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Explaining end-users' intentions to use innovative medical and food biotechnology products

Low public acceptance hinders the successful introduction of biotechnological innovations, such as genetically modified foods or vaccinations against infectious diseases. Earlier studies indicated that a lack of knowledge is not a key barrier to acceptance. This was confirmed in the current study, which examined an integrated theoretical model tested among 579 participants from the Dutch public. The results suggest that communication strategies should instead target attitudes, social norms, and risk perceptions, and appeal to people's tendency (or lack thereof) to be innovative.

Background

Biotechnological innovations in the fields of medicine and food are promising because they offer potential health and economic benefits [1]. However, low public acceptance is a threat to their successful introduction [2, 3]. Even though 40 years of communication about controversial technologies has shown that lack of knowledge is not a key barrier to acceptance [4], no integrated theoretical model of biotechnology acceptance has been presented and tested across a variety of applications. This study aims to address this gap by integrating evidence from previous studies with established behavioral theories, and test the resulting model on decision-making behaviors regarding a variety of food and medical innovations.

Evidence and theory relevant to biotechnology acceptance

The literature that is relevant to biotechnology communication can be broadly divided into three bodies with distinct theoretical foundations, namely social psychology, risk perception, and diffusion of innovations. This is in addition to the (now defamed) knowledge deficit model that posits knowledge as the foremost predictor of acceptance.

Within social psychology, there is general consensus that human behavior is caused by multiple psychological factors, called determinants. Intention is theoretically and empirically regarded as the most immediate determinant of behavior ("I intend to do *x*"). The theory of reasoned action (TRA) is one of the early theories placing intention at the heart of a behavioral model [5]. According to the TRA, the intention itself is explained by two determinants, namely attitude towards the behavior and social norms. Attitude is the evaluation of people, objects or ideas. These evaluations have a cognitive and an affective dimension, for example, the *belief* that a biotechnological product is environmentally friendly, or a positive *feeling* associated with this product. Humans, however, are highly social beings, and are thus prone to the influence of other others. For example, when someone perceives others to approve of buying a biotechnology product, this increases the likelihood that this person buys this type of product, too. This perception is called an *injunctive norm*. A second type of social influence is called the *descriptive norm*, which refers to what people believe others in their social environment are actually doing with regard to a specific biotechnological innovation [6].

Studies on risk perception offer a second relevant literature body. Risk studies indicate that there are two main risk perception dimensions, namely *dread risks* and *known risks* [7]. Dread refers to the severity and irreversibility of consequences people perceive of the (wide-scale) use of a technology. If perceived dread is high, people tend to ignore the probabilities of the event occurring, however small the probability may be. Known refers to the belief about the degree to which the consequences of using the new technology are known to science or society in general. When the consequences are better known, people presumably perceive the related risks to be lower. Additionally, trust is proposed to be relevant, meaning that when people trust the organization responsible for introducing the innovation and monitoring the risks, the perceived risk is lower. On the other hand, if people perceive the motives of these organizations to be driven by profit, the perception of risk might increase [8].

Third, according to diffusion of innovation theory, one important determinant of the rate of adoption of a technology is the degree to which a person is more a 'laggard' or an 'innovator'. Innovativeness is "the degree to which an individual (…) is relatively earlier in adopting new ideas than the other members of a system" [9]. The category of adopters called innovators are the first to adopt new ideas or inventions, whereby they actively seek information about novel products, and do not as much mind the uncertainties that accompany innovations. Thus, the degree to which people perceive themselves to be innovators is assumed to show a positive relationship with the attitude towards adopting new biotechnology applications, either directly or through decreasing risk perceptions.

Abbreviation: TRA; theory of reasoned action

Although all three bodies of literature offer sound theoretical concepts that have gathered empirical evidence, there are few studies integrating this into a theory- and evidence-based explanatory model for biotechnology acceptance. Therefore, we have used these bodies of literature to develop an integrated model in which intention is a central predictor of behavior, and, in turn, attitude and social norms predict intentions. Attitude itself is affected by knowledge, and also by risk perceptions, and the 'innovator' characteristic. Additionally, behavioral theories do indicate that knowledge plays a role in behavior, mainly because the level of knowledge about a particular behavior may influence attitude. Knowledge was, therefore, added as a factor influencing attitude. Finally, innovators influence the perceived social norms, and attitudes and social influences are also expected to relate to each other.

Empirical test of the integrated model

Cross-sectional data were collected among a convenience sample ($n = 579$) of the Dutch general public using a structured, written questionnaire. In return for partial course fulfillment, 35 well-instructed students collected the data at a variety of locations (e.g., train, shopping center, street) in order to get a diverse adult sample. Because the general public, in principle, includes all people, no specific selection criteria were applied. All participants provided written informed consent.

Respondents were introduced to one of seven product descriptions for a new biotechnological application; three about food and four about medical applications. An example of a food application is *in vitro meat*, which is produced in cell cultures by stem cells that turn into muscle tissue. An example of a medical application is *xenotransplantation*, whereby genetically modified animals are raised for the production of organs that can be transplanted into humans. Biotechnology inventions were selected that were not yet on the market, but in a late development stage so that their introduction within the next few years was plausible. The technologies were also intended to be somewhat controversial so that participants could perceive both benefits and risks. In the description that the participants read of each innovation, basic information was provided such as how the innovation is produced (the biotechnology), for whom it is intended (the target group), and how it is applied or used (the application). The information was balanced in terms of benefits versus risks and uncertainties, in order to enable respondents to consider the pros and cons of the innovation. Specifically, "selling" of the innovation by emphasizing the benefits was avoided, without undue negative focus on risks or other drawbacks.

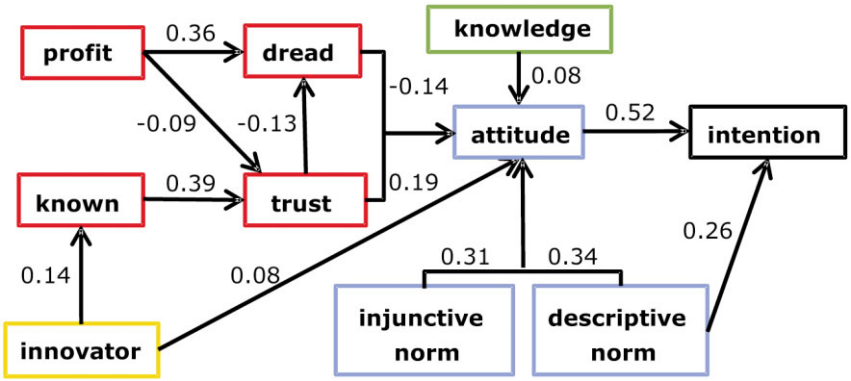

Figure 1. The confirmed relations between the study variables (all β's, $p < 0.05$. β is a standardized coefficient meaning its variance is 1. Therefore, β presents how many standard deviations the dependent variable will change for each standard deviation increase in the predictor variable.) (model fit: $X^2 = 77.69$, ns; RMSEA 0.02; CFI 0.99).

Biotechnology inventions were selected that were not yet on the market, but in a late development stage so that their introduction within the next few years was plausible.

After reading the product information, respondents completed items assessing the theoretical determinants related to buying and using these innovations (intentions, attitudes, social norms, risk perceptions, innovator, knowledge), and participant demographics. Structural equation modeling was used to investigate the theoretical model across the various biotechnology innovations.

The results largely confirmed the theoretical model (see Fig. 1 for confirmed associations). Attitude was the strongest explanatory variable for the intention to use biotechnology innovations ($\beta = 0.52$, $p < 0.001$), with the descriptive social norm being the second strongest ($\beta = 0.26$, $p < 0.001$). Injunctive norms only indirectly – through attitude – explained intentions. Hence, the more positive an attitude towards a biotechnology innovation was, and the stronger the participant's perception that other, important individuals will use the technology, the higher the intention to buy or use this technology. As expected, risk perceptions and the innovator characteristic had an indirect relationship with intentions through attitude.

Knowledge about biotechnology was indeed associated with attitude towards it ($\beta = 0.08$, $p < 0.05$), but this did not transfer into associations with intention to use biotechnology, thus confirming its limited relevance. Furthermore, attitude was positively associated with trust ($\beta = 0.19$, $p < 0.001$), and negatively associated with dread ($\beta = -0.14$, $p < 0.001$). Attitude was not directly associated with either profit or known risks. However, the belief that profitability is a more

important driver for the organization managing the risks than public safety was negatively related to attitude through trust ($\beta = -0.09$, $p < 0.05$), and the perception that the negative consequences of the innovation would be drastic and irreversible (dread) ($\beta = 0.36$, $p < 0.001$). The belief that the dangers of the technology are known to science was positively associated with trust ($\beta = 0.39$, $p < 0.001$).

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Being an innovator showed no association with social norms. The innovator characteristic does explain, however, attitude towards the using the biotechnology applications ($\beta = 0.08$, $p < 0.05$). The relationship of innovator with risk perceptions was limited to known risk ($\beta = 0.14$, $p < 0.001$), implying that the more people see themselves as being an innovator, the more they believe that potential risks of a new technology are known to science.

Taken together, the variance explained in attitudes and intentions is about 50%. The model integrates various bodies of literature from social psychology, risk perception, and diffusion of innovations, to present a number of findings observed across seven hypothetical (but plausible) future innovations. The relatively large study sample and analysis across a variety of cases increase the external validity of these findings and suggest the model is fairly robust. These findings can guide future studies of biotechnology acceptance, and direct the content of future strategic communication.

A few drawbacks of the current research should be mentioned. For one thing, although it is generally accepted that studies explaining intentions are cross-sectional, this type of data does not allow studying the causality of the relations. Study designs that permit stronger causal inferences, such as experimental research, were not judged feasible because of the number of variables examined here.

Recommendations

Our analysis reveals that a theory-driven model that is supported by data offers interesting avenues for organizations that want to communicate with biotechnology end-users, as well as policy makers. It confirms that communication that focuses on the provision of information about biotechnology is not likely to be effective. Instead, communication should target attitudes, social norms, and risk perceptions, and appeal to people's tendency to be innovative (or not). These determinants can be influenced by showing that others use biotechnology and approve of it (perceived social norms), by targeting early communication at innovators, and by addressing concerns about possible dangers of the innovation for future generations, and by fostering trust in the stakeholders who are responsible for its safety (risk perceptions).

As argued in this journal, communication should occur in the R&D phase – before products are marketed – which is what we did in this study [1, 4]. We have tried to show that this is highly recommendable and feasible when using an approach that is based on behavioral theory, and then gathering evidence to support – or discard – associations with key determinants of human behavior. Such a theory- and evidence-based approach can guide communication to introduce food and medical technologies that have the potential to benefit many.

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