

Changes in the personality profile of young women with latent toxoplasmosis

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Abstract. Latent toxoplasmosis is the most widespread parasite infection in developed and developing countries. The prevalence of *Toxoplasma gondii* infection varies mostly between 20 to 80% in different territories. This form of toxoplasmosis is generally considered to be asymptomatic. Recently published results, however, suggest that the personality profiles of infected subjects differ from those of uninfected controls. These results, however, were obtained on non-standard populations (biologists or former acute toxoplasmosis patients). Here we studied the personality profiles of 191 young women tested for anti-*Toxoplasma* immunity during gravidity. The results showed that the differences between *Toxoplasma*-negative and *Toxoplasma*-positive subjects exists also in this sample of healthy women. The subjects with latent toxoplasmosis had higher intelligence, lower guilt proneness, and possibly also higher ergic tension. The difference in several other factors (desurgency/surgency, alaxia/protension, naiveté/shrewdness, and self-sentiment integration) concerned changes in the variances, rather than the mean values of the factors.

One of the most widespread parasites in the Czech Republic is the protozoan *Toxoplasma gondii* Nicolle et Manceau, 1908. The longtime prevalence in normal population of this parasite is about 30%, while the prevalence in higher age categories and within some risk groups increases above 50% (Sengbusch and Sengbusch 1978, Němec et al. 1988, Yamaoka and Konishi 1993). Four distinct forms of toxoplasmosis exist. The most serious form is the congenital toxoplasmosis which often leads to serious malformations including hydrocephaly, intra-cerebral calcification and microcephaly (Koppe and Rothova 1989). The second form is the acquired acute toxoplasmosis. It is characteristic by the presence of *T. gondii* tachyzoites in the blood and other tissues of infected people and by a complex of clinical symptoms which varies from fever and headache to serious neurological and psychiatric malfunctions (Kramer 1966). In the most cases, however, the acute toxoplasmosis is only a mild disease which is often misdiagnosed as a common bacterial or viral infection. Infrequently the acute toxoplasmosis evolves into chronic disease in which the clinical symptoms as well as high titres of specific antibodies persist for many years. Mostly, all symptoms of acute disease quickly fall away, the antibody titres decrease and the toxoplasmosis evolves into the latent form of the infection. During the latent toxoplasmosis the parasite survives in the dormant form of bradyzoites mostly in the neural and muscular tissue of the host. The latent toxoplasmosis probably lasts for the whole life of infected person (Remington and Krahenbuhl 1982) and it can turn into acute toxoplasmosis only after serious violence of integrity of immune systems (AIDS, treatment

with immunosuppressive drugs etc.), (Heitman and Irizarry 1997, Mocsny 1992).

Latent toxoplasmosis is considered to be asymptomatic. Most of the infected people never learn to have met *T. gondii* in the past and carry the dormant stages of the parasite for the rest of their life. Recently, however, significant differences in personality profiles of men and women with latent toxoplasmosis and normal controls were reported to exist (Flegr and Hrdý 1994, Flegr et al. 1996). *Toxoplasma*-positive subjects differ by mean value of some psychologic factors measured by 16 PF Cattell's personality questionnaire. The differences in some of these factors increase with the duration of latent toxoplasmosis (Flegr et al. 1996). This suggests that the changes were induced by the toxoplasmosis rather than the personality factor shift influencing the probability of being infected with *T. gondii*. Under natural conditions the intermediate hosts of *Toxoplasma* are small rodents and the final host is a cat. Therefore, the changes in the human personality can be a product of manipulation activity of the parasite which is primarily aimed to increase the probability of transmission from intermediate to a definitive host by predation. Such manipulation activity of *T. gondii* was observed in many experimental systems (Hutchison et al. 1980a,b, Arnott et al. 1990, Webster 1994, Webster et al. 1994, Berdoy et al. 1995.). The mechanism of manipulation activity of *Toxoplasma gondii* is not known. However, it can probably include the synthesis (or induction of synthesis) of some neuromodulator (Stibbs 1985) or of other biologically active substance (Varela et al. 1956, 1957). In the aberrant host (man) such activity of the parasite is of course nonproductive. However, it can

Table 1. List of sixteen personality factors monitored by Cattell's questionnaire. The names and characteristics in the left column are for persons with low values of the factor, those in the right column for persons with high values of the factor. The traits that increase in young women with latent toxoplasmosis are typed in bold.

SIZOTHYMIA reserved, detached, critical	A	AFFECTOTHYMIA warm-hearted, outgoing, easygoing
LOW INTELLIGENCE	B	HIGH INTELLIGENCE
EGO WEAKNESS	C	HIGH EGO STRENGTH
affected by feelings, emotionally less stable	E	stable, mature, faces reality, calm
SUBMISSIVENESS	F	DOMINANCE OR ASCENDANCE
obedient, mild, easily led, docile	G	aggressive, competitive, stubborn
DESURGENCY	H	SURGENCY
sober, taciturn, serious	I	enthusiastic, heedless, happy-go-lucky
LOW SUPEREGO STRENGTH	L	SUPEREGO STRENGTH, CHARACTER
disregards rules, expedient	M	conscientious, persistent, moralistic, staid
THRECTIA	A	PARMIA
shy, timid, restrained	O	adventurous, "thick-skinned", socially bold
HARRIA	Q1	PREMSIA
tough-minded, rejects illusions	Q2	tender-minded, sensitive
ALAXIA	Q3	PROTENSION
trusting, accepting conditions, tolerant	Q4	suspecting, jealous, dogmatic
PRAXERNIA		AUTIA
practical, has "down to earth" concerns		imaginative, bohemian
NAIVETÉ		SHREWDNESS
forthright, unpretentious		astute, worldly, polished
UNTROUBLED ADEQUANCY		GUILT PRONENESS
self-assured, placed, secured		apprehensive, self-reproaching, insecure
CONSERVATISM OF TEMPERAMENT		RADICALISM
conservative, respecting		experimenting, liberal, analytical
GROUP DEPENDENCY		SELF-SUFFICIENCY
sociably group-dependent, "joiner"		self-sufficient, resourceful, prefers own decisions
LOW SELF-SENTIMENT INTEGRATION		HIGH STRENGTH OF SELF SENTIMENT
uncontrolled, lax, follows own urges		controlled, exacting will power, socially precise
LOW ERGIC TENSION		HIGH ERGIC TENSION
relaxed, tranquil, torpid		tense, frustrated, driven, overwrought

manifest its presence by nonspecific (from the point of view of a manipulation hypothesis) changes in human personality.

In the previous studies the personality changes were studied either on population of biologists or on subjects previously diagnosed for acute toxoplasmosis (Flegr and Hrdý 1994, Flegr et al. 1996). Neither of the experimental sets represents a typical population. Therefore, it is difficult to guess whether the obtained results can be generalised for normal population. Moreover, in both cases the subjects were informed that the aim of the research is to reveal possible influence of toxoplasmosis on human personality. Such information could influence the subject's responses on the questionnaire (at least in the second study in which the subjects were aware to be infected by *Toxoplasma gondii* before the questionnaire testing).

The aim of the present study was to find out whether the differences in personality profiles can be detected also

in a random sample of normal women previously tested for toxoplasmosis during pregnancies. For ethical reasons (a possible fear of young mothers of congenital toxoplasmosis) the women could not be informed that the research concerns the toxoplasmosis. The absence of *a priori* knowledge about the subject of the research helped to eliminate possible intentional or unintentional data distortion by the experimental subjects. The results showed that personality profiles of women with latent toxoplasmosis significantly differed from those of women without the infection. The character and the amount of these personality changes were similar to those observed in the previous studies.

MATERIALS AND METHODS

Experimental subjects. The experimental set (young women) consisted of 191 women 18-39 years old who were serologically tested for toxoplasmosis during pregnancy. Among these women 136 tested negative and 55 had the titres of anti-

Toxoplasma antibodies between 1 : 8 and 1 : 64 which indicates latent toxoplasmosis. According to the levels of IgG and IgM antibodies no woman involved suffered acute toxoplasmosis. All subjects (824) received the personality questionnaire 6-7 months after the serological examination, mostly 2-5 months after the childbirth. In the cover letter they were only asked to voluntarily participate in an unspecified research project (to avoid a possible fear of young mothers of congenital toxoplasmosis). The return rate was approximately 23.2%.

Personality tests. Cattell's sixteen factor questionnaire (form A) (Cattell 1970) was used for characterisation of personality profiles. This questionnaire is still widely used for personality studies in many countries, including the Czech Republic. It covers sixteen personality factors (Table 1). The main advantage of this traditional questionnaire is that it contains only one hundred and eighty-seven (187) questions. Therefore, it can be completed by most subjects within forty minutes. All subjects obtained the questionnaire by mail and were asked to voluntarily participate in an unspecified research project.

Immunological tests for toxoplasmosis. The latent toxoplasmosis in pregnant women was diagnosed with complement-fixation test (CFT), (Warren and Sabin 1942), in the National Diagnostic Laboratory for Toxoplasmosis, National Institute of Public Health, Prague, Czech Republic. The titre of anti-*Toxoplasma* antibodies in sera was measured in dilutions between 1 : 8 and 1:1024. All subjects with the titres from 1 : 8 to 1 : 64 were considered latent toxoplasmosis positive, the subject with titre lower than 1 : 8 latent toxoplasmosis negative. No subjects with titres equal or higher than 1:128 (the indication of recent acute toxoplasmosis) were involved in our study.

Statistical tests. The computation of standard residuals by linear regression (for elimination of the effect of age), the t-tests and the Levene tests were performed by the program package Statistica. The program TREEPT, originally called PTPT (Flegr and Zábaj 1997), was used for all permutation tests including the permutation tests with elimination of false negative cases. This freeware Windows programme for various permutation tail probability tests is available on the address <http://www.natur.cuni.cz/~flegr/programs>. The rationale of the permutation test is described in the legend of Table 3. Differences in variances of personality factors between *Toxoplasma*-negative and *Toxoplasma*-positive subjects were tested by the same permutation tests, however, the absolute values of age-standardized factors instead of age-standardised factors were entered into the program. The rationale of this approach was based on our previous observation that for certain personality factors both minimal and maximal extremes were absent in *Toxoplasma*-positive subjects.

RESULTS

We obtained the personality data from 136 *Toxoplasma*-negative and 55 *Toxoplasma*-positive women. Effect of the age was eliminated by computation of standard residual of linear regression between the age and raw personality factors. The effect of latent toxoplasmosis was tested by t-test and the Levene's test for the homogeneity of variances. The results (Table 2) suggest that no differences in mean values of Cattell's factors exist

between *Toxoplasma*-negative and *Toxoplasma*-positive women.

The diagnosis of latent toxoplasmosis was performed by complement fixation test. This simple serological test is very useful for rapid screening for acute toxoplasmosis. However, it often provides false negative results for subjects with low titres of antibodies, for example for subjects with very old *T. gondii* infections. Therefore, our subset of *Toxoplasma*-negative women must be contaminated by an unknown percentage of *Toxoplasma*-positive women. Such women with old infections (and consequently with low levels of specific antibodies) are known to have the highest amount of the personality factor shift (Flegr and Hrdý 1994, Flegr et al. 1996). Therefore, their presence in the *Toxoplasma*-negative subsets can flatten out any possible difference between the two subsets. The effects of such kind of data contamination can be revealed and eliminated by a permutation test with data reassignment. For this kind of tests we used the program TREEPT which can perform permutation tests analogical to t-test or ANOVA with reassignment of a particular fraction of cases from one group to the other (in this case from the subset of *Toxoplasma*-negative women to the *Toxoplasma*-positive subset). The results of this analysis are shown in the Table 3. The results of permutation tests showed that the *Toxoplasma*-positive women had higher factor B (intelligence), factor O (guilt proneness) and possibly also Q4 (high ergic tension) and Q1 (radicalism). The differences between *Toxoplasma*-negative and *Toxoplasma*-positive women in the factors L and Q3, and possibly also F and N demonstrated its existence by changes in the character of distribution, rather than changes in the mean values of the factors. The histograms of standardised factors (Fig. 1) suggest that the distribution of values of these factors in *Toxoplasma*-positive women have lower kurtosis and can be approximated by the rectangular while that of *Toxoplasma*-negative women by the normal distribution.

DISCUSSION

Our results suggest that the personality profiles of women with latent toxoplasmosis differ in certain factors from those of women without toxoplasmosis. *Toxoplasma*-positive women have higher intelligence, guilt proneness (are more apprehensive, self-reproaching, insecure), possibly also higher ergic tension and radicalism. The changes in other personality factors were manifested by difference in distribution of values of the factor rather than in differences in the mean values of the factor.

These changes, however, cannot be observed directly when the women are sorted into the *Toxoplasma*-negative and positive groups on the basis of routine serological tests (like CFT). These tests are optimised for early diagnosis of acute toxoplasmosis. They are able to prove the existence of high titres of specific anti-*Toxoplasma*

Table 2. Differences in 16 Cattell's factors between *Toxoplasma*-positive and *Toxoplasma*-negative women. The factors are described in Table 1.

	Mean Toxo-negat.	Mean Toxo-posit.	t separ. var.est.	df	p	Levene F(1,189)	p Levene
A	12.79	12.80	-0.17	92.51	0.87	0.28	0.60
B	8.32	8.93	-1.80	125.90	0.07	2.65	0.11
C	14.07	13.56	0.99	97.35	0.33	0.40	0.53
E	11.88	12.11	-0.29	93.03	0.77	0.59	0.44
F	13.08	12.87	0.07	88.02	0.95	2.06	0.15
G	11.91	12.00	-0.04	112.59	0.97	0.77	0.38
H	12.31	12.67	-0.42	104.24	0.68	0.14	0.70
I	12.74	12.35	0.69	103.82	0.49	0.38	0.54
L	10.00	10.44	-0.94	87.17	0.35	2.82	0.10
M	11.09	11.05	0.39	111.28	0.70	1.24	0.27
N	10.22	10.29	-0.02	86.95	0.99	2.52	0.11
O	10.75	11.73	-1.89	100.65	0.06	0.19	0.66
Q1	5.76	6.25	-1.15	103.72	0.25	0.00	0.97
Q2	11.45	11.24	0.49	107.12	0.62	0.09	0.77
Q3	11.43	11.55	-0.09	88.05	0.93	3.94	0.05
Q4	13.99	14.84	-1.37	105.26	0.17	0.52	0.47

Table 3. The differences between *Toxoplasma*-negative and *Toxoplasma*-positive women tested by permutation tail probability test with data reassignment. The differences in particular age-standardised personality factor was tested by two-sided permutation test. From zero to 60% of subjects with the highest (or lowest) values of a tested factor were relocated from the group of 136 *Toxoplasma*-negative women to the second group of 55 *Toxoplasma*-positive women. Then, the difference of means of these two groups was calculated. In next 2999 steps the empirical values of analysed factors were arbitrary assigned into two groups of the sizes 136 and 55 cases, the same percentage as before of highest (or lowest) cases from the larger group was relocated to smaller group and the difference of the means of the two groups was calculated. Finally, all 3000 differences (including the one calculated from nonpermutated data) were sorted from highest to lowest. The percentage of differences higher or equal to that calculated on the basis of nonpermutated data was considered as the statistical significance (p), i.e. the probability of obtaining the same or higher difference of means of groups 136 and 55 subjects assigned into these groups randomly. The difference in data distribution within the group was tested by the same approach. In this case, however, the absolute values of age-standardised factors instead of standardised factors were entered into the test.

	Means							Distributions	
	p(0%)	p(5%)	p(10%)	p(15%)	p(20%)	p(30%)	p(60%)	p(5%)	p(10%)
A	0.90	0.46	0.44	0.42	0.44	0.50	0.53	0.39	0.41
B	0.12	0.05	0.03	0.03	0.02	0.03	0.04	0.84	0.72
C	0.33	0.81	0.18	0.79	0.80	0.82	0.89	0.26	0.21
E	0.75	0.37	0.39	0.42	0.42	0.41	0.54	0.31	0.32
F	0.92	0.53	0.50	0.59	0.65	0.73	0.81	0.08	0.09
G	0.97	0.46	0.47	0.45	0.46	0.44	0.36	0.81	0.80
H	0.72	0.36	0.32	0.31	0.28	0.30	0.37	0.61	0.61
I	0.50	0.72	0.28	0.64	0.63	0.57	0.56	0.74	0.74
L	0.28	0.16	0.18	0.19	0.23	0.33	0.55	0.04	0.05
M	0.61	0.64	0.30	0.58	0.56	0.55	0.44	0.84	0.84
N	0.98	0.56	0.60	0.61	0.61	0.64	0.74	0.06	0.09
O	0.06	0.02	0.02	0.03	0.03	0.05	0.09	0.32	0.28
Q1	0.26	0.09	0.09	0.09	0.09	0.09	0.17	0.43	0.41
Q2	0.64	0.68	0.29	0.63	0.63	0.66	0.63	0.51	0.44
Q3	0.93	0.47	0.49	0.55	0.58	0.68	0.74	0.01	0.01
Q4	0.20	0.10	0.09	0.07	0.07	0.07	0.09	0.67	0.68

antibodies which are characteristic for patients with an acute phase of acquired toxoplasmosis. In most of clinical laboratories the samples of sera are either measured from the titre 1 : 8 or the subjects with the titres less than 1 : 8 are considered as *Toxoplasma*-negative (and are excluded from further analysis by more specific tests, for example

by IgM ELISA). The women in our experimental set were screened for toxoplasmosis during routine clinical examination in pregnancy. Their sera were tested by complement fixation test (Warren and Sabin 1942) and the subjects without positive reaction in 1 : 8 dilution were considered as *Toxoplasma*-negative. The clinical records

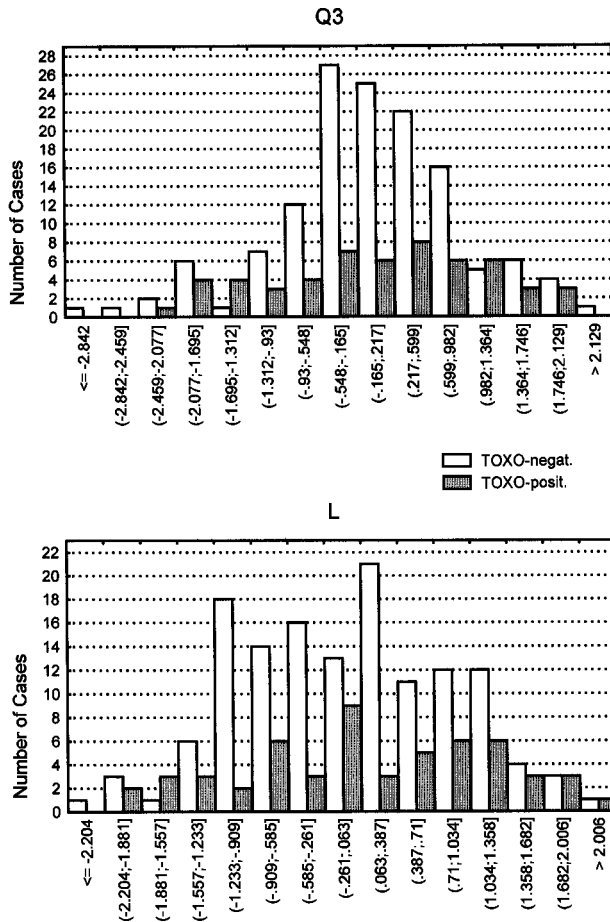


Fig. 1. Distribution of age-standardised factors L and Q3.

as well as the comparison of results of CFT and IgG ELISA tests suggest that the titres of specific antibodies estimated by CFR can decrease below 1 : 8 within a few years after the end of acute toxoplasmosis. Therefore, our group of 136 *Toxoplasma*-negative women must be contaminated by an unknown percentage of women with old *Toxoplasma gondii* infection. The results of our observation of toxoplasmosis patients during the interval of 13 years after infection (Flegr et al. 1996) showed that at least some of the *Toxoplasma gondii*-induced personality changes are very slow. Therefore, the personality of subjects with longest infections (who might be often misdiagnosed as *Toxoplasma*-negative) can express the most prominent changes in our experimental set. Even a small percentage of such subjects in the *Toxoplasma*-negative set can flatten out the possible differences between the two subsets of women. In the first study (Flegr and Hrdý 1994) in which prominent differences between *Toxoplasma*-negative and *Toxoplasma*-positive were observed, the toxoplasmin intradermal delayed hypersensitivity test (Feldman 1954) was used for diagnosis of latent toxoplasmosis. This old test monitors cellular rather than humoral immunity. The

clinical experience shows that the positive reactions in the intradermal delayed hypersensitivity test persists for a very long time, probably for the whole life of an infected person (Remington and Krahenbuhl 1982). When the toxoplasmosis is diagnosed with a common serological test like CFT the presence of unknown percentage of false negatives must be anticipated and the existence of any differences between *Toxoplasma*-negative and *Toxoplasma*-positive subjects must be tested by proper statistical method (such as the permutation test with data reassignment).

In our study the permutation tests revealed the existence of differences in mean values of factors B, O, possibly also Q4 and Q1. In the factors F, L, N and Q3 the latent toxoplasmosis affected the distribution of personality factor's values, rather than their mean values. The lower kurtosis of the distribution as well as the absence of distinct peak in the histogram of the distribution can be explained by the fact that the *Toxoplasma*-induced personality shift is probably a long-lasting process. Our results (Flegr et al. 1996) suggest that the process is triggered by the infection, however, it takes many years to fully evolve. Consequently, the women with a relatively fresh infection are *Toxoplasma*-positive on the basis of serological tests, however, their personality profile has still the *Toxoplasma*-negative character. As our experimental set contains the women with toxoplasmosis of various length no distinct peak but rather a flat plateau can be observed on the histograms of personality factors of *Toxoplasma*-positive women. As discussed above, the absence of significant difference of mean values of the factor can be explained by misdiagnosis of the most changed subjects (with lowest antibody titres) as *Toxoplasma*-negative.

The results of present analysis of the set of young women slightly differ from those obtained on the set of students and teachers of biology of the Charles University (Flegr and Hrdý 1994, Flegr et al. 1996). They are, however, similar to those obtained on the set of acute toxoplasmosis patients and on the subset of 55 *Toxoplasma*-positive women (submitted). In the set of biologists the *Toxoplasma*-positive women had higher A (affectothymia), Q3 (strength of self sentiment), and lower L (protension). In the set of 230 women with clinical history of acute toxoplasmosis the duration of infection positively correlated with G (superego strength), and Q3 (strength of self-sentiment) while in the set of 55 young women with latent toxoplasmosis the length of infection (estimated on the basis of antibody titres) positively correlated with A (affectothymia), F (surgence), G (superego strength), H (parmia) and L (protension). The differences between the results obtained on particular experimental sets can be probably explained by special nature of some of these sets. Especially the biologists represent a highly atypical population sample which differs in many personality traits from a general population. Despite the differences a similar set of

personality factors (usually incorporating the factors A, F, G, L, O, Q3 and Q4) seems to be influenced by latent toxoplasmosis in all examined sets of women. The results of discrimination analysis and of logistic regression (Flegr and Hrdý 1994, Flegr et al. 1996) suggest that only some of these factors are influenced by the parasite directly while the others are changed because of their correlation with other (toxoplasmosis influenced) factors. As the correlation matrices of Cattell's factors often differ among various social and professional groups, the changes in secondary-influenced factors might vary among different experimental sets.

The results of the current study are very important in two respects. First, in the comparison with all previous studies the experimental set represents a homogeneous sample of normal population of young women. The experimental set of biologists (Flegr and Hrdý 1994) represents highly untypical population of university students and teachers. The second experimental set (Flegr et al. 1996) is a relatively good representation of Czech population. However, the age-structure of the sample is highly heterogeneous. Moreover, all men in this sample experienced relatively severe acute toxoplasmosis disease (in contrast with most of other infected people they were diagnosed for acquired toxoplasmosis and received a medical help). In both cases it is not clear whether the results and conclusions can be extrapolated for normal population.

Secondly, in all previous studies the subjects were informed about the aim of the projects before the experiment. In this study neither toxoplasmosis nor *T. gondii* were mentioned in the cover letter (to avoid possible fear of young mothers of congenital toxoplasmosis). For the first time we fully excluded any possible intentional or unintentional distortion of data by the experimental subjects.

It is not possible to decide on the basis of present data whether the toxoplasmosis induces the changes in personality or whether the certain combination of the personality traits increases the probability of contact with *T. gondii* infection. There are, however, several reasons to believe that former possibility is the correct one: (1) Significant positive correlation exists between the duration of latent toxoplasmosis and the amount of personality shift in the sets of men (Flegr et al. 1996) and women (submitted) diagnosed with acute toxoplasmosis during the period of 13 and 14 years, respectively in various Prague hospitals. (2) Significant negative correlation exists between the level of anti-*Toxoplasma* antibodies (which indirectly reflects the duration of latent toxoplasmosis) and the amount of personality shift in the sets of biology students (Flegr and Hrdý 1994) and *Toxoplasma*-positive young women (submitted). (3) No correlation exists between the major toxoplasmosis-risk factors (consumption of raw meat and contact with cat) and the personality factors influenced by toxoplasmosis (Flegr et al. 1998). (4) All but one (factor O) personality factors influenced by toxoplasmosis are shifted in the opposite direction in *Toxoplasma*-positive men and women. It is difficult to explain how the oppositely changed factors can promote the same effect in men and women, namely the increase of probability of *T. gondii* infection.

It can be only speculated whether the induction of personality changes in men is connected with an attempt of the parasite to manipulate the host behaviour or whether it is only a byproduct of a non-specific decline in the quality of host life (connected, for example, with *Toxoplasma*-induced general immunosuppression).

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