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Toxoplasma gondii infection affects cognitive function – corrigendum

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In the recent issue of Folia Parasitologica (59: 93–98), Guenter et al. (2012) published results of a study showing that the effect of latent toxoplasmosis on cognitive function of 70 subjects cannot be proved to exist using a panel of five neuropsychological tests (Guenter et al. 2012). It must be mentioned that the data (mostly ordinal variables without normal distribution) were analysed either with parametric tests (GLM) or with more proper nonparametric tests, but without controlling for age and sex of subjects. It is known for a long time that shifts in personality profile and behaviour associated with latent toxoplasmosis differ very often in their direction between men and women (Flegr and Hrdý 1994, Flegr et al. 1996; Lindová et al. 2006, 2010). This raises the question whether cognitive functions reveal a similar phenomenon.

Therefore, we re-analysed the data on 56 women and 14 men separately. To control for the effect of age, which is known to influence the performance of subjects and also the probability of being *Toxoplasma*-infected, we analyzed the data with partial Kendall regression, the nonparametric technique that controls for one confounding variable (Kaňková et al. 2011). The results showed that, generally, women scored worse in tests except Digit span-backward test (significantly worse only in the verbal fluency test, $p = 0.015$), whereas males scored better in all tests except in percentage of correct answers in N-back test (significantly better in digit span-forward, $p = 0.008$ and in Stroop test I, $p = 0.017$).

Published results of a simple reaction time test show that psychomotor performance of both men and women is lower in subjects with latent toxoplasmosis (Flegr et al. 2008). However, most of personality factors and in some population also intelligence are shifted in an opposite direction in *Toxoplasma*-infected men and women

Table 1. Effect of latent toxoplasmosis on cognitive functions. Table shows means for *Toxplasma*-free (Toxo-) and *Toxoplasma*-infected (Toxo+) women and men, and effect size (Tau) and significance (p) of the effect of toxoplasmosis on performance in particular tests estimated with partial Kendall correlation tests. The significant p are printed in bold. Positive Tau for TMT A and B, Stroop test I and II, and N-back test reaction time (everything measured in seconds) indicate worse cognitive function in *Toxoplasma*-infected subjects, negative Tau for these tests means better cognitive function for *Toxoplasma*-infected subjects. The opposite is true for other tests.

	women				men			
	mean Toxo-	mean Toxo+	Tau	p	mean Toxo-	mean Toxo+	Tau	p
TMT A (sec.)	19.639	20.850	0.041	0.656	23.000	19.833	-0.329	0.102
TMT B (sec.)	45.583	52.750	0.078	0.398	44.500	45.667	-0.201	0.317
Stroop Test I (sec.)	19.194	20.100	0.054	0.560	19.500	17.167	-0.478	**0.017**
Stroop Test II (sec.)	46.417	49.000	0.009	0.918	43.625	43.333	-0.166	0.408
Verbal Fluency Test	44.917	39.700	-0.224	**0.015**	46.500	41.833	0.190	0.343
Digit Span forwards	6.500	6.050	-0.101	0.273	6.750	9.500	0.532	**0.008**
Digit Span backwards	6.750	6.600	0.085	0.354	9.125	8.500	0.112	0.577
N-back Test – % correct answers	90.667	82.400	-0.126	0.171	95.500	87.000	-0.250	0.213
N-back Test – reaction time (sec.)	607.694	743.200	0.068	0.458	546.500	450.167	-0.302	0.132

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(Flegr and Havlíček 1999). The results in most cognitive tests are influenced not only by cognitive performance of a subject but also by his/her motivation. We speculate that the differences in shift of personality profile, for example those related to increased motivation of testosterone-high *Toxoplasma*-infected male subjects (Flegr et al. 2008), can explain the present data that show better performance of *Toxoplasma*-infected men in several cognitive tests.

REFERENCES

Flegr J., Havlíček J. 1999: Changes in the personality profile of young women with latent toxoplasmosis. Folia Parasitol. 46: 22–28.

Flegr J., Hrdý I. 1994: Influence of chronic toxoplasmosis on some human personality factors. Folia Parasitol. 41: 122–126.

Flegr J., Novotná M., Lindová J., Havlíček J. 2008: Neurophysiological effect of the Rh factor. Protective role of the RhD molecule against *Toxoplasma*-induced impairment of reaction times in women. Neuroendocrinol. Lett. 29: 475–481.

Flegr J., Zitková Š., Kodym P., Frynta D. 1996: Induction of changes in human behaviour by the parasitic protozoan *Toxoplasma gondii*. Parasitology 113: 49–54.

Guenter W., Bielinski M., Deptula A., Zalas-Wiecek P., Piskunowicz M., Szwed K., Bucinski A., Gospodarek E., Borkowska A. 2012: Does *Toxoplasma gondii* infection affect cognitive function? A case control study. Folia Parasitol. 59: 93–98.

Kaňková Š., Kodym P., Flegr J. 2011: Direct evidence of *Toxoplasma*-induced changes in serum testosterone in mice. Exp. Parasitol. 128: 181–183.

Lindová J., Kuběna A.A., Šturcová H., Křivohlavá R., Novotná M., Rubešová A., Havlíšek J., Kodym P., Flegr J. 2010: Pattern of money allocation in experimental games supports the stress hypothesis of gender differences in *Toxoplasma gondii*-induced behavioural changes. Folia Parasitol. 57: 136–142.

Lindová J., Novotná M., Havlíček J., Jozífková E., Skallová A., Kolbeková P., Hodný Z., Kodym P., Flegr J. 2006: Gender differences in behavioural changes induced by latent toxoplasmosis. Int. J. Parasitol. 36: 1485–1492.

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