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UNDERSTANDING AND ACCEPTANCE OF EVOLUTIONARY THEORY AMONG TURKISH UNIVERSITY STUDENTS

TÜRK ÜNİVERSİTE ÖĞRENCİLERİ ARASINDA EVRİM TEORİSİNİ ANLAMA VE KABUL ETME

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ABSTRACT: Acceptance level of evolutionary theory and factors predicting it were examined among Psychology majors from Doğuş University and Bahçeşehir University ($N=99$). About half of the students accepted evolutionary theory, which is a higher percentage than in previous reports. Positive attitudes towards science and parents' education were positively correlated with acceptance whereas religiosity was negatively correlated. Understanding of evolutionary theory was surprisingly low. Understanding the theory and understanding the nature of science were unrelated to acceptance. Recommendations are made to improve the teaching of evolutionary theory.

Keywords: Accepting Evolution; Understanding Evolution; Science Education; Turkish Undergraduates

JEL Classification: I21; I29

ÖZET: Doğuş Üniversitesi ve Bahçeşehir Üniversitesi Psikoloji Bölümü öğrencileri ($N=99$) arasında evrim teorisini kabul etme düzeyi ve bunu belirleyen faktörler incelendi. Öğrencilerin yaklaşık yarısının evrim teorisini kabul ettiği bulundu. Bu oran önceki bulgulardan daha yüksektir. Bilime karşı olumlu tutuma sahip olmak ve anne-baba eğitim düzeyi kabul düzeyiyle pozitif korelasyon gösterirken dindarlık negatif korelasyon gösterdi. Evrim teorisini anlama düzeyi şaşırıcı derecede düşüktü. Teoriyi anlama ve bilimin doğasını anlamayla teoriyi kabul düzeyi korelasyon göstermedi. Bulgulardan hareketle evrim teorisi eğitiminde nasıl daha ileri gidilebileceği tartışıldı.

Anahtar kelimeler: Evrim Teorisini Kabul Etme; Evrim Teorisini Anlama; Bilim Eğitimi; Türk Üniversite Öğrencileri

1. Introduction

Evolutionary theory has a unique place in modern science. Although it is one of the most important scientific theories in terms of its explanatory scope and in terms of the diversity of evidence that supports it, it is also one of the least understood and least accepted aspects of modern science among general public. This dichotomy poses a challenge for science educators. Although no science education is complete without evolutionary theory, making students understand and accept the theory has proved to be a very difficult task. Identifying the factors that create resistance against understanding and accepting evolutionary theory is therefore important for science education.

Religiously motivated resistance against evolutionary theory has been present since its inception 150 years ago (Alters and Alters, 2001; Pigliucci, 2002; Scott, 2009). A recent article (Miller, Scott & Okamoto, 2006) shows that this state of affairs shows no signs of changing. In their study, Miller et al. compared the level of public acceptance of evolution among European countries, Japan and the United States of America. Respondents were asked whether they agreed with the statement “Human beings developed from earlier species of animals”. People in different countries showed varying degrees of acceptance, with United States coming near the bottom where only 40% of the responders said the above statement was true. The authors attributed the relatively low level of acceptance of evolutionary theory in the United States to fundamentalist religion and politicization of science in that country.

Fundamentalist religion, in the sense of strong adherence to the literal reading of religious texts, and politicization of science are widespread in Turkey as well (Çetinkaya, 2006; Peker, Cömert & Kence, 2010). In fact, Turkey was the country that showed the lowest level of acceptance of evolution in the study by Miller et al. (2006). Similarly, Deniz, Donnelly and Yılmaz (2008), Apaydın and Sürmeli (2009) and Peker et al. (2010) also report a disconcertingly low level of understanding and acceptance of evolution among Turkish pre-service biology teachers. Other recent studies (e.g., Nadelson, 2009, in the United States; McCrory & Murphy, 2009, in Northern Ireland; Asghar, Wiles & Alters, 2007, in Canada) demonstrate that from one-fifth to one-third of science teachers do not accept evolution and have limited understanding of it. Studies on high school and university students (e.g., Chinsamy & Plaganyi, 2007, in South Africa; Prinou, Halkia & Skordoulis, 2009, in Greece; and Aroua, Coquide & Abbes, 2009, in Tunisia) reveal similarly low levels of acceptance and understanding of evolution. Clearly, there is cause for concern for science educators.

1.1. Factors Influencing the Acceptance of Evolution

Miller et al. (2006) revealed several factors related to the acceptance level of evolutionary theory. One prominent factor, as mentioned above, was religiosity. More specifically, praying frequency and belief in divine intervention showed a strongly negative correlation with the acceptance of evolution in the United States. Monotheistic religions have a well-known narrative about the creation of life forms and of human beings and, when interpreted literally, this narrative contradicts some aspects of the theory of evolution regarding the origin and diversification of life in general and of humans in particular. However, religiosity by itself did not necessarily lead to the rejection of evolutionary theory. In European countries, for example, the above-mentioned correlation was not so strong. The authors attributed this inter-continental difference to the fact that there is an active religiously-motivated political movement resisting the teaching of evolutionary theory in the United States. In addition, fundamentalist interpretation of religion is less common in Europe than in United States. Thus, it appears that it is a particular interpretation of religion coupled with a particular social and political structure that leads to the rejection of evolutionary theory. Similar results on the relation between religiosity and acceptance of evolution have been reported by Lombrozo, Thanukos and Weisberg (2008), Trani (2004), and Chinsamy and Plaganyi (2007).

Level of education is another obvious candidate that might influence the acceptance of evolution. Generally, highly educated people are more prone to accepting evolution than less educated people (Miller et al., 2006). However, results on the

effect of having taken a course on evolution are mixed. Although Apaydın and Sürmeli (2009) in Turkey and Ladine (2009) in the United States found that a prior course on evolution increases acceptance among university students, Chinsamy and Plaganyi (2007) in South Africa found no such relation. In addition, Deniz et al. (2008) found that the education level of the parents is also positively correlated with the acceptance of evolution among university students.

Finally, some cognitive and motivational factors also play a role in the resistance against evolutionary theory. Bloom and Weisberg (2007) argue that it is a natural cognitive disposition for children to develop a teleological view of the world where everything exists for a purpose and is consciously created for that purpose. This disposition makes it difficult for children to see how natural selection as an unconscious process can produce the adaptive traits of living organisms. Similarly, Sinatra, Brem and Evans (2008) argue that essentialist thinking tendencies (that things, including living things, have unchangeable essences) fostered since childhood create resistance towards the evolutionary idea that species can turn into each other by the accumulation of small changes through millions of years. Deniz et al. (2008) found that disposition to open-minded thinking (being open to changing one's mind, taking into account different views, not dogmatically believing something, etc.) is positively correlated with the acceptance of evolution. Finally, Brem, Ranney and Schindel (2003) report that university graduates had emotional resistance to what they perceived as the negative implications of accepting evolution: atheism, justification of racism and selfishness, seeing life as meaningless and purposeless, and seeing free will as impossible, leaving no basis for traditional morality. Creationists and non-creationists were little different in terms of these perceptions.

1.2. Understanding Evolution, Understanding the Nature of Science, and their Relation to Acceptance

Some fundamental misunderstandings of the evolutionary process and the nature of evolutionary theory persist in high school and university students despite taking formal courses on evolution. That evolution is “just a theory”, not understanding that variation is essential for evolutionary change in a population, that it is individual organisms (rather than populations) that change over time in the evolutionary process, and that acquired characteristics can be inherited are among these misunderstandings (Dagher and BouJaoude, 2005). Concepts used differently in everyday language and in science, like “theory”, “fitness”, and “adaptation”, play a role in some of these misunderstandings.

It seems natural to think that increased understanding of evolutionary theory would lead to an increased acceptance of it. However, most studies show little or no correlation between the two (but see Deniz et al., 2008). Both Sinatra, Southerland, McConaughy and Demastes (2003) and Lombrozo et al. (2008) demonstrate that, although understanding evolution is not related to its acceptance among university students, understanding the nature of science *is* related to the acceptance of evolution. What is meant by the nature of science is the fundamental assumptions, methodology and the limits of science. Especially relevant to the acceptance of evolution was understanding that scientific theories cannot be definitively proved but are still more than mere guesses, that hypothesis testing is a complex process which requires more than one step and takes more than one form, and that there is no one single scientific methodology (Lombrozo et al., 2008). It is obviously an

essential educational goal to make students understand evolutionary theory. However, these findings suggest that, rather than teaching a specific body of knowledge, teaching directed towards creating a conceptual change in the students' understanding of science in general is more effective in bringing about acceptance of evolution.

1.3. The Present Study

There are few studies on the acceptance of evolutionary theory among university students in Turkey and those that exist mostly used Biology students and pre-service teachers as participants (e.g., Apaydın and Sürmeli, 2009; Deniz et al., 2008; Peker et al., 2010). The present study, in contrast, used Psychology students who do not take a special course on evolution but who are nevertheless expected to be knowledgeable about evolutionary theory as part of their major programme of study. The purpose of this study was to measure the level of understanding and acceptance of evolutionary theory and to investigate their relation to each other and to understanding the nature of science, to attitudes towards science, to rational thinking dispositions, and to several demographic and social variables such as religiosity, political orientation and level of parental education. In line with previous studies, we expected the level of acceptance of evolutionary theory to be positively correlated with understanding the nature of science but not with understanding evolutionary theory.

2. Method

2.1. Participants

Ninety nine first-year ($N=57$) and second-year ($N=42$) Psychology students (88 female, 11 male) participated from two universities in İstanbul, Dođuş University ($N=50$) and Bahçeşehir University ($N=49$). Students from Dođuş University received 1 course credit for their participation in a freshman and a sophomore course. Students' mean age was 21 (minimum 19, maximum 33).

2.2. Materials and Procedure

A questionnaire was used in the study. On the first page, there were demographic questions, a question about political view in a Likert-type scale which ranged from extreme right-wing (1) to extreme left-wing (10), and two questions about prior biology and evolution education.

The questionnaire contained four scales taken from Lombrozo et al. (2008) and translated into Turkish. Responses were indicated on a 5-point scale from "strongly disagree" to "strongly agree". The first scale was about understanding the nature of science (NOS). Participants were asked whether they agreed with statements such as "To be accepted, scientific theories must be supported by much evidence" and "Scientific investigations could not proceed without laboratory experiments". We used the first 10 statements on the themes of theory support, theory limits, theory testing, nonlinearity and theory construction because Lombrozo et al. had shown that these were the themes most predictive of acceptance of evolutionary theory. The second scale asked about attitudes towards science (Attitude) and contained five statements such as "I am generally more interested in science than my peers are" and "I think that science often has more negative repercussions for society than positive repercussions". The third scale was about the acceptance of evolution (Acceptance) and contained five statements such as "I believe that animals have changed over

time by a process of evolution” and “I believe that the theory of evolution by natural selection has many gaps and problems”. The fourth scale was about religiosity (Religiosity) and contained five statements such as “I believe in God” and “I do not think religion can or should make claims about the natural world”.

Next, the questionnaire contained the Turkish translation of the Conceptual Inventory of Natural Selection (CINS; Anderson, Fisher & Norman, 2002) to measure the participants’ understanding of evolutionary theory. CINS consists of 20 multiple-choice questions about the concepts of population growth, competition for resources, variation, mutation, selection, inheritance, and speciation. The questions are based on the results of actual scientific studies and use common misunderstandings as distractors. It has been shown to be fairly reliable and suitable to be used in non-biology majors (Nehm & Schonfeld, 2008).

Lastly, the questionnaire contained the Turkish translation of 13 items from the Master Rationality Motive scale (MRM; Stanovich, 2008). MRM measures the disposition to make rational decisions and the motive to act in accordance with reasons. It consists of statements such as “Intuition is the best guide in making decisions” and “I like to gather many different types of evidence before I decide what to do” with which the respondents are asked to indicate how much they agree (1: strongly disagree; 5: strongly agree).

Most participants filled the questionnaire in a classroom at the beginning of a class. Average time taken to fill the questionnaire was 25-30 minutes. Each participant answered the questions individually.

3. Results

3.1. Demographic and Educational Background

For 66 participants (67%), İstanbul was the city they inhabited for most of their lives. Mothers of 34 participants had elementary education or less, 50 had high school degree, and 15 had university degree or above. Fathers of 32 participants had elementary education or less, 34 had high school degree, and 32 had university degree or above. Eighty nine participants (90%) responded to the question on political view. The median response (from 1 to 10) was 6, which indicates a slightly left-wing orientation. If we divide the spectrum into right-wing (1-5) and left-wing (6-10), 32 participants fall on the right-wing side and 57 participants fall on the left-wing side. Ninety five participants had a biology course in high school and 51 participants had a biology course in university. Seventy six participants (77%) indicated that evolution was taught in these courses.

3.2. Acceptance of Evolution and its Relation to Other Variables

The Acceptance scale contained five Likert-type items. Each item was coded in such a way that “1” would indicate the lowest level of acceptance and “5” would indicate the highest level acceptance. Thus, a total score of 5 indicated the lowest possible acceptance level and a total score of 25 indicated the highest possible acceptance level. The mean overall acceptance score was 16.11 ($N=98$, $SD= 4.56$). The minimum score was 5 and the maximum score was 25. When the item “I believe that all species, including humans, have a common evolutionary origin” was specifically examined, it was seen that 47 participants (48%) agreed somewhat or completely

with this item, 25 participants disagreed somewhat or completely and 26 were undecided.

Parents' education had a significant influence on acceptance level. The mean acceptance levels for participants who had mothers with elementary, high school and university education was 14.32 ($SD=5.04$), 16.63 ($SD=3.88$), and 18.47 ($SD=4.24$), respectively. A one-way ANOVA yielded a significant result, $F(2, 95)=5.37, p<.05$. Similarly, the mean acceptance levels for participants who had fathers with elementary, high school and university education was 14.26 ($SD=5.51$), 16.76 ($SD=3.13$), and 17.44 ($SD=4.23$), respectively. A second one-way ANOVA again yielded a significant result, $F(2, 94)=4.61, p<.05$. Educational background in evolution, on the other hand, was not related to acceptance. Participants who were exposed to evolution in either high school or university did not accept evolution more than those who were not exposed to evolution, $t(93)=0.37, p>.05$. Similarly, neither gender nor city (İstanbul vs. other) was related to the level of acceptance.

The correlation between the scores on the Religiosity scale and acceptance was significant, $r=-0.43, p<.05$. Less religious participants accepted evolution more. The correlation between political view and acceptance was also significant, $r=0.53, p<.05$. Participants leaning towards left-wing political ideas accepted evolution more.

Another variable that was thought to affect the acceptance of evolution was attitude towards science. The correlation between the two was significant, $r=0.20, p<.05$. Participants who had a more positive attitude towards science accepted evolution more. Similarly, there was a significant correlation between acceptance and rationality as revealed by MRM, $r=0.24, p<.05$. Participants who reported that their behaviour was guided by reasons and who sought to make rational decisions tended to accept evolution.

The two central questions of the study were the relation of acceptance of evolution to understanding evolution and to understanding the nature of science. The level of understanding, as revealed by scores on CINS, was strikingly low. Out of a possible score of 20, the mean score was 5.98 ($SD=2.10$), the minimum score was 0, and the maximum score was 11. The correlation between acceptance and understanding of evolution was not significant, $r=-0.19, p>.05$. Given the very low variation in the understanding scores, this was not surprising. What was a little surprising was that the correlation between the two was negative. CINS scores were not significantly related to either positive attitudes towards science, $r=0.16, p>.05$, or to rationality scores on MRM, $r=0.19, p>.05$. Participants who were and were not exposed to evolution in either high school or university did not differ in terms of CINS scores, $t(94)=0.48, p>.05$.

Scores on NOS revealed a medium level of understanding of the nature of science. Mean score on NOS was 35.72 ($SD=3.29$) out of a possible score of 50. The correlation between acceptance and NOS was not significant, $r=0.07, p>.05$. This could again be because of the low level of variation in NOS scores. The correlation of NOS scores with CINS scores was not significant either, $r=0.01, p>.05$.

4. Discussion

The results reveal that acceptance level of evolutionary theory among our participants is higher than the acceptance level of the Turkish public in general as indicated by Miller et al. (2006) and the acceptance level of university students as indicated by Peker et al. (2010). In Miller et al., about half of the Turkish participants disagreed with the statement that humans were the product of evolution, whereas slightly more than one quarter agreed with the statement. In the present study, on the other hand, about half of the participants agreed with the statement and about one quarter disagreed with it. The main reason for this difference is probably the level of education of the participants in the two studies: Higher levels of education are associated with higher acceptance levels (e.g., Miller et al., 2006). In Peker et al., about 28% of the participants accepted evolution and about 21% rejected it. One possible reason for the difference in the level of acceptance between our study and Peker et al. is socioeconomic differences. For example, Peker et al. report that, among their participants, regular access to the Internet at home had a significant effect on the acceptance level of evolutionary theory. Although we did not directly measure it, we suspect that virtually all participants in our study have regular access to the Internet at home.

A surprising finding of the study is the very low level of understanding of evolutionary theory. Responses on the Conceptual Inventory of Natural Selection (CINS) revealed that participants did not understand how the process of natural selection works. Specifically, participants did not understand that there is competition for resources among organisms within a population and not everyone survives, that there is variation in the biological traits of the organisms, that this variation stems from mutations and recombination, that variation is genetically inherited from parents to offspring, that offspring with more adaptive traits reproduce more, that gene frequencies within a population change over generations because of differential reproductive success, and that two populations may become two different species if they remain separate for a long time without interbreeding (see Anderson et al., 2002). Although most participants were exposed to evolutionary theory in high school or university courses, it is clear that this exposure was not sufficient to bring about a conceptual understanding of the process of natural selection. In fact, there was no difference in terms of understanding level between those who did and those who did not take courses on evolution.

Two major findings of the study are that acceptance of evolution is not related to understanding it or to understanding the nature of science. The first finding seems to imply that participants who accept the theory do so without really understanding it. However, it should be noted that the Acceptance items and CINS are about two different aspects of evolutionary theory. Acceptance items measure whether the participants agree with the common descent of organisms, whereas CINS measures the level of understanding of natural selection, the main process whereby organisms diversify from common descent. Although the idea of the common descent of humans and other animals presents an emotional barrier for many people, it is not particularly difficult to understand what it entails. Natural selection, on the other hand, is conceptually much more challenging. Therefore, it is not really surprising that no relation is found between understanding and acceptance, especially given the very low level of understanding. Similar results have been reported by Sinatra et al. (2003) and Lombrozo et al. (2008).

Although understanding and acceptance of evolution are generally found to be unrelated, previous studies (e.g., Lombrozo et al., 2008) *did* find a relation between understanding the nature of science and acceptance of evolution. This is usually taken to mean that students who go beyond a simplistic conception of scientific method and who understand that direct mechanical causation (as in the physical sciences) is not the only legitimate kind of scientific explanation are more prone to accepting that evolutionary theory is a legitimate scientific theory (Dagher and BouJaoude, 2005). However, no relation was found in the present study between understanding the nature of science and acceptance of evolution. One possible reason for this lack of relation is the relatively low level of variation in NOS scores. Participants mostly tended to choose the “neither agree nor disagree” option on NOS. It is therefore difficult to conclude anything on the basis of these results about the participants’ understanding of the nature of science.

The present findings on other variables that were related to acceptance level are generally in parallel with previous studies. Like Deniz et al. (2008), we found that higher parental education level is associated with higher level of acceptance of evolutionary theory. Like Miller et al. (2006) and Lombrozo et al. (2008), we found that religiosity is negatively correlated with acceptance. Political ideas also have an effect on acceptance; according to the results, participants who are politically inclined towards the left are more likely to accept the theory. A similar result was obtained by Miller et al. (2006) where being politically liberal was positively correlated with the acceptance of evolution. Furthermore, positive attitude towards science had a positive effect on acceptance in the present study. Miller et al. (2006) also reported that belief in the promise of science and technology is positively correlated with the acceptance of evolutionary theory. Finally, participants who tended to make more rational decisions also tended to accept evolution more. Similarly, Deniz et al. (2008) report that open-mindedness is positively correlated with the acceptance of evolution.

4.1. Implications and Conclusion

What can be done to promote the understanding and acceptance of evolutionary theory in schools? Several recommendations can be made on the basis of available empirical evidence.

- The more general problem in education is failing to teach critical thinking skills. According to Pigliucci (2007), the American public not only rejects evolution but also believes in astrology, telepathy and other pseudoscience. Having gained critical thinking skills is a prerequisite for students to benefit from high level science courses (see also Alters & Nelson, 2002; Çetinkaya, 2006).
- A more specific problem is to teach the nature of science. Although we could not demonstrate it in the present study, several studies show that understanding the nature of science is correlated with understanding evolution (e.g., Lombrozo et al., 2008). Martin-Hansen (2007) goes further and shows that teaching the nature of science increases the level of understanding of evolutionary theory. Methodology, philosophy and history of science should be part of science education.
- An even more specific problem is that imparting technical knowledge about evolution is usually not sufficient to bring about understanding when students come to class with erroneous prior conceptions about evolution (Pigliucci,

2007). When these erroneous conceptions are made explicit and dealt with directly in class, understanding and acceptance of evolution is better promoted (Verhey, 2005; Robbins & Roy, 2007).

- An effective way to bring about conceptual change in students is to adopt active learning and the constructivist model of education (Nehm & Reilly, 2007; Nelson, 2008). For example, asking students to solve a problem in biology first with their erroneous conception and then with the correct conception increased students' conceptual understanding of evolution (Baumgartner & Duncan, 2009; see also Kampourakis & Zogza, 2009).
- Finally, since religion, at least its creationist version, seems to be a hindrance to accepting evolution, discussion of it should not be avoided in the classroom. For most creationist students, creationism is not simply a misconception but a broad worldview (Reiss, 2009; but see Williams, 2009). Therefore, we should not expect students to give up creationism as a result of taking one course. Instead, the aim should be more modest: Explaining to the students that the goal is not to change their religious beliefs but to make them understand how science works; that science has a different methodology and epistemology from religion but the two are not necessarily in conflict since science does not, and cannot, deal with the supernatural; and that how to reconcile their religious views with science in general and evolution in particular is a personal matter (Alters & Nelson, 2002; Anderson, 2007; Martin-Hansen, 2007; Nelson, 2008).

Understanding *and* accepting modern science is indispensable for individuals in a modern society because acceptance affects both personal decisions and decisions about public policy regarding scientific/technological issues. Since evolutionary theory is one of the least understood and accepted aspects of modern science, every effort should be made by science educators to teach it better both in and out of school settings.

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