0.066	0.05 ^d
Putamen left (volume, mm ³)	5367.57 (748.49) ^f	5053.67 (633.66)	0.052	0.05 ^d
Putamen right (volume, mm ³)	5223.60 (810.85) ^f	5071.32 (673.14)	0.480	0.01 ^d
Thalamus left (volume, mm ³)	8831.50 (1090.09) ^f	7998.49 (918.22)	< 0.001	0.17^d
Thalamus right (volume, mm ³)	8401.30 (1052.73) ^f	7777.74 (948.27)	0.012	0.08 ^d
Global and regional MRI lesion load characteristics				
Total lesion load (volume, mm ³)	NA	3363.22 (5328.87)	NA	NA
Caudate nucleus left (volume, mm ³)	NA	150.69 (190.58)	NA	NA
Caudate nucleus right (volume, mm ³)	NA	140.51 (183.85)	NA	NA
Cerebellum left (volume, mm ³)	NA	10.96 (35.12)	NA	NA

Table 1 (continued)

	Controls (<i>n</i> = 41)	Early MS (<i>n</i> = 52)	<i>p</i> values	Effect sizes
Cerebellum right (volume, mm ³)	NA	9.49 (28.41)	NA	NA
Frontal lobe left (volume, mm ³)	NA	104.90 (265.65)	NA	NA
Frontal lobe right (volume, mm ³)	NA	116.22 (258.26)	NA	NA
Insula left (volume, mm ³)	NA	3.09 (10.51)	NA	NA
Insula right (volume, mm ³)	NA	15.49 (77.66)	NA	NA
Occipital lobe left (volume, mm ³)	NA	265.35 (410.59)	NA	NA
Occipital lobe right (volume, mm ³)	NA	156.92 (268.15)	NA	NA
Parietal lobe left (volume, mm ³)	NA	230.02 (441.07)	NA	NA
Parietal lobe right (volume, mm ³)	NA	277.51 (553.62)	NA	NA
Putamen left (volume, mm ³)	NA	2.98 (11.64)	NA	NA
Putamen right (volume, mm ³)	NA	1.43 (3.83)	NA	NA
Temporal lobe left (volume, mm ³)	NA	156.90 (339.75)	NA	NA
Temporal lobe right (volume, mm ³)	NA	167.02 (352.29)	NA	NA
Thalamus left (volume, mm ³)	NA	3.84 (13.05)	NA	NA
Thalamus right (volume, mm ³)	NA	4.41 (9.85)	NA	NA
Periventricular left (volume, mm ³)	NA	678.12 (1315.60)	NA	NA
Periventricular right (volume, mm ³)	NA	865.20 (1466.74)	NA	NA

Demographic, neuropsychological, navigational and MRI characteristics. The values represent mean (SD) unless indicated otherwise. Values in bold indicate significant differences after Holm–Bonferroni correction for multiple comparisons

MS multiple sclerosis, *EDSS* Expanded Disability Status Scale, *BDI* Beck Depression Inventory, *BAI* Beck Anxiety Inventory, *MSNQ* Multiple Sclerosis Neuropsychological Questionnaire, *NART* National Adult Reading Test, *RAVLT* Rey Auditory Verbal Learning Test, *RAVLT delayed* RAVLT delayed recall after 30 min, *BVMT-R* Brief Visuo-spatial Memory Test Revised, *BVMT-R delayed* BVMT-R delayed recall after 25 min, *SDMT* Symbol Digit Modalities Test, *PASAT* Paced Auditory Serial Addition Test, *TMT* Trail Making Test, *COWAT* Controlled Oral Word Association Test, *JLO* Judgement of Line Orientation, *CFT* Category Fluency Test, *nBP* normalized brain parenchymal volume, *nWM* normalized white matter volume, *nGM* normalized grey matter volume, *npGM* normalized peripheral grey matter volume

^aEffect size reported using Cohen's *d*

^bEffect size reported using Cramér's *V*

^cBased on the analyses controlled for age, gender and education

^dEffect size reported using partial eta-squared

^eBased on an analysis of covariance with log transformed data

^fBased on a sample restricted to those who underwent an experimental MRI protocol (*n* = 32)

Table 4 should be:

Table 4 Characteristics of the participants with early multiple sclerosis with normal and less accurate spatial navigation

	Normal navigators (<i>n</i> = 37)	Less accurate navigators (<i>n</i> = 14)	<i>p</i> values	Effect sizes
Demographic characteristics				
Age (years)	31.81 (6.28)	29.93 (8.68)	0.395	0.27 ^a
Women, <i>n</i> (%)	21 (56.80)	7 (50.00)	0.665	0.06 ^b
Education (years)	15.51 (2.85)	13.86 (2.66)	0.066	0.67 ^a
EDSS (score)	1.61 (0.50)	1.82 (0.75)	0.245	0.37 ^a
Neuropsychological characteristics^c				
BDI (score)	8.95 (11.33)	7.29 (6.29)	0.457	0.01 ^d
BAI (score)	9.57 (11.11)	9.93 (6.92)	0.986	0.00 ^d
MSNQ (score)	12.54 (9.44)	16.79 (11.18)	0.122	0.06 ^d
NART (score)	117.38 (8.04)	112.57 (9.94)	0.302	0.03 ^d
RAVLT 1–5 (score)	52.65 (9.44)	52.14 (9.22)	0.377	0.02 ^d
RAVLT delayed (score)	10.73 (2.96)	10.50 (2.35)	0.453	0.01 ^d
BVMT-R 1–3 (score)	27.00 (4.49)	25.07 (5.39)	0.385	0.02 ^d
BVMT-R delayed (score)	10.56 (1.29)	9.50 (2.07)	0.084	0.07 ^d
SDMT (score)	58.00 (10.64)	51.21 (8.69)	0.034	0.11 ^d
PASAT (score)	45.78 (10.99)	42.21 (12.19)	0.814	0.00 ^d
Digit span forward (score)	8.97 (2.15)	9.00 (1.62)	0.837	0.00 ^d
Digit span backward (score)	6.95 (2.47)	6.86 (2.28)	0.945	0.00 ^d
TMT A (time in s)	31.49 (9.81)	33.07 (7.65)	0.072	0.08 ^d
TMT B (time in s)	66.00 (22.03)	85.57 (29.04)	0.015	0.14 ^d
COWAT (score)	41.43 (10.73)	33.79 (11.76)	0.212	0.04 ^d
JLO (score)	26.11 (3.58)	24.50 (6.12)	0.399	0.02 ^d
CFT animals (score)	25.6 (6.69)	21.36 (4.53)	0.162	0.05 ^d
CFT shopping (score)	27.08 (8.15)	21.50 (4.59)	0.067	0.08 ^d
MRI volumetric characteristics^c				
nBP (volume, cm ³)	1469.09 (60.45)	1453.77 (95.56)	0.263	0.03 ^d
nWM (volume, cm ³)	682.82 (33.44)	664.78 (47.11)	0.044	0.09 ^d
nGM (volume, cm ³)	786.27 (51.01)	788.99 (61.01)	0.905	0.00 ^d
npGM (volume, cm ³)	616.29 (40.26)	623.10 (48.76)	0.861	0.00 ^d
Amygdala left (volume, mm ³)	1442.17 (243.16)	1383.28 (220.94)	0.393	0.02 ^d
Amygdala right (volume, mm ³)	1516.93 (275.13)	1474.82 (264.69)	0.885	0.00 ^d
Caudate nucleus left (volume, mm ³)	3410.73 (477.37)	3473.19 (634.03)	0.949	0.00 ^d
Caudate nucleus right (volume, mm ³)	3609.67 (563.63)	3559.44 (589.87)	0.437	0.01 ^d
Hippocampus left (volume, mm ³)	3886.77 (565.02)	3758.08 (645.75)	0.166	0.04 ^d
Hippocampus right (volume, mm ³)	3951.74 (533.41)	3876.73 (652.92)	0.514	0.01 ^d
Globus pallidus left (volume, mm ³)	1818.11 (219.10)	1812.95 (269.69)	0.701	0.00 ^d
Globus pallidus right (volume, mm ³)	1862.36 (225.97)	1832.45 (278.90)	0.461	0.01 ^d
Putamen left (volume, mm ³)	4988.25 (577.08)	5226.59 (760.08)	0.335	0.02 ^d
Putamen right (volume, mm ³)	5044.01 (607.51)	5143.49 (844.39)	0.873	0.00 ^d
Thalamus left (volume, mm ³)	8070.67 (856.52)	7807.73 (1075.74)	0.204	0.04 ^d
Thalamus right (volume, mm ³)	7864.07 (897.40)	7549.57 (1072.91)	0.198	0.04 ^d
Global and regional MRI lesion load characteristics^c				
Total lesion load (volume, mm ³)	2695.92 (4302.49)	5126.79 (7303.38)	0.110	0.06 ^d
Caudate nucleus left (volume, mm ³)	155.54 (180.42)	137.86 (222.03)	0.855	0.00 ^d
Caudate nucleus right (volume, mm ³)	135.41 (182.62)	154.00 (193.34)	0.380	0.02 ^d
Cerebellum left (volume, mm ³)	6.73 (24.97)	22.14 (53.20)	0.226	0.03 ^d
Cerebellum right (volume, mm ³)	11.27 (32.72)	4.79 (10.36)	0.634	0.01 ^d
Frontal lobe left (volume, mm ³)	57.41 (134.99)	230.43 (444.49)	0.020	0.11 ^d
Frontal lobe right (volume, mm ³)	54.68 (78.08)	278.86 (447.65)	0.006	0.16 ^d

Table 4 (continued)

	Normal navigators (<i>n</i> = 37)	Less accurate navigators (<i>n</i> = 14)	<i>p</i> values	Effect sizes
Insula left (volume, mm ³)	2.14 (5.81)	5.64 (17.95)	0.489	0.01 ^d
Insula right (volume, mm ³)	5.14 (11.53)	42.86 (147.37)	0.167	0.04 ^d
Occipital lobe left (volume, mm ³)	257.27 (356.33)	286.71 (544.16)	0.576	0.01 ^d
Occipital lobe right (volume, mm ³)	114.95 (149.56)	267.86 (443.10)	0.093	0.06 ^d
Parietal lobe left (volume, mm ³)	194.51 (373.74)	323.86 (590.24)	0.286	0.03 ^d
Parietal lobe right (volume, mm ³)	190.51 (353.39)	507.43 (868.63)	0.049	0.08 ^d
Putamen left (volume, mm ³)	1.92 (6.00)	5.79 (20.25)	0.454	0.01 ^d
Putamen right (volume, mm ³)	1.73 (4.32)	0.64 (1.91)	0.294	0.02 ^d
Temporal lobe left (volume, mm ³)	116.35 (252.58)	264.07 (500.23)	0.079	0.07 ^d
Temporal lobe right (volume, mm ³)	149.14 (349.44)	214.29 (368.61)	0.422	0.01 ^d
Thalamus left (volume, mm ³)	5.00 (15.13)	0.79 (2.67)	0.209	0.03 ^d
Thalamus right (volume, mm ³)	4.03 (9.64)	5.43 (10.68)	0.678	0.00 ^d
Periventricular left (volume, mm ³)	614.24 (1268.93)	846.93 (1468.24)	0.488	0.01 ^d
Periventricular right (volume, mm ³)	615.87 (1170.86)	1524.14 (1957.91)	0.054	0.08 ^d

Demographic, neuropsychological, and MRI characteristics. The values represent mean (SD) unless indicated otherwise. Values in bold indicate significant differences after Holm–Bonferroni correction for multiple comparisons

EDSS Expanded Disability Status Scale, *BDI* Beck Depression Inventory, *BAI* Beck Anxiety Inventory, *MSNQ* Multiple Sclerosis Neuropsychological Questionnaire, *NART* National Adult Reading Test, *RAVLT* Rey Auditory Verbal Learning Test, *RAVLT delayed* RAVLT delayed recall after 30 min, *BVMT-R* Brief Visuo-spatial Memory Test Revised, *BVMT-R delayed* BVMT-R delayed recall after 25 min, *SDMT* Symbol Digit Modalities Test, *PASAT* Paced Auditory Serial Addition Test, *TMT* Trail Making Test, *COWAT* Controlled Oral Word Association Test, *JLO* Judgement of Line Orientation, *CFT* Category Fluency Test, *nBP* normalized brain parenchymal volume, *nWM* normalized white matter volume, *nGM* normalized grey matter volume, *npGM* normalized peripheral grey matter volume

^aEffect size reported using Cohen's *d*

^bEffect size reported using Cramér's *V*

^cBased on the analyses controlled for age, gender and education

^dEffect size reported using partial eta-squared

Acknowledgements section should read:

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The original article has been corrected.