

1 Do *Toxoplasma*-infected subjects have better leadership skills? Comment on paper “Puppet
2 master: possible influence of the parasite *Toxoplasma gondii* on managers and employees“

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20 Houdek (2017) performed a thorough literature survey to demonstrate that latent infection by
21 protozoan parasite *Toxoplasma* could have specific effects on personality traits and cognitive
22 performance. These effects could, among other things, influence an infected individual's
23 career outcome, as well as the inner workings of teams and firms. Based on published data on
24 specific *Toxoplasma*-associated behavioral changes, he made several predictions concerning
25 possible impacts of *Toxoplasma* infection on the career outcome of affected persons. Most of
26 the suggested impacts are negative, however, some predict possible positive effects of the
27 infection on the career outcome. Later hypotheses are rather contra intuitive and 'sexy', and
28 therefore they have a potential for attracting the attention of the professional as well as the
29 general audience. Houdek suggests, for example, that due to an increased concentration of
30 testosterone leading to higher masculinity and dominance, the infected men could have better
31 leadership skills and executive abilities. This conclusion, however, appears to contradict an
32 anecdotal observation published in the first paper reporting the behavioral effects of
33 toxoplasmosis in humans (Flegr & Hrdý, 1994). It was mentioned there that among the
34 professors of the Faculty of Science, Charles University, out of 29 members that were
35 *Toxoplasma-free*, 10 were members in senior positions (heads of department, vice-deans, and
36 deans). In the same study, out of 14 *Toxoplasma*-infected members, only one subject was the
37 head of a department. Houdek is aware about the probable transient nature of increased level
38 of testosterone, as well as about cumulative nature of many negative effects of toxoplasmosis.
39 Therefore, he suggests that positive effects of the *Toxoplasma* infection on the career outcome
40 can also be just as transient. Here, I decided to test five Houdek's predictions concerning the
41 better career output of infected subjects.

42 In one of our ongoing studies, we had already collected questionnaire data from nearly
43 forty thousand Czech volunteers, primarily members of the Facebook group 'Guinea pigs'
44 (Kankova, Flegr, & Calda, 2015). Within our electronic questionnaire focusing on the sexual

45 behavior of the Czech population, we included questions asking how many subordinates the
 46 responder presently had at his/her work, and how satisfied he/she was with his/her current
 47 economic situation. The questionnaire also contained the 12 items of the assertiveness scale of
 48 the International Personality Item Pool (Goldberg, 1999).

49 The assertiveness questions, the questions concerning the number of subordinates
 50 (proxy of the leadership skills) and the question on the satisfaction with current economic
 51 situation, were answered by 5075, 3689 and 4823 subjects, respectively, who knew their
 52 toxoplasmosis status. The population consisted of 45.9 % men and 54.1 % women and the
 53 prevalence of toxoplasmosis was 7.6 % in men and 16.4 % in women. The effect of
 54 toxoplasmosis was analyzed by multivariate ANCOVA with three binary factors:
 55 toxoplasmosis, sex, youth and their interactions, and two confounding variables: achieved
 56 education level, and size of the place where they spent their childhood. The output variable
 57 “number of subordinates” had no-normal distribution; therefore this variable was log-
 58 transformed before the analysis. However, the results were qualitatively the same when a
 59 nonparametric test, namely the partial Kendall correlation was used for the analysis.

60 The results of the ANCOVA analysis (Table 1) showed significant effects of
 61 toxoplasmosis and toxoplasmosis-sex interaction. The figures. 1-2 illustrate the effects of
 62 toxoplasmosis on number of subordinates and the satisfaction of participants with their
 63 economic situation and also the absence of any effect of triple interaction toxoplasmosis-sex-
 64 youth.

65 Table 1

	subordinates		assertiveness		economic situation	
	p	Partial eta ²	p	Partial eta ²	p	Partial eta ²

Intercept	0.000	0.040	0.000	0.455	0.000	0.223
size of place of living	0.093	0.001	0.013	0.001	0.271	0.000
education	0.000	0.011	0.000	0.008	0.000	0.038
toxoplasmosis	0.002	0.003	0.322	0.000	0.010	0.001
sex	0.000	0.008	0.000	0.019	0.000	0.004
youth	0.000	0.023	0.000	0.012	0.002	0.002
toxoplasmosis-sex	0.006	0.002	0.932	0.000	0.299	0.000
toxoplasmosis-youth	0.656	0.000	0.852	0.000	0.329	0.000
sex-youth	0.216	0.000	0.082	0.001	0.555	0.000
toxoplasmosis-sex-youth	0.619	0.000	0.981	0.000	0.214	0.000

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67 *Results of three multivariate ANCOVAs for the output variables the number of subordinates,*
68 *assertiveness, and satisfaction with personal economic situation. The values lower than*
69 *0.00005 were coded as 0.000.*

70 The results suggest that the latent *Toxoplasma* infection could have impacts on career
71 outcome. However, the observed effects contrasted with those based on prediction of Houdek
72 (2017).

73 Prediction 1: **Infected subjects should have higher number of subordinates due to**
74 **increased concentration of testosterone in men and increased extroversion/warmth in**
75 **women.** In fact, the infected men had a lower number of subordinates. No effect of the
76 infection on the number of subordinates was observed in women.

77 Prediction 2: **Toxoplasmosis may be a partial culprit in the inequality in leading**
78 **positions in men and women due to their specific (positive) effect on the level of**
79 **testosterone in men.** In fact, toxoplasmosis had a very opposite effect on the inequality in

80 leading positions. Among the *Toxoplasma*-free participants, the men reported much higher
81 numbers of subordinates than the women. In contrast, the number of reported subordinates
82 was approximately same in the *Toxoplasma*-infected men and women after the age 30
83 (actually it was a little bit lower in men).

84 Prediction 3: **The career dynamics of the *Toxoplasma*-infected subjects would look**
85 **like “shine brightly and burn out”, as they would more frequently fail at their task due**
86 **to their lower consciousness.** This prediction can be right, however, we found no formal
87 evidence for it as the effects of triple interaction toxoplasmosis-sex-youth and binary
88 interaction toxoplasmosis-youth were not significant. However, the negative effects of
89 toxoplasmosis on the number of subordinates and on the self-reported economic situation
90 seem to be much stronger after the age 30.

91 Prediction 4: **The effects of toxoplasmosis on career outputs should be stronger in**
92 **subjects with the blood group Rh minus because the Rh positive subjects, namely Rh**
93 **positive heterozygotes, are protected against most of the negative effects of**
94 **toxoplasmosis.** This prediction is most probably right, despite the fact that (due to low
95 number of Rh negative, *Toxoplasma*-infected men) the corresponding effects were not
96 significant. The comparison of the figures 1 with 2 and 3 with 4 suggests that the effect of
97 toxoplasmosis on the number of subordinates and the satisfaction with economic situation is
98 stronger in Rh negative subjects than that observed in the whole population.

99 Prediction 5: **Toxoplasmosis could affect the quality of relationships between men**
100 **and women in workplaces or the prevalence of sexual harassment in firms as the**
101 **infected men have higher testosterone levels and the infected women tend to exhibit**
102 **more warmth.** In fact, both *Toxoplasma*-infected men and women reported to have problems
103 with too low sexual desire (men: $p = 0.028$, $\text{Tau} = 0.04$; women: $p = 0.041$, $\text{Tau} = 0.03$),

104 lower frequency of sexual intercourses within past 365 days (men: $p < 0.00001$, Tau = -0.08;
105 women: $p = 0.049$, Tau = -0.03), and men also reported lower numbers of sexual partners
106 within past 365 days ($p = 0.005$, Tau = -0.05). More details on specific effects of
107 toxoplasmosis on sexual life of men and women can be found in our recent publication (Flegr
108 & Kuba, 2016).

109 The most probable explanation for the contradiction between the theoretical
110 predictions and the empirical data is that other effects of toxoplasmosis, possibly its effects on
111 the health of infected subjects, cancel out the behavioral effects of increased concentration of
112 testosterone and higher extroversion. It has been published that toxoplasmosis increases
113 incidence and morbidity of many disorders , including some cardiovascular diseases, mental
114 health disorders and certain types of cancer, for review see (Flegr, Prandota, Sovickova, &
115 Israili, 2014). In the present study, several health-related variables were monitored. It was
116 observed that infected men reported to have visited a higher number medical specialists
117 within the past two years ($p = 0.032$, Tau = 0.04) while infected women more frequently
118 reported to have worse mental health ($p < 0.0001$, Tau = 0.07), to have more psychiatric
119 disorders diagnosed by medical specialists, ($p = 0.002$, Tau = 0.06), and consumed more types
120 of drugs prescribed by medical doctors ($p = 0.006$, Tau = 0.05) (Flegr & Escudero, 2016). It
121 must be admitted, however, that our data also showed very strong effects of the infection with
122 the bacterium *Borrelia burgdorferi* (the cause of Lyme borreliosis) on the physical health of
123 our responders (much stronger than the effects of toxoplasmosis). At the same time, this
124 infection had no effects on the number of subordinates or on the satisfaction with personal
125 economic situation. Possibly, some more specific effects of latent toxoplasmosis (its effects
126 on mental health?) or on motivation (Flegr, Novotná, Lindová, & Havlíček, 2008) are
127 responsible for the observed impacts of the *Toxoplasma* infection on the career outputs.
128 There are some indirect indices for lower ambitiousness of the infected subjects. The present

129 electronic questionnaire contained also a short projective test. The subjects were asked if they
130 would be born as an animal in their next life, which of ten different animals they would prefer
131 to be. In the *Toxoplasma*-free men, the most popular animal was the lion and in women the
132 dog. In the *Toxoplasma*-infected men the most popular animal was dog and in the infected
133 women the cat. It is indicative that the largest negative difference between popularity in the
134 *Toxoplasma*-infected and *Toxoplasma*-free men, i.e., the largest *Toxoplasma*-associated
135 decrease in popularity, suffered the lion ($p < 0.0001$, Tau = -0.07), the dog (n.s.) and the
136 largest increase in popularity underwent the cat ($p < 0.0001$, Tau = 0.09) and the squirrel ($p <$
137 0.0001 , Tau = 0.09). In the women, popularity of all animals was higher in the *Toxoplasma*-
138 infected raters. However, the smallest increase was in the dog (n.s.) and the parrot (n.s.) , and
139 the lion (n.s.) while the largest was in the cat ($p < 0.0001$, Tau = 0.09) and the mice ($p <$
140 0.0001 , Tau = 0.09). These results suggest that infected men and women have lower
141 ambitiousness than their *Toxoplasma*-free peers (or they would all enjoy turning into cats,
142 which *Toxoplasma* must greatly enjoy).

143 Discussion

144 There are several explanations for the difference between present empirical data and
145 Houdek's theoretical predictions. Most likely, the toxoplasmosis-associated increase of
146 testosterone is just transient, and after some time it returns to its original (or an even lower)
147 level, possibly due to cumulative negative effects of latent toxoplasmosis on human health
148 (Flegr & Escudero, 2016). A very similar phenomenon has been already described (Kaňková
149 et al., 2007). Women infected with *Toxoplasma* for less than two years give birth to 2.5 more
150 sons than daughters, while the women infected for a longer time give birth to significantly
151 more daughters than sons. The long term negative effect of toxoplasmosis on offspring sex
152 ratio is more important than the transient positive effect of toxoplasmosis on the offspring sex
153 ratio, as the secondary sex ratio (fraction of newborn males) correlates negatively with

154 prevalence of toxoplasmosis in particular countries (Dama, Novakova, & Flegr, 2016).
155 Despite the fact that our data brought no formal proof for this, Houdek could be right when
156 saying: "*Toxoplasma*-positive people can achieve high positions, but their performance may
157 decline due to a decrease in conscientiousness, increased neuroticism, and possible health
158 risks." Houdek (2017) p. 71.

159 Limitations of present study

160 The participants provided information, about their *T. gondii* infection status themselves. Some
161 of them probably provided incorrect information and some of them may have provided
162 obsolete information because they acquired the infection only after their test for anti-*T. gondii*
163 antibodies had been done. However, an independent analysis showed excellent (99·5%)
164 agreement between the toxoplasmosis status reported by 3827 subjects during registration to
165 Guinea Pigs community and the toxoplasmosis status obtained in serological tests performed
166 in our laboratory (Flegr, 2017). The same study also reported very good (99·2%) agreement in
167 393 responders who signed their questionnaire in a previous epidemiological study and also
168 reported their toxoplasmosis status during registration (Flegr, 2017). The subjects also self-
169 reported how many subordinates they have. It is probable that this information can be
170 imprecise or even biased. The personality profiles of *Toxoplasma*-infected and *Toxoplasma*-
171 free subjects differ (Flegr, 2010). The infected subjects have, e.g., lower conscientiousness,
172 and therefore it is possible that they do not know how many subordinates they, in fact, have.
173 Because of this, the infected subjects could report to have less subordinates, despite having
174 the same (or a higher) a number of subordinates than the *Toxoplasma*-free subjects. Therefore,
175 it would be important to confirm the results of the present study and the original study
176 performed on the university professors using independent empirical case control studies, i.e.,
177 by comparing the seroprevalences of toxoplasmosis in subjects in various working positions.

178 Conclusions

179 The present data confirmed that *Toxoplasma* infection probably had certain effects on career
180 outcome. However, in most subjects, various effects of toxoplasmosis on human physiology
181 and behavior or even the nonspecific effects of impaired health status have probably had
182 stronger impacts than the more specific, but weaker, effects of the changed levels of
183 hormones and neurotransmitters. These conclusions are based on the analysis of data of just
184 one very large new and one small already published study and both these studies were
185 originally designed to solve unrelated questions. Therefore, the results and conclusions must
186 be considered only preliminary until the results of other independent and specifically designed
187 studies will be available.

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232 Biography

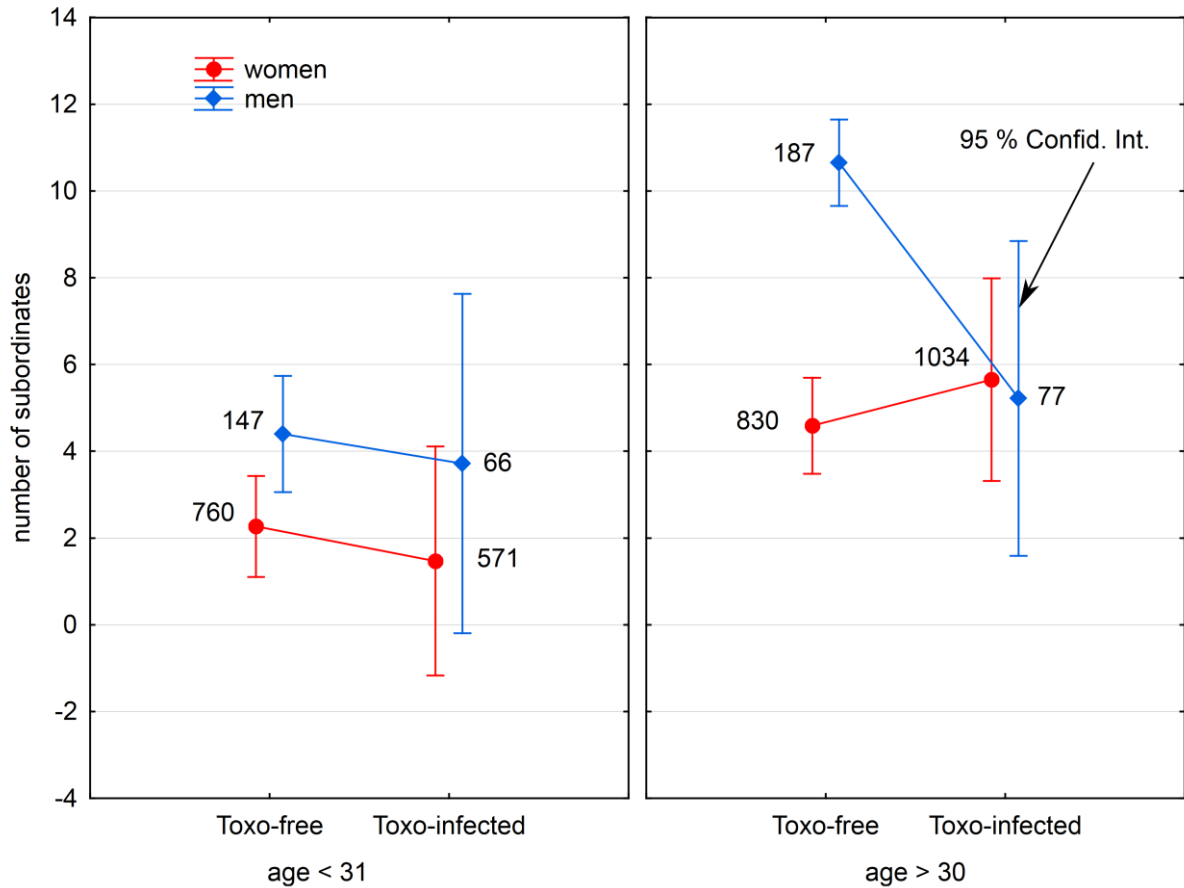
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240 Fig. 1. Effect of toxoplasmosis and gender on number of subordinates



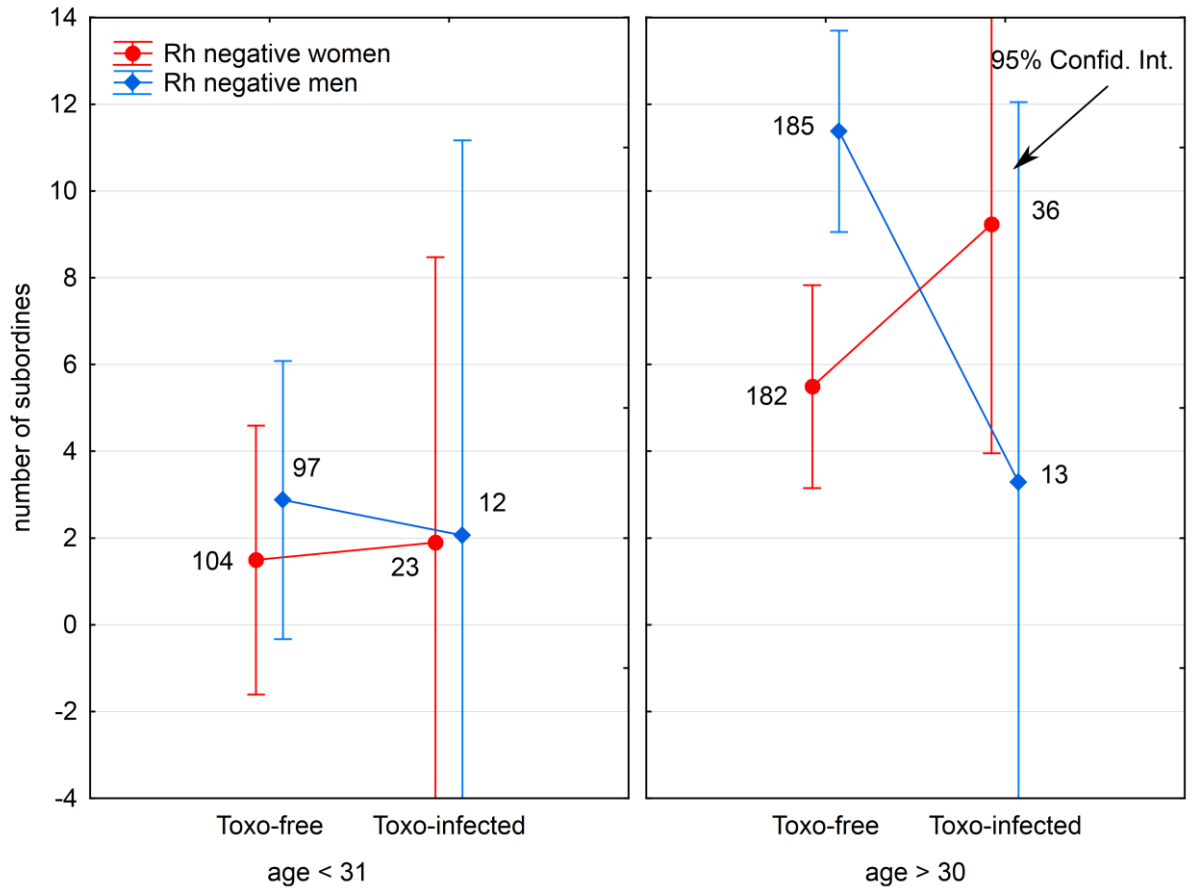
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242 *The numbers denote amount of responders in particular groups. The means reflect, but not*
243 *correspond to, number of subordinates as for 0-100 one point on the scale corresponded to*
244 *one subordinate while for 101-140 one point on the scale corresponded to 10 subordinates.*
245 *The code 141 meant 500 and more subordinates (this code was used by 14 participants).*

246 Fig. 2 Effect of toxoplasmosis and gender on number of subordinates in Rh negative
 247 responders

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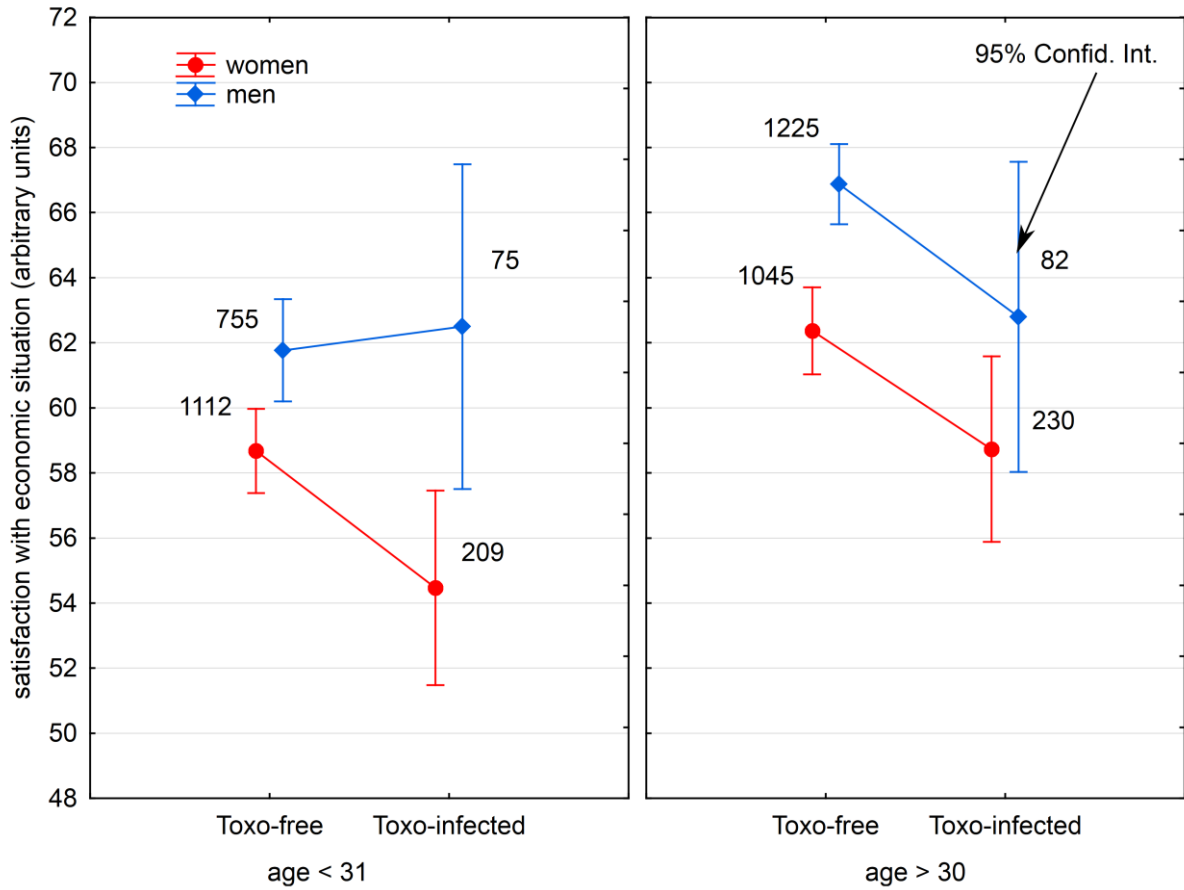
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251 For the legend see the Fig. 1

252 Fig. 3 Effect of toxoplasmosis and gender on self-reported satisfaction with personal
 253 economic situation



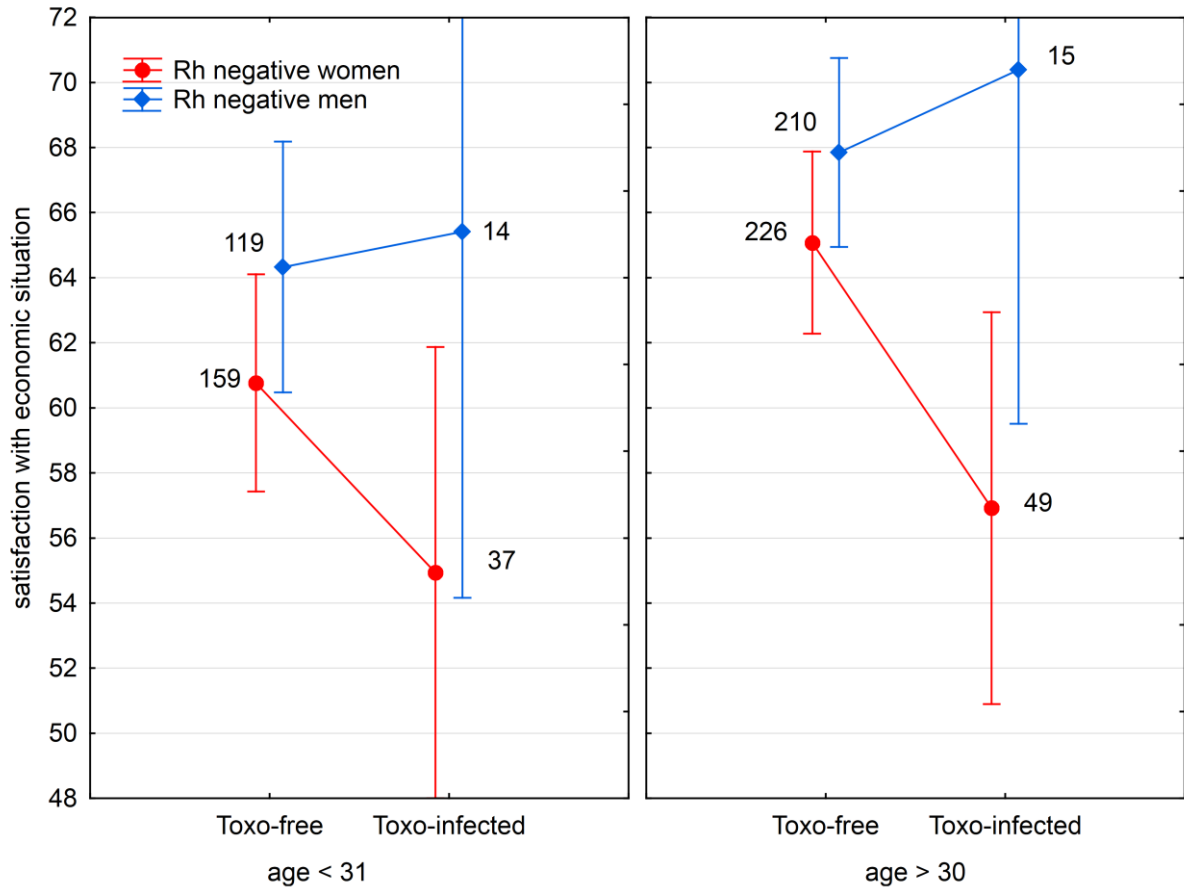
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255 *The numbers denote amount of responders in particular groups. The responders used 0-100*
 256 *scale to rate the satisfaction with their personal economic situations.*

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259 Fig. 4. Effect of toxoplasmosis and gender on self-reported satisfaction with personal
 260 economic situation in Rh negative responders



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262 *For the legend see the Fig. 3.*

263