Measuring the Acceptance of Synthetic Biology - The SynBio-Questionnaire

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Abstract

The *SynBio-Questionnaire* was constructed to measure people's attitude toward synthetic biology and was verified in two separate studies. In the first study with 130 test-subjects we proved the reliability and the item characteristics of the questionnaire. On the base of this analysis we revised the questionnaire and tested the second version in a following study with 71 participants.
The results show, that the *SynBio-Questionnaire* is a reliable, objective and economic questionnaire. Furthermore it was validated referring its discriminant validity.
The finished instrument consists of 22 items measuring people's attitude toward Synthetic Biology.

Introduction

Synthetic Biology is a raising scientific field with an enormous potential for the future. Like for every new invention not only the scientific progress is important for its future development, also the public perception is essential. From this follows that measuring public perception and attitude toward Synthetic Biology is an important aspect of scientific research. But how can we measure people's acceptance toward Synthetic Biology?
The literature research indicates that there have not been constructed questionnaires or scientific tests referring the acceptance of Synthetic Biology in the past. There have been some attempts of past iGEM teams to create questionnaires [1] [2] [3] [4] which are able to measure the public acceptance of Synthetic Biology. Unfortunately these questionnaires were unprofessional constructed and have a lot of failures.
For example, none of these groups wrote about how they constructed the questionnaire. The reader has no information about if they used a specific

construction principle or which principle they exactly used. Furthermore none of the groups estimated statistical values which describe the worth of a questionnaire. Such statistical values for example are objectivity, reliability and validity. Just one group (team Heidelberg 2008) wrote about their theoretical base for constructing the questions of the questionnaire. The other groups didn't mention their sources. Another critic is that one team (team Valencia 2009) used pictures aside their questions, which might have influenced the test-subjects in their response. In psychometrics this influence is known as a confounding variable.

These were just a few critical examples of the questionnaires constructed by the past teams and should only demonstrate the absence of methodical correctness and the decreasing explanatory power of their constructions.

In contrast, our objective was to construct the present questionnaire methodically correct, using a common construction principle and considering every step that has to be passed through during the process of constructing a questionnaire. With this we hope to raise the professional standard of further test construction in a field like iGEM enormously.

Construction of a questionnaire

Because of the theoretical impact of our construct, the attitude of people toward Synthetic Biology, we decided to use the rational construction principle for constructing our questionnaire. The rational construction principle is quiet common in empirical and especially psychometrical test construction. The main idea is that people differ from each other referring different constructs like intelligent, creativity or their attitude toward something. These constructs can be theoretically defined, specialized and differentiated into each other. From the definition of the construct we can derive different pattern of behavior, feeling and thinking which can be used as indicators for the construct. These patterns of behavior are the base of formulating test questions (in the following called "items") and therewith measuring the construct.

The rational construction principle includes different steps that have been passed through:

1. Defining the construct

   The first step is to define, specialize and characterize the construct that has to be measured. Important is to define what the construct exactly means, its differentiation to other constructs and what kind of behavior could be indicating.

Because of the theoretical standard of the rational construction principle, the most important base for the defining is the literature research. Besides of that other methods like cluster of associations could be used as well.

2. Developing an Itempool

   After defining the construct and its typical behavior, test items should be developed. For the following selection it is important to create more items than necessary (we had about 150 items and needed just 40), referring to various indicating behavior.

3. Creation of the test-preversion

   The Itempool is the base for selecting the Items for the perversion. Creating a first preversion (before creating the endversion) is important because of the opportunity to revise the test after a first analysis. After discussing each item respectively to its theoretical importance, formulation and similarity to other items, only the best items should be selected. The amount of chosen items differs along various questionnaires. We chose 40 items.

4. Data collection 1

   After finishing the first version of the test it should be distributed and filled in by some test-subjects. The data can be used for the following analysis and selection of the items.

5. Analysis of the items

   The statistical analysis of the test-preversion includes:

   a) Analysis of reliability of the constructed test (α): Reliability is an important criterion for the wealth of a questionnaire. It shows if the test measures its construct adequate (independently if this construct is meant to be measured, see validation (step 7)). Range of values: 0-1(with 0=bad reliability and 1=perfect reliability). The reliability is mostly estimated by measuring the internal consistency of a test (correlation of each item with another).

   b) Analysis of standard deviation for each item (SD): In which extend have different people made different responses to the same item. Range of values depends on the range of the item values (the higher the standard deviation, the more variance do we have in the responses between different test-subjects).

   c) Analysis of difficulty for each item (P): How many people have responded to the item according to a high construct meaning? Range of values: 0-1 (with 0=very heavy item (nobody has responded to the item according to a high

construct meaning) and 1=very easy item (everybody has responded to the item according to a high construct meaning)).

For example: if the construct meaning is: acceptance of Synthetic Biology; the item is: "Synthetic Biology has more advantages than disadvantages"; referring this item just 20% of the participants answered "yes", than this item is a very heavy item.

d) Analysis of discriminability for each item (r_{it}): How representative is the item for the whole test? Range of values: 0-1 (with 0=no representativeness at all and 1=perfect representativeness).

Furthermore other statistical values can be analyzed like the descriptive statistics (e.g. number of participants, sex, age, education, employment).

5. Selection of the items and creation of the test-endform

Based on the analysis of the test-preversion we can now select the items for the endversion. Which items are selected do not only depend on the statistical analysis but also on theoretical impacts like theoretical fitting of the item or personal preferences. Statistically there are some rules of thumb to consider:

a) Standard deviation (SD): Eliminate the items with a standard deviation about 0.
b) Difficulty (P): Choose a wide range of difficulty indices. Most Items should have a difficulty of about P≈0.50, just a few should have extreme indices like P>0.80 and P<0.20.
c) Discriminability (r): Choose only items with high discriminability.

6. Data collection 2

The latest version of the questionnaire will be filled in again by some test-subjects. The data will be the base for another analysis, to prove the quality of the questionnaire and to ensure that the item selection in the last step had course some methodical improvements.

7. Experimental validation

Validation is another important criterion for the wealth of a new test. It shows if the constructed questionnaire really measures what it is meant to measure. If there is no validation, the test could only be used with insecurity referring its construct. The principle of validation is to think about other constructs which are a) theoretically near to the construct measured by the main questionnaire (convergent validity) and b) have nothing to do with the construct measured by the main questionnaire (discriminant validity). After collecting Data for the validation constructs as well

(normally this goes along with the data collection 2), scientists can estimate the correlation between the construct of the main test and the validation constructs. If the validation works, there is a high positive correlation expected for a) and a zero correlation expected for b).

For profit test construction and publication of the constructed questionnaire, three other steps have to be passed through (in a collegiate environment like iGEM these steps are not necessary):

8. Standardization of the test-endform
9. Data collection 3 (sample of standardization)
10. Publication of the results

Method

The Base of constructing this questionnaire for measuring people's attitude toward Synthetic Biology (*SynBio-Questionnaire*) was an Itempool generated by student members of the iGEM team Heidelberg 2010. After defining the theoretical construct of "the attitude to something" and especially for our questionnaire "the attitude to Synthetic Biology", we identified different pattern of indicating behavior and aspects of the construct (like: the knowledge of Synthetic Biology, perceived risk and consequences, perceived benefits, practical experience, attitude toward related topics like genetic engineering, need of action, and much more). Defining the construct based on the literature research [5], [6] and an association cloud made by our team members. After defining the construct, every person of the team created as much items as possible to measure people's attitude toward Synthetic Biology. Out of these items we created our itempool. We discussed every item and chose the best 40 to be part of the test-preverson. Before finishing the perversion we proved that every relevant aspect of the construct was represented und that half of the items were positive formulated and half of them negative (this ensures that the participants can't go through the items without reading them). Afterwards the perversion was tested in the first study.

Study 1

Participants

Base of the survey were 130 randomly selected participants who filled in the questionnaire online.The online-version of the test was availably for 10 days; the link to the page was distributed by the members of our team to their friends and families, in online-forums and over university mailing lists. Before filling in the questionnaire, the participants had to read a short and neutral introduction of synthetic biology to ensure that every participant have already heard of Synthetic Biology and knows what it means.

Measure

We proved the descriptive statistics, the reliability and the attributes of the items (standard deviation, difficulty, discriminability). For this we used the statistical program SPSS. The analysis should be the base for selecting those items of the perversion, which could measure our construct the best.

Results 1

Descriptive statistics

Altogether 130 test-subjects (63 female (49%), 56 male (43%), 1 no declaration of sex) filled in the questionnaire. The mean age was 24.67 (SD: 7.60). The education level was relatively high (15 without graduation (12%), 4 examined advanced training (3%), 67 general qualification for university entrance (52%), 39 graduate degree (30%), 4 others (4%), 1 without declaration of education). Considering the employment, $^{2}/_{3}$ of our test subjects were students (14 pupils (11%), 3 during advanced training (2%), 76 students (59%), 23 employees (18%), 2 self-employed (2%), 5 unemployed (4%), 7 others (5%)).

First estimation of reliability

The first estimation of reliability shows a result of α=.93. This is a really high value for reliability and indicates that our questionnaire measures its construct quiet good.

Item analysis

As a last step we analyzed the attributes of the items like standard deviation, difficulty and discriminability. We eliminated those items which had a standard deviation around 0 and a low discriminability. The difficulty of most of the items should be about P=0.50, additional to some items with extremely high (P<0.20) and extremely low (P>0.80) indices. In the end we eliminated 20 items and kept 20 items for the test-endversion. Because of the majority of easy items we found in our analysis, we invented also two new, relatively heavy items and added them to the questionnaire. The test-endversion now consists of 22 Items to measure people's attitude toward Synthetic Biology. You can find the complete item characteristics of the preversion in the appendix.

Study 2

Participants

Base for the second study were a sample of 71 test-subjects. The subjects took part in a psychological study (see: F.Koeppe: Does the knowledge of Synthetic Biology effects its acceptance.) and in the scope of this project they filled in the questionnaire. The test-subjects were randomly selected and took not part in our first study.

Measure

The Results of the first study led us to overhaul the questionnaire. The new formulated test-endversion consists of 22 items to measure the attitude toward Synthetic Biology. This first part of the questionnaire was already proved in the first study. In addition to that we added four complex Items to measure the perception and application of Synthetic Biology (part 2) and one construct to prove the validation of Synthetic Biology (part 3). The validation construct was taken from the NEO-FFI, a famous personality questionnaire. From this questionnaire we took the scale "openness", which measures openness for other values and opinions. We expected a high positive correlation between our construct and the construct "openness".

The aim of the second study was the further examination of the item characteristics (had our selection course some improvements) and the validation. Furthermore we

hoped to get some information about the public perspective of Synthetic Biology and their application (this aspect is not part of the construction process; for results please look at: F.Koeppe: Does the knowledge of Synthetic Biology effects its acceptance).

Results 2

Descriptive statistics

We had 71 test-subjects (40 female (56%), 31 male (44%)) who filled in the questionnaire. The mean age was 28.27 (SD: 10.75). The mean education level was again 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). In view of the employment, we had a majority of Students (5 pupils (7%), 40 students (53%), 11 employees (1%), 1 self-employed (1%), 3 unemployed (4%), 9 others (13%) and 2 without declaration of employment). Referring the religion, 37 persons decelerated themselves as religious (52%) (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 without declaration. of religion

Reliability

In comparison to the first study the estimation of the reliability doesn't changed much. We still have a very high reliability of α=.93, which indicates that our construct is measured very well.

Item analysis

Allover we received good indices for discriminability and standard deviation. From the 22 items none had a standard deviation lower than 0.90. This indicates an overall high variance of people's responses. Considering all items only 2 items had a low discriminability of $r<0.30$. The majority of the items had a high discriminability of $r>0.50$. This suggests that almost every item is representative for the whole test. You can find the complete item characteristics of the endversion in the appendix.

Validation

As shown in figure 1 the correlation between the construct of the questionnaire (acceptance of Synthetic Biology) and the validation construct (openness) was r=0.085. This is just a light, not significant positive correlation witch disproves our hypothesis that there is a strong positive connection between a positive attitude toward Synthetic Biology and openness for other values. The results could have different explanations:

a) Openness has nothing to do with acceptance of Synthetic Biology and therefore is a construct of discriminant validity.
b) There is no significant positive correlation because the scale “openness” is not reliable (r=0.53). This indicates that the scale “openness” from the NEO-FFI couldn’t measure openness for values itself.

Correlation (2-sided)

		Validation	Acceptance
Validation	Correlation (Pearson)	1	,085
	Significance (2-seitig)		,483
	N	70	70
Acceptance	Correlation (Pearson)	,085	1
	Significance (2-seitig)	,483	
	N	70	71

Figure 1: Correlation between acceptance of synthetic biology and openess

Objectivity

A further important criterion for a psychological test is objectivity, which measures if the results of a test are independent from the person responsible for the execution of the test, from the person responsible for the analysis of the test and from the person responsible for the interpretation of the test. Our test is a questionnaire and with this a fixed form to be filled in by the participants (that means independent from the person responsible for the execution). Furthermore the analysis of the test is 100%

objective and considers only the responses filled in by the participant. Objectivity of interpretation refers to the interpretation of individual values (to say something about the acceptance of an individual participant). To be able to do this the questionnaire need to be standardized. This indicates that for consideration of public acceptance the objectivity of interpretation is not necessary.

Discussion

We created a reliable, objective and in its application economic questionnaire to measure people's attitude toward Synthetic Biology. The *SynBio-Questionnaire* was validated on a sample of 71 test-subjects and it was constructed following the common principles of psychometric test construction. The endversion is capable of measuring the acceptance of synthetic biology with 22 items, obtains good item characteristics and a fantastic internal consistency.

But still there are some things to discuss and to address for the future:

The *SynBio-Questionnaire* was constructed with a big amount of relatively easy and medium-heavy items referring the statistical difficulty. This could be a problem if scientist would like to differentiate individuals or groups with high acceptance of Synthetic Biology. In the future the questionnaire should be extended with some additional heavy items, so that the *SynBio-Questionnaire* is able to differentiate people with every kind of attitude toward Synthetic Biology.

The validation of the *SynBio-Questionnaire* should also be completed. So far we have found only one construct for discriminant validity. To have a fully valid questionnaire there are more constructs necessary (e.g. attitude toward genetic engineering as a construct of convergent validity).

The questionnaire could be used in further research, or as a tool of classification of individual opinion. So far the *SynBio-Questionnaire* is the only existing professional constructed questionnaire for measuring people's attitude toward Synthetic Biology.

Appendix

I. Overview: statistical values test-preversion (sorted in ascending order of difficulty)

Item	M	SD	P	r_{it}
Item_32	1,67	1,05	33,23	0,29
Item_22	2,12	1,09	42,46	0,09
Item_23	2,15	1,21	43,07	0,56
Item_02	2,34	1,15	46,76	0,16
Item_14	2,44	1,22	48,46	0,08
Item_28	2,69	1,41	53,84	0,57
Item_31	2,75	1,33	54,15	0,65
Item_38	2,75	1,25	55,07	0,25
Item_35	3,06	1,17	61,23	0,50
Item_21	3,09	1,10	61,84	0,66
Item_40	3,10	1,34	62	0,55
Item_13	3,20	1,25	63,53	0,60
Item_33	3,22	1,11	64	0,69
Item_34	3,21	1,15	64,15	0,22
Item_08	3,25	1,17	65,07	0,60
Item_37	3,27	1,19	65,38	0,41
Item_16	3,28	0,97	65,53	0,60
Item_03	3,28	1,25	65,53	0,29
Item_18	3,30	0,97	66	0,68
Item_27	3,44	1,06	68,30	0,64
Item_25	3,42	1,15	68,46	0,71
Item_30	3,43	1,35	68,61	0,70
Item_19	3,58	1,06	71,53	0,59
Item_26	3,59	0,99	71,84	0,40
Item_20	3,62	1,12	72,30	0,57
Item_17	3,73	1,01	74	0,51
Item_01	3,72	0,95	74,46	0,71
Item_29	3,78	1,18	74,92	0,65
Item_07	3,77	1,11	75,38	0,66
Item_05	3,84	1,02	76,30	-0,43
Item_10	3,88	0,91	77,07	0,51
Item_12	3,86	0,97	77,23	0,53
Item_04	3,93	0,97	78	0,67
Item_39	3,92	1,21	78,46	0,63
Item_11	4,01	1,16	80,15	0,45
Item_09	4,05	0,97	81,07	0,54
Item_36	4,21	1,07	84,15	0,47
Item_24	4,21	0,93	84,15	0,48
Item_06	4,25	0,78	84,92	0,27

II. Overview: statistical values test-endversion

Item	M	SD	r_{it}
Item_01	3,31	1,050	,868
Item_02	3,23	1,209	,275
Item_03	3,66	1,121	,691
Item_04	3,83	1,095	,739
Item_05	3,89	,854	,429
Item_06	3,73	1,133	,512
Item_07	2,99	1,165	,481
Item_08	3,32	,938	,701
Item_09	3,39	1,189	,665
Item_10	2,23	1,173	,682
Item_11	3,41	1,116	,581
Item_12	3,18	1,211	,827
Item_13	2,35	1,374	,532
Item_14	3,66	1,218	,778
Item_15	3,28	1,300	,781
Item_16	2,86	1,162	,689
Item_17	1,42	,905	,297
Item_18	4,23	1,031	,338
Item_19	3,46	1,053	,436
Item_20	2,92	1,092	,412
Item_21	3,34	1,041	,724
Item_22	2,27	1,082	,337

References

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