

Does the knowledge of Synthetic Biology affect its acceptance?

Friederike Koepp

Department of Psychology, University of Heidelberg

Abstract

This empirical study examines the relationship between knowledge and acceptance of Synthetic Biology as well as its public perception. Participants were randomly selected and divided into three experimental groups to get different qualitative knowledge of Synthetic Biology. Afterwards they had to fill in the SynBio-Questionnaire to measure their acceptance toward Synthetic Biology. The results indicate that knowledge has no influence in forming people's attitude of Synthetic Biology. We found a significant effect of sex that indicates that male participants with theoretical and practical knowledge show more acceptance than female participants in the same condition. The perception of Synthetic Biology was all over skeptical. Furthermore we found that participants with theoretical knowledge showed significantly more risk perception than other participants.

Introduction

Synthetic biology is a constantly growing field of science which was gaining more and more scientific impact during the last years. Some supporters actually compared the influence the Synthetic Biology could possibly have with the influence of the IT revolution in the early '90s. In these years, constructing an electronic calculating machine was just a vision of a few scientists. Today almost every person has at least one computer (often more) for the daily use. On the other hand there have been lots of new scientific developments that have been decelerated as the scientific future without ever achieving this claim. So what is it, which makes a new development becoming a revolution?

The answer is as easy as difficult to achieve: One of the main conditions for a new development gaining fundamental influence is its public acceptance. Without public

acceptance a new development will never become commercial and forever stay in the laboratories of the scientists, without ever influencing people's life's.

But what is it that forms public opinion and especially an opinion in favor for a new development like Synthetic Biology? According to findings of Evans and Duran, there is a positive relationship between formal scientific knowledge and attitude toward science [1]. This goes along, that just a knowledgeable citizenry is able of truly democratic decision making [2] and in contrast a lack of knowledge decreases people's ability to understand and debate on scientific developments [3]. Considering biotechnology and genetic engineering M. Siegerist indicates that there is a complex causal model, explaining the acceptance and perception of gene technology [4]. According to Siegerist, not only the knowledge of a topic is important to form people's opinion, also its expected benefits and risks. Other authors indicate that there are two different kind of knowledge to consider: general scientific knowledge and specific knowledge relating to the specific topic, which both influence people's opinion [5]. Also important for forming the public attitude is not only the scientific knowledge itself, but also the consideration of social and ethical issues [6]. Altogether these findings suggest that knowledge is a very important factor in the development of public attitude. Within knowledge should be considered in its various aspects and as a determining factor of scientific success.

There have been a few attempts by past iGEM teams to analyze the relationship between knowledge of Synthetic Biology and its acceptance [7], [8]. Unfortunately these attempts show a lack of methodical correctness and with this a decreased explanatory power. None of these teams tried neither to manipulate the level of knowledge empirically nor measures the acceptance in a correct manner.

The first objective of this study was to prove empirically the connection between knowledge of Synthetic Biology and its acceptance. We supposed a positive correlation between this two constructs: The more funded knowledge people have about Synthetic Biology, the more positive attitudes they will develop referring this field of science. To measure this knowledge-acceptance correlation we decided to manipulate people's knowledge referring Synthetic Biology (no knowledge vs. theoretical knowledge vs. theoretical and practical knowledge) and measure the acceptance afterwards.

Part of the professional examination was the use of a reliable instrument to measure people's acceptance. Because there haven't been constructed such a tool in the past by scientists or past iGEM teams we decided to construct a special questionnaire to measure the acceptance of Synthetic Biology as well (SynBio-Questionnaire; for more information take a look at: F. Koeppel: How to measure people's acceptance of Synthetic Biology.).

A second objective was to get an impression of people's perception toward Synthetic Biology and the applications of Synthetic Biology they accept. We were interested in how this perception differs considering the different levels of knowledge. To measure people's perception and the accepted applications we formulated four additional questions and added them to the questionnaire.

Patients and Methods

Participants

The psychological study took place on the 18th of September 2010 at the BioQuant-institute in Heidelberg, Germany. The study started around 2 pm and lasted 3 hours until 5 pm.

The participants were recruited via a notice posted on campus and public offices, via an advertisement on a local newspaper and the local newspaper website and via personal contact. All participants received 32.65 \$ (25 €) for their participation.

Altogether 71 participants took part (40 female (56%), 31 male (44%)). The mean age was 28.27 (SD: 10.75). The mean education level was relatively high (1 without graduation (1%), 9 General Certificate of Secondary Education (13%) 37 general qualification for university entrance (52%), 22 graduate degree (31%) and 2 without declaration of education). Considering the employment, we had a majority of students (5 pupils (7%), 40 students (56%), 11 employees (16%), 1 self-employed (1%), 3 unemployed (4%), 9 others (13%) and 2 without declaration of employment). Referring the religion, 37 persons declared themselves as religious (52%), with 18 catholic (25%), 15 protestant (21%), 2 others (3%), 2 without declaration of confession, 24 as not religious (34%), 8 as agnostic (11%) and 2 made no declaration of religion.

Comparison groups

To prove if knowledge really influences the attitude toward Synthetic Biology we had to manipulate the participant's knowledge. For this we divided them randomly into three groups, which received different type of knowledge:

- a) No knowledge: the first group got just one DIN A4 paper with the most important information about Synthetic Biology. The information was arranged as notes and tried to keep neutral.
- b) Theoretical knowledge: the second group heard a 20 minute lasting oral report about synthetic biology. The report consists of the same information like the first group got but was more detailed and with much more examples. As in the first group the information didn't include any judgment.
- c) Theoretical and practical knowledge: the last group heard the same report like the second group did. Additional they watched a short movie about the daily routine in a laboratory. The movie was commented by a member of our team, who tried as well to keep his speak neutral. Beside of this the participants of the third group could view and touch some materials out of a laboratory like pipettes or a PCR-machine.

As you can see in Table 1 the three groups didn't differ significantly in sex, age, education, employment or religion. All speeches (entrance speech, instruction, and oral report) were held by the same person, a philosopher who was the most neutral person referring Synthetic Biology in our team. Only the comment of the movie in the third group was held by a biologist, who could explain these practical processes better.

Measurement

To measure the acceptance of Synthetic Biology we used the SynBio-Questionnaire. The questionnaire consists of 22 items to measure people's attitude toward Synthetic Biology and five items for descriptive statistics (sex, age, education, employment, religion). In a previous study this questionnaire was proved as reliable. For the group comparisons we estimated the mean of acceptance per group.

To measure people's perception of Synthetic Biology and their acceptance of different areas of application we added four complex questions to the questionnaire. Each question was formulated as an open sentence with different opportunities to

complete it. Participants were asked to decide, which answers (multiple answers were possible) completed the question the best.

| | | Sex | Age | Education | Employment | Religion | Confession |
|---|----|------|-------|-----------|------------|----------|------------|
| UV 1 | N | 20 | 20 | 20 | 20 | 20 | 18 |
| | M | 1,45 | 28,50 | 4,05 | 3,85 | 1,55 | 0,83 |
| | SD | 0,51 | 11,41 | 0,96 | 1,76 | 0,69 | 0,92 |
| UV 2 | N | 23 | 23 | 23 | 23 | 23 | 22 |
| | M | 1,74 | 31,65 | 4,17 | 4,09 | 1,61 | 0,64 |
| | SD | 0,45 | 11,73 | 0,65 | 1,83 | 0,66 | 0,79 |
| UV 3 | N | 26 | 26 | 26 | 26 | 26 | 26 |
| | M | 1,54 | 26,31 | 4,19 | 4,19 | 1,58 | 1,00 |
| | SD | 0,51 | 8,97 | 0,69 | 1,60 | 0,76 | 1,06 |
| Sign. ($\alpha = 0.05$) | | 0,13 | 0,20 | 0,82 | 0,83 | 0,79 | 0,62 |

Table 1: Randomization of participants

*** Legend

N = number of participants

M = mean

SD = standard deviation

Sign. ($\alpha = 0,05$) = level of significance. Significance below 0.05 indicates that the groups differ significantly from each other.

Sex: 1=male; 2=female

Education: 1=without graduation; 2+ 3=general certification of secondary school; 4=general qualification for university entrance; 5=graduate degree

Employment: 1=self-employed; 2=public servant; 3=employer; 4=student; 5=pupil; 6=unemployed; 7=other employment

Religion: 1=religious; 2=not religious; 3=agnostic

Confession: 0=not religious/agnostic; 1=catholic; 2=protestant; 3=orthodox; 4=other confession

Additional to these two parts of the questionnaire we added eight items for the validation of the SynBio-Questionnaire. These items are not important for the present study (for details take a look at: F.Koeppe: How to measure people's acceptance of Synthetic Biology.)

For the measurement of people's knowledge we created two short additional questionnaires: The first should measure their knowledge before the experimental manipulation and consists of seven questions referring their knowledge of Synthetic Biology, genetic engineering, genetics and biology en general. The second

questionnaire consists only of three questions and was added to the SynBio-Questionnaire to measure people's knowledge after the experimental manipulation. To summarize the procedure of the study: the participants were asked to fill in the questions about their knowledge of Synthetic Biology first (SynBio-Questionnaire-A). Then they got different kind of information about Synthetic Biology (manipulation). Afterwards they had to fill in a second questionnaire (SynBio-Questionnaire-B) with a second declaration of their knowledge, the items referring the acceptance, the items referring the perception of Synthetic Biology and the validation items.

For the statistical analysis we used the statistic program SPSS. To estimate the effects we used to different statistical test:

- a) Analysis of Variance (ANOVA): this test is usable for interval scaled data (e.g. the items for measuring the acceptance). In a comparison of more than two groups it measures if there is a significant difference between at least two groups.
- b) Chi²-test: we used this test for data, which was not interval scaled (e.g. the items to measure the perception and application of synthetic biology). It measures if the expected frequency of a value differs significant from its real frequency.

The interval scale refers to the complexity of the data. Data with interval scale have normally more than two opportunities to response (not just yes/no).and so they got a higher explanatory power.

Results

Acceptance

First step of analysis was to prove the knowledge of the participants before the manipulation: We found no significant difference. This means that every group started at the same level of knowledge. Afterwards we tested the self-reported learning gains of the participants after their manipulation: The results show a significant effect of different learning gain between the first group and the other two groups. There were no effect found between the second and the third group what might indicate that the practical part didn't taught the participants so much new information.

As a second step we analyzed the relationship between the quality of different knowledge and the acceptance of the persons with the help of the Analysis of Variance (ANOVA). We found no significant difference between the experimental condition (belonging to different groups) and peoples attitude toward Synthetic Biology. Table 2 shows the significance of all multiple group comparisons. Only a significance lower than 0.05 indicates that there is a significant difference between two groups referring their acceptance. Figure 1 shows also a graphical demonstration of the mean acceptance considering the three experimental conditions. This disproves our hypothesis, that more funded knowledge raises the acceptance of Synthetic Biology.

Multiple comparisons

Acceptance SynBio

LSD

| (I) experimental condition | (J) experimental condition | Mean difference (I-J) | Standard deviation | Significance | 95%- confidence interval | |
|----------------------------|----------------------------|-----------------------|--------------------|--------------|--------------------------|-------------|
| | | | | | lower limit | upper limit |
| no knowledge | theoretical knowledge | 2,783 | 4,663 | ,553 | -6,52 | 12,09 |
| | practical knowledge | ,385 | 4,529 | ,933 | -8,65 | 9,42 |
| theoretical knowledge | no knowledge | -2,783 | 4,663 | ,553 | -12,09 | 6,52 |
| | practical knowledge | -2,398 | 4,475 | ,594 | -11,33 | 6,53 |
| practical knowledge | no knowledge | -,385 | 4,529 | ,933 | -9,42 | 8,65 |
| | theoretical knowledge | 2,398 | 4,475 | ,594 | -6,53 | 11,33 |

Table 2: Comparison of experimental conditions referring their acceptance of synthetic biology

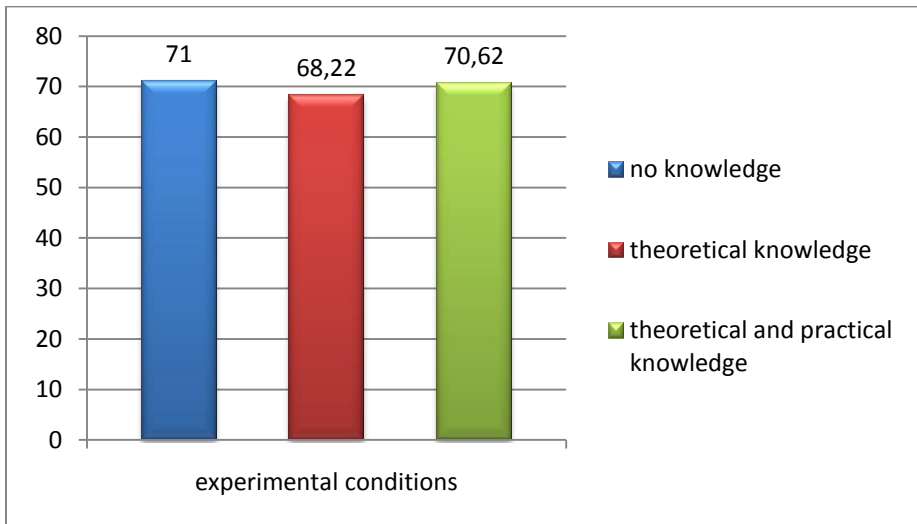


Figure 1: Mean acceptance of synthetic biology considering all experimental conditions

The third step in analyzing our data was to prove the relationship between the descriptive variables (sex, age, education, employment, religion) and acceptance. We found no significant difference between the three experimental groups referring age, education, employment and religion. But we found a significant effect between the groups referring sex (figure 2): as demonstrates especially male participants of the third group showed significantly more acceptance than female participants of the same group. This might indicate that men are more affected by practical knowledge and demonstrations than female.

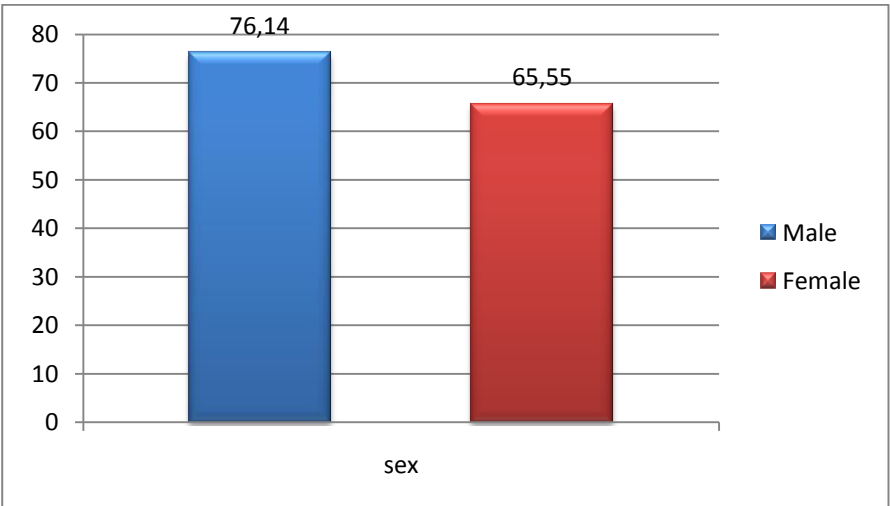


Figure 2: Mean acceptance of synthetic biology over all groups considering the significant sex difference

Perception and application

To get information about how the public perception of Synthetic Biology is and if this perception differs between the three experimental groups the participants had to answer four complex questions:

“Synthetic Biology is ...”

We found no group differences referring this question. Over all groups the most frequently filled in answers were:

- „... the genetically manipulation of a natural organism“ (63%)
- „... the inserting of foreign genes to another organism” (79%)

“In difference to genetic engineering, synthetic biology is ...”

We found a significant group difference referring this question.

- Significant more participants without knowledge (group 1) completed the sentence with “... applying principles of engineering”.
- Significant more participants with theoretical knowledge (group 2) completed the sentence with “...using other laboratory techniques, which can modify an organism more than the classical laboratory techniques could” and “... using very new and unproved laboratory techniques”.

This results show that people with theoretical knowledge have more risk perception than people with basic knowledge or theoretical and practical knowledge.

“The systematic genetically manipulation of creatures is justifiable referring the following applications: ...”

We found no difference in accepting different applications referring to different experimental groups but we found some applications that have been accepted highly over all experimental conditions:

- “Medicine” (83%)
- “Protection of environment” (65%)
- “Energy” (80%)

Figure 3 overviews public accepted of referring different fields of application.

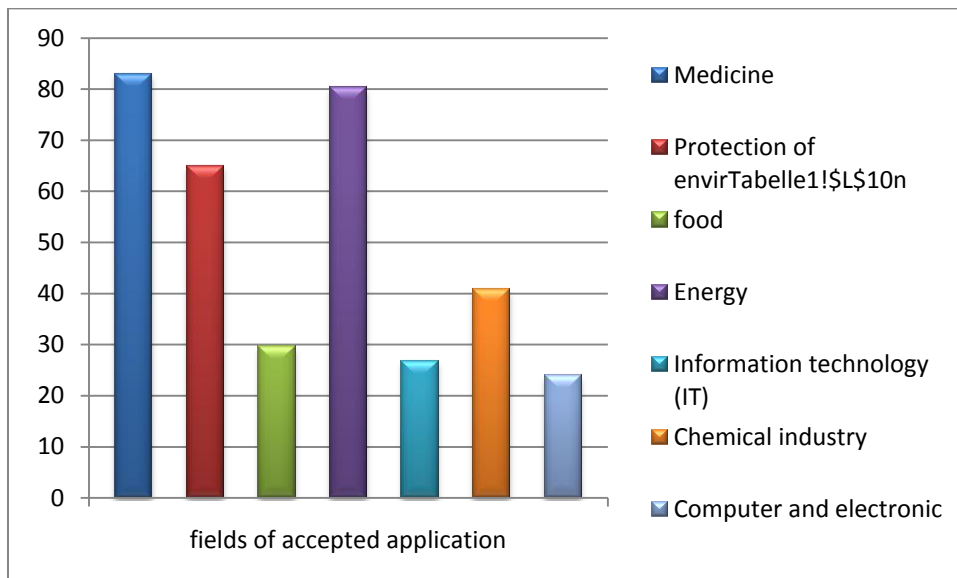


Figure 3: Public acceptance of applications in %

Furthermore we found an effect, that men think significantly more than women, that IT is an acceptable application.

Additional we could prove that, the more someone is in favor for synthetic biology, the more fields of application this person accepts. This effect was highly significant. „I could accept Synthetic Biology better, if ...”.

We also found no group differences referring this question. The most eye-catching effect was that over all groups the less frequently filled in answer was:

- “It doesn’t have to change anything.” (22%).

This indicates a high skepticism and mistrust toward synthetic biology over all groups.

Discussion

The first objective of our empirical study was to prove the relationship between knowledge of Synthetic Biology and its acceptance. We suggested that the more funded knowledge a person has about Synthetic Biology the more this person will form his or her opinion in favor for this field of science. To manipulate the level of knowledge we divided our 71 participants into three groups. The first group got just a basic knowledge of Synthetic Biology, the second group got funded theoretical knowledge and the third group got theoretical and practical knowledge. All three groups were randomized according their level of knowledge before the intervention,

their sex, age, education, employment and religion. After informing the participants we used the SynBio-Questionnaire, a reliable instrument, to measure their acceptance of Synthetic Biology. We found no significant difference between people with basic knowledge, people with funded theoretical knowledge and people with theoretical and practical knowledge referring their acceptance of Synthetic Biology. But we found an effect of sex, especially in the third group: male participants accepted synthetic biology significantly more than female participants.

The fact that we could not find a correlation between knowledge and acceptance could have different reasons:

- a) Knowledge is actually not important for forming people's acceptance.
- b) We could not find an effect because our sample was too small. Just 71 participants took part in our study but referring to previous calculations we needed a sample of at least 77 test-persons to get an obvious effect.
- c) Our operationalization of manipulating people's knowledge was inadequate. Maybe the participants needed more time to form their opinion after getting information about Synthetic Biology or the third group needed more than a movie to get an impression of daily laboratory practice.

Another point to consider in future research is a better operationalization of the religion. In the present study we just asked our participants if they are religious and if yes, which confession they belong to. Future researchers should also focus on the intensity of practiced religion.

The second objective of this study was to get an impression of people's perspective of Synthetic Biology referring the different level of knowledge.

Over all groups Synthetic Biology was seen as "genetically manipulation of a natural organism" and "the inserting of foreign genes to another organism". We found that people with theoretical knowledge have more risk perception compared to people with just basic knowledge and people with fully theoretical and practical knowledge. Considering the application of Synthetic Biology the most accepted fields were medicine, protection of environment and energy. Furthermore we could significantly prove that the more a person accepts Synthetic Biology, the more fields of application are accepted as well. Referring the question: "I could accept synthetic biology better, if ..." the most important result was that over all groups just 22% of participants elected the answer "It doesn't have to change anything.". This represents a high mistrust referring the status quo of developments in Synthetic Biology.

References

- [1] Durant, J., Evans, G., Thomas, G.: Public understanding of science in Britain: the role of medicine in the popular representation of science. *Public Understanding of Science* 1992; 1, 82-161.
- [2] Evans, G., Durant, J.: The relationship between knowledge and attitudes in the public understanding of science in Britain. *Public Understanding of Science* 1992; 4, 57-74.
- [3] Doble, J.: Public opinion about issues characterized by technological complexity and scientific uncertainty. *Public Understanding of Science* 1995; 4, 95-118.
- [4] Siegrist, M.: A Causal Model Explaining the Perception and Acceptance of Gene Technology. *Journal of Applied Social Psychology* 1999; 29 (10). 2093-2106.
- [5] Sturgis, P., Cooper H., Fife-Schaw C.: Attitude to biotechnology: estimating the opinions of a better-informed public. *New Genetics and Society* 2005; 24 (1), 31-57.
- [6] Bal, S., Keskin Samanci, N, Bozkurt, O.: University Students' Knowledge and Attitude about Genetic Engineering. *Eurasia Journal of Mathematics, Science and Technology Education* 2007; 3 (2), 119-126.
- [7] Human Practice, Team Edinburg 2009:
[http://2009.igem.org/Team:Edinburgh/ethics\(publicperception\)](http://2009.igem.org/Team:Edinburgh/ethics(publicperception))
- [8] Human Practice, Team Valencia2009:
<http://2009.igem.org/Team:Valencia/Human/Survey>