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The Relationships Between Paranormal Belief, Creationism, Intelligent Design and Evolution at Secondary Schools in Vienna (Austria)

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Abstract The present study is the first to investigate the relationships between a multiple set of paranormal beliefs and the acceptance of evolution, creationism, and intelligent design, respectively, in Europe. Using a questionnaire, 2,129 students at secondary schools in Vienna (Austria) answered the 26 statements of the Revised Paranormal Belief Scale (R-PBS) and three statements about naturalistic evolution, creationism and intelligent design (ID). The investigated Austrian students showed an average R-PBS score of 82.08, more than 50% of them agreed with naturalistic evolution, 28% with creationism, and more than a third agreed with ID, the latter two closely correlated with each other. Females generally showed higher belief scores in the paranormal, creationism and ID. The agreement with naturalistic evolution correlated negatively with religious belief, but not with other paranormal beliefs, whereas the two non-scientific alternatives to evolution significantly correlated with both traditional and paranormal beliefs. Religious belief showed a significant positive correlation with other paranormal beliefs. All subscales of paranormal belief decreased during the eight grades of secondary school, as did acceptance of creationism and ID. However, the acceptance of naturalistic evolution did *not* correlate with age or grade. Possible reasons and implications for science education and the biology curriculum at Austrian secondary schools are discussed.

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1 Introduction

Paranormal belief in its various forms has always been a common phenomenon not only among adults, but also especially in adolescents. Neutrally defined, paranormal beliefs "transcend the explanatory power of mainstream science" (Gray 1991, p. 7), because "paranormal phenomena, if genuine, would violate basic limiting principles of science" (Broad 1953, p. 44). Popular trends of superstitious and other supernatural beliefs are widespread among children and teens (Harder 2001), to whom a senseless and chaotic world might feel especially frightening. The rituals of both traditional religion and superstition appear to provide a certain comfort (Gorsuch 1988; Emmons and Paloutzian 2003), particularly under suboptimal living conditions (Schiemann 2010). Scientific thinking does not provide the same feeling of security with regard to individual fate, but ultimately provides a higher degree of insight into and predictability of the world's phenomena.

We assert that science education is the natural antagonist of any form of paranormal belief (Martin 1994; Martin-Hansen 2008; Matthews 2009). For example, astrology, fortune telling, or psychokinesis fundamentally violate the laws of physics, and we expect that students' belief in these ideas decreases after having understood the principles of science. A scientific, naturalistic worldview emerges not only without supernatural explanations, but is fundamentally contradicted by them (Martin-Hansen 2008; for a thorough review of scientific implications on supernatural claims see Fishman 2009).

The secondary school years span the pupils' transition from childhood to adulthood, and are therefore formative in terms of either their adherence to paranormal beliefs or their use of scientific reasoning and independent critical thinking (Kuhn 1999). Therefore it is of particular interest to determine whether or not paranormal belief decreases during the years of secondary school. Austrian secondary school starts after primary school at an age of approximately 10 years with grade 5, and ends after grade 12 with a final examination called "Matura" (equivalent to the German "Abitur") for admission to university. In 2009, more than 82% of all Austrians between the ages of 25 and 34 have at least passed this final examination (Schwabe and Radinger 2010). A study at secondary school level can therefore provide broad insight into the opinions of Austria's younger generation, as well as a rough forecast of the next decades' opinion spectrum.

So far, no systematic evaluation of paranormal beliefs among Austrian children and teenagers exists. The only tested group were university students (Hergovich and Arendasy 2005; Hergovich et al. 2005), using the Paranormal Belief Scale (PBS) developed by Tobacyk and Milford (1983). Recent studies on paranormal belief in Europe were made in Iceland (Haraldsson and Houtkooper 1996; Thalbourne and Hensley 2001), Germany (Thalbourne and Houtkooper 2002), the U.K. (Huntley and Peeters 2005), and Finland (Lindeman and Aarnio 2006, 2007). A comprehensive overview on the research status in Europe is given by Hergovich (2005).

2009 was the 150th anniversary of Charles Darwin's *Origin of Species*. It was therefore of special interest to us to gauge students' acceptance of naturalistic evolution, and to check if alternative explanations such as creationism (a supernatural explanation of life on earth) or intelligent design (ID, a pseudoscientific variation of creationism; Pennock 2003) were correlated with paranormal beliefs. As with paranormal belief, it seems reasonable to expect that belief in creationism and ID would decrease between grades 5 and 12 due to increasing knowledge of biology, and the acceptance of natural evolution should increase.

In 2002 and 2005, a large survey compared the public acceptance of evolution in 32 European countries, Japan, and the USA (Miller et al. 2006). In 2002, one third of the

Austrian respondents fully agreed with the statement "Human beings, as we know them, developed from earlier species of animals", another third considered the statement as "probably true", and less than 20% denied the existence of evolution. Three years later, the overall agreement with the above statement had fallen from two thirds to less than 60%, while almost 30% of respondents denied evolution. In 2009, a large oral opinion survey about the Austrians' attitude towards creationism and evolution asked participants "what should be taught at Austrian schools?" Only 50% agreed with a naturalistic definition about the "origin of the world", while 21% advocated creationism (GfK Austria 2009). Both the development of paranormal belief and/or acceptance of evolution, creationism and ID during 8 years at secondary school could inform new aims and purposes of science education as well as its efficacy.

Several previous studies confirmed the obvious relationship between creationism, ID, and religiosity.[1] Others found a positive correlation between religiosity and "superstitious" paranormal belief.[2] This suggests an investigation of the so far unidentified relationships between attitudes about evolution/creationism/ID and paranormal beliefs, respectively. With the present study, we aim to examine the following questions:

1. How strong are different supernatural beliefs among Austrian secondary school students, and are there gender differences?
2. How many students agree with naturalistic evolution, with creationism, and intelligent design, respectively?
3. Do the opinions about evolution/creationism/ID correlate with paranormal beliefs?
4. Do students' attitudes change towards scientific thinking between grades 5 and 12; i.e. does the agreement with evolution increase, whereas paranormal beliefs and the agreement with creationism/ID decrease?

2 Materials and Methods

2.1 Survey Participants

In a preparation phase, before performing the study on a large scale, we interviewed 316 students belonging to 18 different secondary schools (two of them outside Vienna) in the street, where we asked 30 of them for detailed feedback about the questionnaire to ensure that each statement was well understood by the students. According to these interviews and the preliminary statistical analysis ($N = 316$), minor changes were made in translation and layout to improve the questionnaire for the large-scale survey. Subsequently, ten secondary schools voluntarily participated in the main phase our study, each located in a different Viennese district, altogether providing a representative cross section of secondary schools in Vienna.

A total of 2,166 students answered our questionnaires; 37 of them were excluded due to a large number of missing, double, or obvious hoax answers (e.g. zigzag patterns), which resulted in a final number of 2,129 participating students.

[1] See Shankar (1989), Bishop and Anderson (1990), Scharman and Harris (1992), Shankar and Skoog (1993).

[2] See Haraldsson (1981), Irwin (1985), Svensen et al. (1992), Goode (2000), Orenstein (2002), Thalbourne (2003), Hergovich et al. (2005).

2.2 Questionnaire

Our questionnaires consisted of the revised Paranormal Belief Scale (R-PBS) by Tobacyk (2004, see Appendix 1) in German translation (available at http://phaidra.univie.ac.at/o:50750).

Tobacyk (2004) defined the following subscales: "Traditional Religious Belief" = -Mean of Items (1, 8, 15, 22); "Psi" = Mean of Items (2, 9, 16, 23); "Witchcraft" = Mean of Items (3, 10, 17, 24); "Superstition" = Mean of Items (4, 11, 18); "Spiritualism" = Mean of Items (5, 12, 19, 25); "Extraordinary Life Forms" = Mean of Items (6, 13, 20); "Precognition" = Mean of Items (7, 14, 21, 26). For a conversion to the previously used, five-scaled PBS (Tobacyk and Milford 1983), we used the formula: R-PBS = 1.5 (PBS − 26) + 26. For a separation of traditional religiosity from other paranormal beliefs, we subtracted questions 1, 8, 15, and 22 from R-PBS, which resulted in a "cleared" R-PBS_c (R-PBS without traditional religious belief).

As a measurement for naturalistic evolution (1), creationism (2), and intelligent design (3), respectively, we used the three following statements (German original, first used by FOWID 2005):

1. Life on earth has emerged without the influence of any supreme being and has evolved through a natural developmental process. (Statement "evolution")
2. God directly created life on earth, including all species, as described in the Bible. (Statement "creationism")
3. Life on earth was created by a supreme being (God), and has undergone a long developmental process directed by this supreme being (God). (Statement "ID")

Although improvements could be suggested for both the R-PBS[3] and evolution[4] statements, we did not change the detailed wording of the statements in order to be able to compare the results with previous studies. As in Tobacyk (2004), we used a seven-point Likert scale for all 29 questions, allowing respondents to precisely describe their beliefs (7 strongly agree—6 moderately agree—5 slightly agree—4 uncertain—3 slightly disagree—2 moderately disagree—1 strongly disagree). To exclude response order effects (Krosnick and Alwin 1987; McClendon 1991; Lemay et al. 2009) and to avoid copying answers from neighbouring students, we used three different versions of the questionnaire, with a randomly varied order of the items. Additionally, the following demographic data were collected in the questionnaire: sex, age, grade, and religious denomination. Without any time pressure, filling in the questionnaires took approximately 10 min, for the lower grades up to 15 min.

2.3 Statistics

Original data (available at http://phaidra.univie.ac.at/o:50750) were subjected to principal components analysis (PCA) using the correlation matrix. Only principal components that accounted for variances greater than 1 (Kaiser-Guttman criterion) were used to represent

[3] E.g. the „life on other planets" statement seems not to be a measurement for paranormal belief any more (cf. Burchell 2009); and Thalbourne (pers. comm. 1991, cit. in Irwin 1993) critically discussed the subscales defined by Tobacyk and Milford (1983).

[4] The "ID" statement used more accurately represents "theistic evolution". ID exponents try to evoke doubts about naturalistic evolution via the "irreducible complexity" argument, but usually do not explicitly define how the actual diversity of organisms came to existence. However, in German speaking countries, theistic evolution is usually seen as synonymous with ID.

the data. A 'varimax' rotation was applied to the retained components to redistribute the variance among factors to obtain PC scores (James and McCulloch 1990; Norušis 1990; Jolliffe 2002). Correlation and regression analyses were used to test the relationships between the independent variables and the dependent original variables, e.g. between grades in the three evolution statements and in R-PBS. T-tests were used to test gender differences in the R-PBS subscales. Chi square tests were used to test differences between observed and expected values for the evolution statements. All statistical analyses were performed using SPSS for Windows, Version 11.5 (Norušis 2002).

3 Results

The 2,129 usable questionnaires were filled in by 1,046 male and 1,083 female secondary school students. 172 of the students attended grade 5, 226 grade 6, 343 grade 7, 334 grade 8, 293 grade 9, 333 grade 10, 212 grade 11, and 216 grade 12. The most frequent denomination present was Roman Catholic (1,191), the next largest group was religiously unaffiliated (342), followed by Muslims (269), Protestants (133), and Serbian Orthodox (81). Only few students were Greek Orthodox (15) and Jewish (6), or belonged to "other denominations" (92, not evaluated in detail).

The principal component analysis of our data (see Appendix 2) confirmed the seven subscales defined by Tobacyk (2004). Seven principal components together explained 63.1% of the total variance.

3.1 Paranormal Belief

The mean total R-PBS score of our sample was 82.08 (SD = 27.55), which corresponds to a calculated PBS of 63.39. Five years ago, Austrian university students scored higher than our sample (PBS 71.01 $\approx$ R-PBS 93.5, Hergovich 2005). Also in the southern United States, university students scored with a higher PBS of 72.9 ($\approx$R-PBS 96.53, Tobacyk and Milford 1983) and, more recently, with a R-PBS of 89.1 (Tobacyk 2004).

Paranormal belief is associated with gender: females showed a significantly higher R-PBS score (85.33, SD 25.77) than males (78.65, SD 28.78) ($p = 0.0000$). This was mainly due to the subscales "traditional religious belief", "spirituality", and, less significantly, to subscale "psi" and "witchcraft". No significant difference was found in the subscales "superstition" and "precognition". The only subscale showing a higher agreement value in males was "extraordinary life forms".

3.2 Evolution, Creationism, ID

Little more than half of the students (50.49%, Fig. 1) agreed with evolution (remarkably, most of them "fully"), 22.45% were uncertain, and 27.05% disagreed. Almost identical with the number of students disagreeing with evolution, 27.85% agreed with the "creationism" statement, 18.79% were uncertain, and 53.36% disagreed. More than a third of the students (34.38%) agreed with the "ID" statement, 24.28% were uncertain, and 41.33% disagreed.

Similarly to paranormal belief, females agreed more strongly with creationism ($p = 0.0123$) and ID ($p = 0.0000$) than males, and males significantly agreed more strongly with naturalistic evolution ($p = 0.0000$).

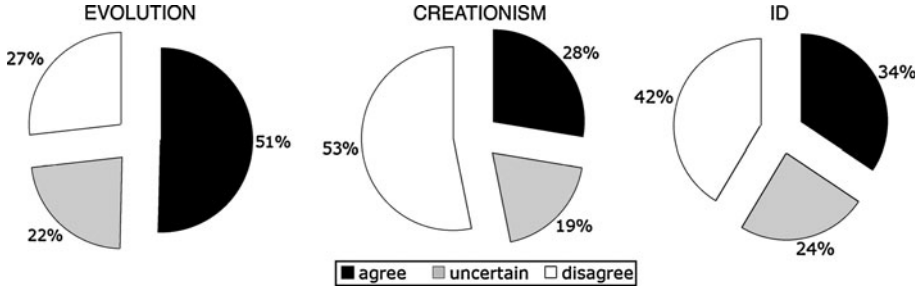

Fig. 1 Overall agreement with the statements "evolution", "creationism", and "ID" (N = 2,129). *Black* segments: agreement (agreement scores 5–7), *grey*: uncertain (score 4), *white*: disagreement (scores 1–3). There is statistical evidence that the observed distribution of the agreement data is different from an expected random distribution ($X^2 = 7.558$, $p = 0.0023$)

3.3 Paranormal Belief and Evolution/Creationism/ID

The two alternatives to evolution that rely on supernatural forces to explain the nature and history of the natural world, creationism and ID, correlated positively with paranormal beliefs (Table 1): both of them were correlated with high statistical significance with the R-PBS as well as the R-PBS_c (without traditional belief) and the subscale "traditional religious belief". The explained variance was highest for the subscale "traditional religious belief". For naturalistic evolution, on the other hand, we did *not* find any significant correlation with paranormal assumptions—except for a significantly negative correlation with the subscale "traditional religious belief", with low effect size, however.

Consequently, we also calculated the relationship between the subscale "traditional religious belief" and all other paranormal beliefs ("cleared" R-PBS_c). We found a significant positive correlation between traditional religious belief and other paranormal beliefs (R-PBS_c), explaining approximately 28% of the total variance (Table 1).

Table 1 Crossover correlations of agreement with evolution (EVO), creationism (CREA), intelligent design (ID), the subscale "traditional belief" (TRAD), and the revised Paranormal Belief Scale, "cleaned" of traditional belief (R-PBS_c), respectively. Pearson's r = correlation coefficient, r^2 = coefficient of determination, N = 2129

		CREA	ID	TRAD	R-PBS_c
EVO	Pearson's r	−0.31	−0.34	−0.29	−0.04
	r^2	0.10	0.12	0.08	0.00
	p	0.0000	0.0000	0.0000	0.0886
CREA	Pearson's r		0.59	0.60	0.33
	r^2		0.34	0.36	0.11
	p		0.0000	0.0000	0.0000
ID	Pearson's r			0.65	0.36
	r^2			0.43	0.13
	p			0.0000	0.0000
TRAD	Pearson's r				0.53
	r^2				0.28
	p				0.0000

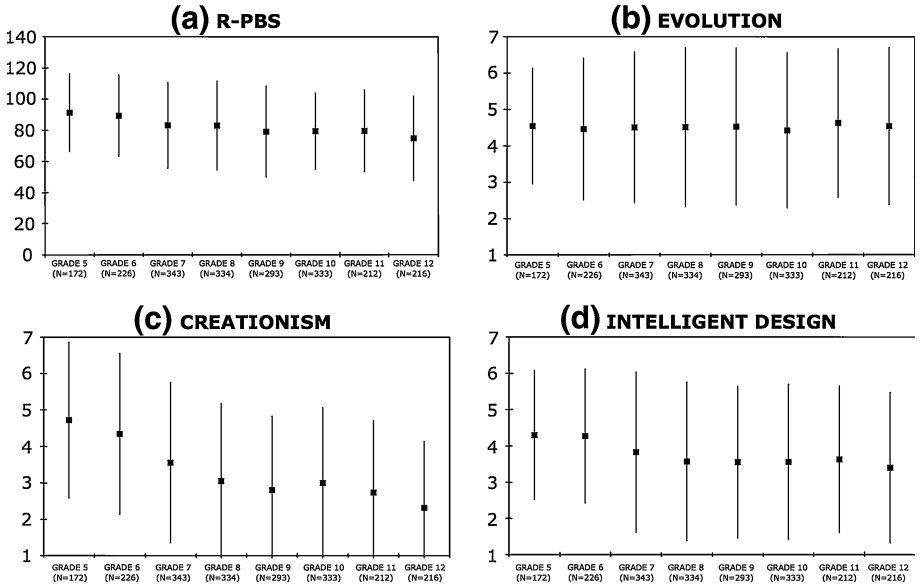

Fig. 2 (**a**) R-PBS score and grade, (**b**) evolution and grade, (**c**) creationism and grade, (**d**) ID and grade. X-axis shows grade, y-axis shows R-PBS score (**a**) and Likert scale 1–7 (**b–d**). *Black squares* indicate mean values; *bars* indicate standard deviations (N = 2,129)

3.4 Development from Grade 5–12

Paranormal belief decreased significantly with rising grade (linear regression analysis, $p = 0.000$, Fig. 2a). In grade 5, total R-PBS score was 91.28 (SD = 25.14), and decreased continuously until 74.81 (SD = 27.28) in grade 12. Similarly, the single subscales decreased over the 8 years of secondary school: there were highly significant differences in the subscales "traditional religious belief" ($p = 0.000$, $r^2 = 0.013$), "psi" ($p = 0.000$, $r^2 = 0.011$), "superstition" ($p = 0.000$, $r^2 = 0.056$), "extraordinary life forms" ($p = 0.000$, $r^2 = 0.012$), "precognition" ($p = 0.000$, $r^2 = 0.023$), significant differences in "spiritualism" ($p = 0.005$, $r^2 = 0.004$), and no significant differences were found in the subscale "witchcraft" ($p = 0.309$, $r^2 = 0.000$).

The relationships between school grade and the statements about life on earth are complex: surprisingly, we could *not* observe any significant differences in the agreement with naturalistic evolution among the eight grades of secondary school ($p = 0.778$, Fig. 2b). However, there was a highly significant negative correlation between belief in creationism and grades ($p = 0.000$, Fig. 2c) as well as between belief in ID and grades ($p = 0.000$, Fig. 2d). At grade 12, the median value for "creationism" ended up at 1, which is the lowest possible value ("strongly disagree").

4 Discussion

Regarding paranormal beliefs, Vienna's secondary school students seem to possess a well-established critical worldview. Their R-PBS score was relatively low, even compared with graduate students from the University of Vienna (Hergovich and Arendasy 2005;

Hergovich et al. 2005). More than half of our students agreed with the following statements: "I believe in God", "there is life on other planets", "the soul continues to exist though the body may die", and "life on earth has emerged without the influence of any supreme being and has evolved through a natural developmental process", followed by 821 students who agreed that "mind reading is *not* possible". This means that among the "top five" statements, there were only two clearly paranormal statements, both of them belonging to traditional religious belief. "Life on other planets" should be considered as an indicator of scientific curiosity rather than as a paranormal belief, the explicit denial of mind reading surpassed all paranormal belief statements, and the "naturalistic evolution" statement reached number four of the top five statements of our questionnaire. Nevertheless, no reason to sit back and do nothing.

4.1 Evolution in the Austrian Secondary School Curriculum

With no doubt, evolution is the "Ariadne's thread" in life science, underlying and explaining all existing phenomena in biology. However, the idea of this red thread seems to be missing in the biology curriculum at Austrian secondary schools (BGBl II Nr133 2000; BGBl II Nr 277 2004).

The subject "Biologie und Umweltkunde" at Austrian secondary schools has to deal with numerous highly relevant matters, pressed into a maximum of 2 weekly hours. In particular, the Austrian curriculum emphasizes the topics "human body and health", "animals and plants", "ecology and environment" (grades 5–8), and additionally "understanding world and nature" and "biology and production" for grades 9–12. In all grades, the curriculum is structured around these topics, designated to achieve the following objectives: "the students should become familiar with the principles, cycles and interdependences involved in biology, as well as understand the methods of hypothesizing and experimenting used in the natural sciences. The students should gain an understanding of their own bodies so as to foster a sense of responsibility for themselves (acceptance of their bodies, sexuality and health). The students should recognize and understand the dependence of humans upon nature and the environment, and be motivated to environmental consciousness and sustainability". This list continues, and we did not find a single objective in it that could be considered unimportant. However, with the discussion of evolution only intermittently involved in the topics "animals and plants" (grade 7, defined as "the history of development of earth and life, including mankind") and "understanding world and nature" (grade 12, "the principles of chemical and biological evolution, evolutionary theories, overview of the course of phylogeny"), it is left to the teacher's responsibility and ability to include evolution as an underlying theme throughout biology. Most biology textbooks present these topics as isolated subjects, without emphasizing the connections between them. Evolution is presented as one of these "chapters", and not as a continuous explanation of life and nature (for an international comparison, see Skoog 2005). This may be one of the reasons why the agreement with the "evolution" statement in our questionnaire did not increase significantly between grades 5 and 12 (Fig. 2b). However, the belief in the two alternative supernatural explanations of life on earth decreased significantly within the eight examined grades of secondary school (Fig. 2c, d).

There may be other relevant factors that influenced the students' agreement to our "evolution" statement. One aspect is upbringing. The opinions of children and teens are greatly influenced by their parents. As the percentage of pro-evolution respondents in our study was almost equal to that in Austrian adults (GfK Austria 2009), we suppose that opinions about the origin of species are borrowed from the parents, similarly to religious

belief (Gorsuch 1988). Familiar convictions are more resistant to environment and school education than other opinions, and both attitudes in favour of or against evolution may persist almost unchanged throughout secondary school. Another aspect may be the wording of the statements. There is, for example, a fundamental difference between the statement "Human beings, as we know them, developed from earlier species of animals" (Miller et al. 2006) and "Life on earth has emerged *without the influence of any supreme being* and has evolved through a natural developmental process" (FOWID 2005), while both claim to represent "evolution". In the case of our questionnaire, the formulation "without…any supreme being" (an exclusion that applies to naturalistic science *per definitionem* and makes the crucial difference here between theistic and Darwinian evolution) may have hindered some religious students who otherwise would have agreed with the general idea of evolution from accepting this statement.

4.2 Agreement with Evolution: International Comparison

Among 34 countries examined for the agreement with evolution in 2005 (Miller et al. 2006), Austria fell in the last third, while the United States exhibited the second lowest acceptance of evolution (40%) and surpassed only Turkey. Considering that "no European country has experienced the politicization of the evolution issue that has occurred in the United States in recent decades" (Miller et al. 2006, SOM p. 7), it is not surprising that throughout all studies performed, Austria showed a higher agreement with evolution than the USA. In Austria, the Roman Catholic Church is predominant, and pope John Paul II acknowledged Darwin's theory being "more than a hypothesis" in 1996. In 2007, his successor Benedikt XVI rejected creationism and acknowledged scientific evidence of evolution (see Brasseur 2009). However, the position of the Catholic Church is not uniform: In 2005, the influential cardinal archbishop of Vienna caused an emotional public discussion about ID with an article published in the New York Times (Schönborn 2005, for a thorough comment see Junker 2007), a topic that was formerly thought to be specific to the USA. The ongoing discussions in mass media made ID popular in Austria, as there were only few scientists who dared to contradict a cardinal archbishop in the public. In March 2009, the market research company GfK Austria performed a large oral opinion survey (N = 1,500) about the Austrians' attitude towards creationism and evolution (GfK Austria 2009). Informants had, quite similarly to our study, to agree or to disagree with various statements. However, GfK Austria asked mostly for "interests" instead of beliefs or opinions, and the questionnaire showed major deficits in the questioner's understanding of evolution. For a comparison with our study, the possibly most suitable question in GfK Austria (2009) was "what should be taught at Austrian schools?" because these answers most probably reflect the respondents' own opinions: 50% agreed with a naturalistic definition about the "origin of the world" (18% disagreed), 21% with creationism (62% disagreed). There was no question about "intelligent design" in this study. These data correspond well with the answers of our students (Fig. 1): regarding the naturalistic definition, students showed approximately the same level of agreement as adults, but a remarkably higher level of disagreement (27%). For creationism, our students showed a higher agreement than adults (28%) and less disagreement (53%) than adult Austrians.

For Germany, different results in relation to age were shown in a survey about belief in creationism and agreement with evolution by FOWID (2005): 70.8% of people between ages 14 and 29 agreed with naturalistic evolution which was more than the percentage of older people: at an age between 30 and 44, 67.4% agreed with evolution, which decreased to 48.8% for participants aged over 74. The reason why FOWID (2005) generally received

higher levels of agreement than our study is most probably that choosing one of the three statements was obligatory, and therefore there were almost no "uncertain" answers. To compare our data with the FOWID (2005) results, we re-calculated the percentages: without the answer "uncertain", 65.4% of Austrian students agreed with evolution (61% in Germany), 34.6% with creationism (12% in Germany), and 44.7% with ID (25.2% in Germany). For the latter two, there is a considerable overlap in our study (11%), as students had the option of agreeing with more than one statement. Still, the agreement with the non-scientific explanations of life on earth was much higher in our data than in the German study. This might be due to the fact that there is less influence of the Roman Catholic Church in Germany than in Austria, as there are only 30% Catholics and Protestants each, and 34.1% without religious denomination in Germany (FOWID 2008).

4.3 Evolution and (Paranormal) Belief

Our data show creationism and ID correlating both with religiosity and other paranormal beliefs. On the other hand, the agreement with evolution correlates negatively with religiosity, but not with other paranormal beliefs. Evolution as a scientific finding interferes with the creation myth of the Bible (and corresponding verses of the Koran, see Riexinger 2009), and accepting both naturalistic evolution and traditional religious myths requires either an unorthodox, metaphorical exegesis of the holy scriptures or a strict intellectual separation of naturalistic science on the one hand and spiritualism on the other. Both ways of coping with this contradiction seem to be difficult at the age of a secondary school student, which might explain why so many of them chose ID as a seemingly convincing alternative, including both a creator *and* evolution. As outlined by Pennock (2003) and Perakh (2003) among many others, ID is not the most intellectual solution for the dilemma science versus belief, as it requires continuous interventions by the "intelligent designer", who would have to control each single mutation and recombination to achieve his goals: ID is no more than a perpetuated creationism. It is therefore no surprise that we found very high correlations between ID and creationism (explaining 34% of total variance, see Table 1) and between both of them and traditional religion. ID correlated even more strongly with the "traditional religious belief" subscale than creationism. Remarkably, both ID and creationism correlated highly significantly with all other paranormal assumptions ("R-PBS_c", without traditional belief), which identified them as paranormal concepts. Recent studies discuss the evolutionary advantages of both religion (Bulbulia 2004) and superstition (Foster and Kokko 2009), which paradoxically gives an evolutionary explanation for the popularity of creationism and ID. Other authors found high paranormal belief to be associated with lower intelligence,[5] and in this regard, future research regarding cognitive abilities and the belief in creationism or ID seems a promising topic.

It is obvious that evolution on the one hand and creationism/ID on the other hand represent contradictory worldviews (cf. Graf 2010), and hardly surprising that they correlate with religious beliefs. However, some German studies claimed not to find any connection between religion and the agreement with evolution, such as Illner (2000) for German students of Christian denominations and Demastes et al. (1995). Wandersee et al. (1995) state that no study so far has succeeded in showing any correlation between religious belief and the acceptance of evolution. The mentioned studies were long-term interviews with sample sizes of $n = 4$ (Demastes et al. 1992, cit. in Wandersee et al. 1995)

[5] See Tobacyk (1984), Wierzbicki (1985), Messer and Griggs (1989), Musch and Ehrenberg (2002).

and n = 5 (Illner 2000), and without any clear methodical exclusion of the interviewer's influence on the students. This kind of research may be helpful to understand a single child's knowledge or thoughts, but does not justify general conclusions. Other authors outlined a clear relationship between creationism, ID, and religiosity.[6]

Paranormal and scientific attitudes frequently show a long-term coexistence within a single person (Lindeman and Aarnio 2006, 2007), a contradiction in terms that is usually neglected by the individual. Our data show for example that many people simultaneously believe in God and are convinced that origin and evolution of life on earth happened without any god, a combination that is not explicitly covered by any doctrine of the predominant European religions. The inclusion of religious and other paranormal assumptions in everyday life may seem harmless to the observer, but can lead to wrong individual (e.g. susceptibility to sects, cf. Abgrall 2000) and political (e.g. susceptibility to right-wing authoritarianism, cf. Heard and Vyse 1999, Hunsberger et al. 1999) decisions: "An 'all things are equal' attitude may seem appealing and tolerant, but is in fact dangerous" (Council of Europe 2007).

4.4 Religion and (Other) Paranormal Beliefs

The differences between religion and other, non-institutionalized, beliefs in the supernatural may be less than traditionally assumed (Irwin 1993; Rice 2003). The claim that "the paranormal is undoubtedly a common characteristic of both religion and parapsychology" (Hergovich et al. 2005, p. 293) is supported by a significant correlation in our study, showing traditional religiosity hand in hand with all other subscales of the paranormal: it seems that one who believes[7] tends to believe anything.[8] This contradicts the hypothesis that esoteric ideas serve as a substitute for religion for those who are not traditionally religious (Emmons and Sobal 1981; Persinger and Makarec 1990; Beck and Miller 2001). The so-called substitution theory is not supported by our data, aside from a few individual exceptions. There were in fact students in our sample to whom the substitution hypothesis seems to apply due to their simultaneously low adherence to traditional religious beliefs yet high levels of belief in other aspects of the paranormal. These cases are rare, however, and our sample contained less than 1%. Almost as rare are non-superstitious religious persons, who exhibit strong belief in traditional religion but very little belief in other supernatural claims. We did not ask for regular church attendance in our questionnaire, which could be a possible factor for non-superstitious religiousity (McKinnon 2003). The majority seems to confirm Blaise Pascal's saying "Il y en a beaucoup qui croient, mais par superstition" (there are many who believe, but due to superstition; Pensées IV, 256).

Consequently, a common characteristic of religion and other paranormal beliefs must be an (at least partial) ignorance or even denial of scientific methods and findings. If not already falsified in detail (such as astrology: Carlson 1985; von Eye et al. 2003), paranormal statements either contradict basic principles of nature (such as the first two laws of thermodynamics) or ignore methodological principles like parsimony or null hypothesis (e.g. the very improbable existence of a Loch Ness monster). The significant PBS decline between grades 5 (age 10–11) and 12 (age 17–18) indicates that the more students know

[6] See Shankar (1989), Bishop and Anderson (1990), Scharman and Harris (1992), Shankar and Skoog (1993).

[7] i.e. in God.

[8] i.e. any other paranormal ideas.

about science, the less they believe in the paranormal. This applies both to traditional and to non-religious paranormal beliefs.

4.5 Science Education in Austria—Outlook and Recommendations

Does science education work at Austrian secondary schools? In the context of this study, we would answer with a careful "yes, but it could work better".

Significantly decreasing paranormal belief from grades 5–12 can be interpreted as a result of school education, increasing scientific knowledge and critical thinking. However, it could also be interpreted simply as an effect of cognitive maturation, as developmental psychology has known for long that religious (and therefore other paranormal) beliefs of adolescents decrease with age (Ausubel 1971; Oerter 1973). It is not easy to separate maturation and education from each other, but in the case of creationism and ID we think that it is possible. Whereas R-PBS decreases continuously with grades (Fig. 2a), belief in creationism and ID show the most significant decrease at/after grade 7 (Fig. 2c, d), the year when evolution is first taught at school. This case indicates the influence of secondary school curriculum on the students' worldview, and therefore we think that science education does have a stake in decreasing paranormal beliefs.

One stain remains, however: the acceptance of naturalistic evolution does not change during 8 years of secondary school. Still, it should be possible to get across the compelling arguments for evolution and to reduce teleological interpretations (cf. Johannsen and Krüger 2005): "It is not a matter of opposing belief and science, but it is necessary to prevent belief from opposing science" (Council of Europe 2007). It would be a surrender of the education system to accept that almost 50% of secondary school graduates *miss the point* of 8 years of biology education—because evidently (almost) "nothing makes sense in biology except in the light of evolution" (Dobzhansky 1964).

We therefore urge a change in the Austrian syllabus of biology towards an immanent evolutionary understanding in all grades instead of the common "natural history" approach. Good teachers have been doing so for long; but both scientific and pedagogical knowledge (van Dijk and Kattmann 2010; van Dijk and Reydon 2010) are crucial to appropriately cope with the difficulties of students' understanding of evolution and scientific theory in general. Extra-occupational courses combining evolution theory, "nature of science", and science didactics (cf. Rudolph and Stewart 1998) should be an obligatory standard in postgraduate science teacher education.

There is no explicit "science education" at Austrian schools: physics, chemistry and biology are taught as three independent subjects, mostly without any overlapping projects, except for extracurricular programs such as IMST (Krainer and Müller 2010). In 2006, the Programme for the International Student Assessment (PISA) surveyed the competencies in science of 15 year-old students in OECD and non-OECD member countries ($n = 59$). Based on the percentage of students at 7 levels of student proficiency in science, Austria ranked 19th with a mean of 551 (overall mean = 500).[9] To improve these competencies, we propose a concept change from merely subject-oriented lessons towards a comprehensive teaching of science as a unifying concept of physics, chemistry, and biology. Above all, teaching of the scientific method and theory in the sense of NOS (nature of science) is not stipulated in the Austrian curriculum. There is no systematic instruction on scientific theory and/or epistemology at all to be found in the Austrian secondary school curriculum below the 11th grade, and therefore also no institutional approach dealing with

[9] For a comparison, the United States ranked 36th with a mean of 489.

para- or pseudoscience. We finally agree with Martin (1994) that science education has to accept the challenge of paranormal and pseudoscientific claims and must not ignore them as unworthy. If science teachers critically evaluate the paranormal as well as pseudoscience, students may learn not just "to understand science but *to be scientific*, that is, to tend to think and act in a scientific manner in their daily lives" (Martin 1994).

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Appendix 1

The original questionnaire of the revised Paranormal Belief Scale by Tobacyk (2004).

R-PBS_01	The soul continues to exist though the body may die
R-PBS_02	Some individuals are able to levitate (lift) objects through mental forces
R-PBS_03	Black magic really exists
R-PBS_04	Black cats can bring bad luck
R-PBS_05	Your mind or soul can leave your body and travel (astral projection)
R-PBS_06	The Yeti (abominable snowman of Tibet) exists
R-PBS_07	Astrology is a way to accurately predict the future
R-PBS_08	There is a devil
R-PBS_09	Psychokinesis, the movement of objects through psychic powers, does exist
R-PBS_10	Witches do exist
R-PBS_11	If you break a mirror, you will have bad luck
R-PBS_12	During altered states, such as sleep or trances, the spirit can leave the body
R-PBS_13	The Loch Ness monster of Scotland exists
R-PBS_14	The horoscope accurately tells a person's future
R-PBS_15	I believe in God
R-PBS_16	A person's thoughts can influence the movement of a physical object
R-PBS_17	Through the use of formulas and incantations, it is possible to cast spells on persons
R-PBS_18	The number "13" is unlucky
R-PBS_19	Reincarnation does occur
R-PBS_20	There is life on other planets
R-PBS_21	Some psychics can accurately predict the future
R-PBS_22	There is a heaven and a hell
R-PBS_23	Mind reading is not possible
R-PBS_24	There are actual cases of witchcraft
R-PBS_25	It is possible to communicate with the dead
R-PBS_26	Some people have an unexplained ability to predict the future

Appendix 2

Principal component loadings for our 29 questionnaire statements, based on a sample size of 2,129 secondary school students. The highest correlations between single statements and principal component axes are given in bold. An asterisk shows the statements originally belonging to one subscale.

The principal components confirm the R-PBS subcales, except for statement 1 ("the soul continues to exist", originally supposed to belong to the subscale "traditional religious belief"), which showed a closer relationship to the subscale "spiritualism" in our sample, and for statement 23 ("mind reading is not possible"), which loaded more closely upon the subscale "precognition". Both the statements 25 ("it is possible to communicate with the dead") and 20 ("there is life on other planets") did not significantly load upon one of the seven principal components.

Principal component (PC) 1 (12% of variance) was equivalent to subscale "traditional religious belief". PC 2 (10.1% of variance) was equivalent to subscale "witchcraft", PC 3 (9.8% of var.) to subscale "precognition", PC 4 (8.5% of var.) to subscale "superstition", PC 5 (8.3% of var.) to subscale "Psi", PC 6 (8.3% of var.) to subscale "spiritualism", and PC 7 (5.7% of var.) to subscale "extraordinary life forms". Remarkably, all three statements on evolution cohered with PC 1: "ID" and "creationism" correlated positively with PC 1, and "naturalistic evolution" correlated negatively with PC 1.

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
R-PBS_01	0.48*	0.10	0.07	−0.03	0.06	**0.63**	0.03
R-PBS_02	0.03	0.22	0.20	0.08	**0.81***	0.16	0.08
R-PBS_03	0.08	**0.66***	0.16	0.17	0.30	0.15	0.06
R-PBS_04	0.15	0.14	0.10	**0.79***	0.08	0.04	0.02
R-PBS_05	0.09	0.25	0.09	0.13	0.27	**0.66***	0.00
R-PBS_06	0.02	0.16	0.13	0.13	0.07	0.05	**0.79***
R-PBS_07	0.13	−0.02	**0.63***	0.34	0.11	0.16	0.16
R-PBS_08	**0.59***	0.46	−0.23	0.14	−0.02	0.13	0.17
R-PBS_09	0.06	0.25	0.15	0.12	**0.78***	0.19	0.14
R-PBS_10	−0.03	**0.69***	0.19	0.11	0.14	0.16	0.23
R-PBS_11	0.12	0.15	0.14	**0.76***	0.06	0.14	0.08
R-PBS_12	0.05	0.28	0.08	0.17	0.19	**0.64***	0.06
R-PBS_13	0.05	0.19	0.14	0.13	0.15	0.01	**0.77***
R-PBS_14	0.11	0.00	**0.61***	0.41	0.16	0.06	0.15
R-PBS_15	**0.78***	−0.07	0.08	0.11	0.07	0.11	−0.06
R-PBS_16	0.08	0.23	0.23	0.13	**0.73***	0.20	0.09
R-PBS_17	0.17	**0.60***	0.18	0.29	0.25	0.16	0.08
R-PBS_18	0.10	0.12	0.12	**0.71***	0.11	0.02	0.12
R-PBS_19	0.03	0.10	0.36	0.06	0.12	**0.65***	0.09
R-PBS_20	−0.31	−0.01	0.02	−0.08	0.06	0.39	0.43*
R-PBS_21	0.10	0.35	**0.69***	0.19	0.15	0.15	0.09
R-PBS_22	**0.72***	0.22	−0.05	0.22	0.02	0.18	0.07
R-PBS_23	0.01	0.26	**0.60**	−0.05	0.10*	0.04	0.01
R-PBS_24	0.03	**0.66***	0.36	0.07	0.18	0.17	0.12

Appendix continued

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
R-PBS_25	0.09	0.45	0.40	0.02	0.21	0.35*	0.07
R-PBS_26	0.06	0.35	**0.63***	0.08	0.29	0.21	0.10
Evolution	**−0.57**	−0.03	−0.13	0.16	0.07	0.20	0.03
Creationism	**0.76**	−0.03	0.13	0.24	0.10	−0.01	0.00
ID	**0.78**	0.03	0.09	0.09	0.10	0.16	−0.02
Explained variance	12.03%	10.13%	9.78%	8.49%	8.35%	8.28%	5.72%

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