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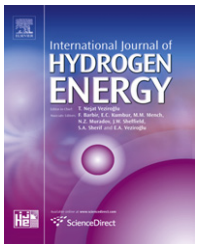

Unknowing but supportive? Predispositions, knowledge, and support for hydrogen technology in the Netherlands

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ABSTRACT

In most papers concerning the public evaluation of hydrogen technology it is found that the general public is generally supportive of hydrogen technology and the knowledge about hydrogen is fairly low. In this paper we hypothesize that several cultural predispositions such as environmental concern and trust in technology play a key mediating role in the degree to which knowledge can be translated into hydrogen acceptance.

Using representative data for the Dutch population gathered in 2008, it is studied whether the relationship between support for hydrogen technology and knowledge about it is not equally strong for every social category in Dutch society. It shows that, pending on particular cultural predispositions, there is no clear-cut relationship at all. For some – based on their cultural predispositions already inclined to support hydrogen technology – there is a very strong relationship, for others – those inclined not to give support to hydrogen technology – there is only a very weak or even no relationship between knowledge and hydrogen support. At the end of the paper the theoretical and public relevance of these findings are discussed.

1. Introduction

Increasingly problems of global warming, unsustainable energy consumption and environmental pollution are brought to the attention of the public at large in many countries [1]. Countering these environmental problems, some promoters claim that, although it is still relatively in the early stages of development, we are about to transition into a so-called sustainable hydrogen economy [2]. Before we can do so, obviously, this should be technologically feasible, and, not unimportant, the public needs to want to change their values and habits and lifestyles accordingly. Specifically Ball and Wietschel point out that public awareness of hydrogen and the acceptance of hydrogen should be high enough to guarantee that hydrogen entrepreneurs will be guaranteed of some clients for their hydrogen products ([2]: pp.626, see also [3]). Moreover, rising public popularity of any kind of measure can also influence governmental policies [4], also when it concerns technologies such as hydrogen which are not widely available to the public yet. Otherwise, when the public at large dislikes or fears a certain type of technology, governments could decide to forfeit the technology in favor of other, less sustainable but more accepted kinds of technology. In other words, many deem it is important to find out how people exactly feel about hydrogen technologies. Unsurprisingly then, an increasing share of research is aimed at surveying the public evaluation of hydrogen technology [5–7].

Previous studies have reported consistently about two findings. First, the available studies conclude that the level of knowledge about hydrogen technology is generally low. Second, these studies show that the level of support for hydrogen technology is high [3,6,7]. Exactly the combination of these two basic findings – while people generally seem to know very little about it, they do tend to support hydrogen

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technology – makes one wonder about the nature of the relationship between the two concepts. To put it bluntly: *If people have no knowledge, how do they form their opinions about such difficult issues as hydrogen technology?* In this paper we will try to answer this question using insights from science communication and cultural sociology.

As Zaller aptly argues: '*Every opinion is a marriage of information and predisposition: information to form a mental picture of a given issue, and predisposition to motivate some conclusion about it*' ([8]: pp.6). The available studies on support for hydrogen technology have all neglected to take into account the central role of cultural 'values' [9], 'pictures in our heads' [8], 'frames of reference' [10], 'stereotypes' [11] 'perceptual screens' [12] or simply our cultural 'predispositions' [13]. In this paper we therefore focus on the intricacies of the relationship between the information one has about hydrogen technology, how one is culturally predisposed and the way one judges hydrogen technology. Following so-called *framing theory* [14] we argue that these cultural predispositions could be the key to understanding why low levels of knowledge about hydrogen could in fact coincide with high levels of support.

Other research on the acceptance of various technologies and science has shown that actual knowledge about a certain technology is not very important for the degree to which people support this particular type of technology [15–17]. Their support may be more deeply rooted in their cultural predispositions. These predispositions may turn out to be more important for people's views on hydrogen technology than what they actually know [18,19]. But cultural predispositions play another, mediating, role as well. There are two views on this mediating role of cultural predispositions. Cultural predispositions may be especially important when people do not know much of the particular technology which is judged [16]. Alternately, cultural predispositions may only be able to function when people have adequate information about a technology [20]. In this paper we will flesh out which of the two perspectives is more accurate when support for hydrogen technology is concerned.

In the next section we will first explain how cultural predispositions enable people to form evaluative conclusions about new technologies such as hydrogen technology, they are not very knowledgeable about, which predispositions should be taken into account, and we will develop some expectations. Then, in the third section we will explain our data and measures we will use. In the fourth section we will test our expectations, and in the final section draw some conclusions.

2. Explaining support for hydrogen technology

2.1. *Predispositions, knowledge, and support*

While, as said, studies incorporate both indicators for knowledge and for acceptance of hydrogen, seldom these concepts are linked. Not surprisingly, knowledge about (any kind of) technology has been found to be positively associated with the latter's evaluation [16,17] – and knowledge about art and culture with having an interest in them, for that matter [21] – but there is no ample empirical evidence about the linkage between hydrogen knowledge and hydrogen acceptance yet. Zachariah-Wolff and Hemmes show that the degree to which people are exposed to negative information leads to more negative evaluations of hydrogen ([7], see also [22]). Yet, the linkage between knowledge of hydrogen technology and support for hydrogen technology may not be as clear cut as is sometimes suggested.

A basic insight in social science is that people base their judgments about any range of issues (including new technologies such as hydrogen technology) not only on what they know of the particular issue, but to a large extent on other factors such as their cultural predispositions and their more general beliefs [18]. There are two basic perspectives on the interplay between knowledge and cultural predispositions. First, these cultural predispositions may play a more important role as one's knowledge is lower. As Scheufele and Lewenstein for instance argue: '*People do not use all available information to make decisions about issues, including new technologies or scientific discoveries (Fiske & Taylor, 1991). Rather, they rely on heuristics or cognitive shortcuts, such as ideological predispositions, religious beliefs and media portrayals, in order to form judgments about issues, …, that they know little or nothing about*' ([17], pp. 660). In this context, Popkin refers to 'low – information rationality' explaining why people are able to make decisions about issues they know little to nothing about [21]. Pending on their cultural predispositions, people will be more willing to accept hydrogen technology as a new technology, or reversely, people will refrain from supporting this new technology when they lack sufficient knowledge on the subject [16,19,23].

Whereas the first perspective leads to the expectation that the less people know about it the more they rely on cultural predispositions for their opinion on hydrogen technology, the second perspective leads to diametrically opposed expectations. As Lippmann rightly notes: '*Inevitably our opinions cover a bigger space, a longer reach of time, a greater number of things, than we can directly observe. They have, therefore, to be pieced together out of what others have reported and what we can imagine*' ([11]:59). In other words, how people think about hydrogen technology is pieced together out of what people already know about it and whether they are culturally predisposed to support the particular technology. In fact, whether or not these cultural predispositions have an impact depends on the degree to which people know what type of issues they are judging. People need some contextual information to know that they are dealing with a specific type of technology before they can base their judgments about this technology on broader cultural predispositions pertaining to technology (compare [9,8]).

That cultural predispositions are perhaps more important than the level of one's knowledge for one's support for hydrogen technology does not, in short, mean that there is no significant role of knowledge of hydrogen technology whatsoever. Two related but opposing views argue that one's cultural predispositions may determine how ones knowledge about hydrogen technology is translated into support. The first perspective holds that as people know very little about hydrogen technology, they will base their judgment more strongly on their cultural predispositions. The second perspective suggests that as people know more about hydrogen technology they can use their cultural predispositions more effectively in their final judgments. Which cultural

predispositions are we talking about? Five important ones are introduced in the next section.

2.2. Which cultural predispositions?

In literature on the support for various kinds of technology religious inspired predispositions have been central – especially when technologies such as biotechnology or cloning which deal with the natural ordering of things. This does not mean that other 'green' predispositions, which are not directly religiously inspired, do not have an impact on support for hydrogen technology. Two non-religious cultural predispositions are, therefore, used in this study. The first one is the degree to which people are concerned about the environment. While traditionally hydrogen technology is seen as contributing to sustainable development (see also our introduction), and although hydrogen technology certainly does have its merits for sustainability – like improving local air-quality – hydrogen cells are mere energy carriers and the real environment-friendliness is determined by the way the energy stored in hydrogen is produced. If for instance the energy is produced by nuclear power plants, hydrogen is likely to face lower acceptance of those who are concerned about the environment [2]. Several studies indicate that negative associations with hydrogen technology are not uncommon [24,25]. Hence, it is the question whether those with higher levels of environmental concern see hydrogen as a possible solution for environmental problems and are more willing to accept hydrogen as a means to reduce environmental problems [26].

Secondly, as the modern ambition to master and manipulate nature by means of advanced technology, so as to liberate mankind from nature-imposed limitations and to make nature more humanly useful and profitable, has increasingly been seen as a major course of environmental problems since the 1960s and 1970s [27], environmental concern and technological skepticism have become two closely related phenomena in contemporary western society [28,29]. This tendency to construct the application of advanced technology as incompatible with ecological sustainability today poses a major obstacle to the introduction of new technologies to help bring about a sustainable future. On the one hand, those people with high levels of trust in technology will therefore be more willing to support hydrogen technology. Those who are rather skeptical of technology – those who do not trust technology – will expectedly not embrace hydrogen technology.

Lastly, in studies of acceptance of science and technology it is not uncommon to include religiosity and religious predispositions in the analysis [9,30,17]. Three central religious orientations may play a role in determining support for hydrogen technology. Firstly, while not undisputed, Lynn White claims that because of Christian ideals of mastery over nature, Christians are less concerned with the environment [31]. From this perspective, we expect Christians not to give much support to sustainable technologies such as hydrogen. The second religious orientation is the degree to which people embrace notions of stewardship [32] – the idea that mankind is responsible for the (ecological) well-being of our planet, which ultimately leads to a desire to protect the environment and to use new technologies to do so. Thirdly, and closely related to the stewardship-orientation, we use a secularized cultural orientation towards spiritual-holism [33] in which nature and humanity are increasingly viewed as interconnected and nature effectively becomes sacred. Although spiritual holism has many times been associated with an rejection of supra-individual systems, recent research has shown that spiritual holists do seem to embrace technologies that enable individuals' self-fulfillment [34,35]. It may therefore be expected that technologies that contribute to sustainable development will be judged positively by these spiritual holists.

To sum up, these three religiously-inspired cultural predispositions – ideals of mastery over nature, ideals of stewardship and of holistic spirituality – may hence well lead to support for hydrogen technology.

2.3. Summary and hypotheses

Following other research on the acceptance of various technologies and science it may, in short, be expected that the actual knowledge about hydrogen technology is not very important for the degree to which people support this particular type of technology. Their support may be more deeply rooted in their cultural predispositions. These predispositions – we distinguished five – may turn out to be more important for people's views on hydrogen technology than what they actually know. We test this idea in the first hypothesis.

Hypothesis 1. One's cultural predispositions are more important for support for hydrogen technology and having adequate knowledge about this technology.

But cultural predispositions play another, mediating, role as well. There are two views about this mediating role – the first claims that cultural predispositions are especially important when people do not know much of the particular technology which is judged. This would lead to an increasing explanatory influence of cultural predispositions as the level of knowledge is going *down*. The second view basically predicts the opposite and claims that cultural predispositions are not important at all when people know little to noting about hydrogen technology. This would lead to an increasing explanatory influence of cultural predispositions as the level of knowledge is going *up*. These views are tested in the following set of hypotheses.

Hypothesis 2a. The less one knows about hydrogen technology, the more one's support will be determined by one's cultural predispositions.

Hypothesis 2b. The more one knows about hydrogen technology, the more one's support will be determined by one's cultural predispositions.

3. Data and measurements

3.1. Data

As other studies rely on samples of students [7] – which are typically more educated than the general public – of people on hydrogen buses [36,37] – who have experienced hydrogen

technology and are more knowledgeable of hydrogen technology – of people attending hydrogen demonstrations [5] – showing interest in the subject and are more knowledgeable of hydrogen technology – or people who just happen to be where the interviewers were [5] – creating a biased sample in some unconscious manner – the generalizability of the samples at hand can be seriously questioned, most probably yielding elevated levels of both knowledge of and/or of support for hydrogen technology in the aforementioned studies. This means that there is still need for a survey of the public's values pertaining to hydrogen technology. In this research program we explore how people in the Dutch society at large perceive advantages and risks attached to the introduction of hydrogen systems, and compare these perceptions to those of other technologies. To this end, nationally representative survey data are needed which provide us with a cross-section of the Dutch population. One of the main problems in this type of research is the growing non-response in regular survey methods, yielding unreliable research outcomes as certain sections of the population are systematically over represented while others are underrepresented [38,39]. Through the use of data collected through the nationally representative and validated panel of Centerdata (KUB, Tilburg) this problem is solved. Centerdata is a research institute, affiliated to Tilburg University, which is specialized in online survey research. Centerdata manages an online panel which is representative for the Netherlands and which can be used for surveys such as the one analyzed in this article.

The data were gathered in November 2008 among the members of the panel who are 16 years or older. To increase the response, the questionnaire has been repeated three times for panellists who had not completed it yet. From the 2423 respondents 2121 have actually completed the questionnaire, yielding a response rate of 87.5%. As can be seen from Table 1, compared to statistics of the Dutch statistics agency (Central Bureau of Statistics, CBS) the data are representative for level of education, gender and age.

Table 1 – Demographic characteristics of our survey as compared to official population statistics (CBS).

	N survey	% Survey	% Population
Education			
Low	721	34	38
Medium	658	31	38
High	742	35	24
Gender			
Male	1082	51	49
Female	1039	49	51
Age			
20–40	573	27	33
40–65	1060	50	46
65 or more	488	23	21
Total	2121	100%	100%

3.2. Measurements

Hydrogen support was measured using nine items covering the support for hydrogen and the acceptability of hydrogen. The first five items are Likert-type items that are answerable on a scale from 1, totally disagree, to 5, totally agree. The latter four items were answered on a scale from 1, totally unacceptable, to 10, totally acceptable. Factor analysis showed that these nine items could be taken together in to one scale measuring hydrogen support. Table 2 which reports on the results of this factor analysis, shows the actual items used. After standardizing the items, scale scores were assigned to each respondent having at least 7 valid answers on the nine items posed. Higher scores on the final scale stand for more support for hydrogen technology.

Hydrogen knowledge – Based on the aforementioned study of Zachariah-Wolff and Hemmes [7], see also [19] we measured knowledge of hydrogen technology by the respondents' ability to correctly answer seven questions about hydrogen technology. In order to cover a broader range of information we sought to maximize the number of knowledge questions by asking each respondent randomly seven questions from a larger set of 21 questions. (As respondents are commonly known to skip tedious sections of questionnaires, we wanted to avoid blank answers by reducing the number of questions).

The questions used, the frequency of correct answers, as well as the scale analysis confirming that a scale tapping into the knowledge about hydrogen technology is presented in Table 3.

From this table the conclusion can be drawn that a scale for knowledge about hydrogen technology could be constructed.[1] Higher scores on this scale stand for more knowledge about hydrogen technology.

The scales for the cultural worldviews were all measured using multiple likert-tpe items. *Trust in technology* was measured using five items such as 'technological advanced can be used to solve future problems' and 'risks connected to new technologies have to be seen as temporary problems that will be solved later'. These five items formed a reliable scale (Cronbach's alpha = 0.80). *Environmental concern* was measured by means of five items asking to indicate on a five-point scale how much they are concerned (not at all concerned through very concerned) about specific environmental problems, such as "air pollution" and "global warming". The combination of the five items produces a scale that is reliable (Cronbach's alpha = 0.82). *Stewardship* was measured using five items such as 'We have got the earth/nature on loan and we must preserve her for the next generation'. The combination of the five items produces a scale that is reliable (Cronbach's alpha = 0.75). The *mastery over nature* orientation was measured using five items such as 'Humans are allowed to use nature to their own advantage' The combination of the five items produces a scale that is reliable (Cronbach's alpha = 0.67). The scale for *holistic spiritualism,* finally, consists of seven items such as 'Every person has a higher spiritual 'self' that can be awakened and enlightened'. The combination of these seven items produced a scale that is reliable (Cronbach's alpha = 0.83).

The available studies on the acceptance of hydrogen have shown that the higher educated, males, and to a lesser extent, the young, have stronger support for hydrogen technology

[1] The table does show that the four items at the bottom of the table, which were answered correctly least, do have lower factor-loadings. Not using these items in the remainder of the paper will not yield any substantially different results as the ones presented in this paper.

Table 2 – The measurement of support for hydrogen technology.

	% Totally agree/acceptable	Factor loadings
It is a good idea to invest in hydrogen technology	84.8	.79
It is a good idea to apply hydrogen technology in public transportation such as buses	86.4	.78
The use of hydrogen as a fuel is good for the environment	78.9	.73
We should make the transition to hydrogen technology as soon as possible	45.7	.75
I think using hydrogen as a fuel is a very good idea	81.2	.79
I think using hydrogen as a fuel for me personally is acceptable	73.3	.76
I think using hydrogen as a fuel is acceptable for society	74.1	.79
I think having a hydrogen fueling station at less than 300 meters from my home is acceptable	43.4	.44
I think that the consequences of using hydrogen as a fuel are acceptable for the coming generations of people	67.0	.71
Eigenvalue		4.85
R^2		.54
Reliability (Cronbach's alpha)		.83
N		1508

than the lower educated, females and older people [5,36,22,7]. Equally, studies have shown that on average men, higher educated, and the young are more knowledgeable of hydrogen than their counterparts [22,7]. Age, education, income and gender were therefore added as statistical control variables to the analyses.

4. Results

4.1. *The linkage between knowledge of hydrogen technology and support*

In Table 4 support for hydrogen technology is explained using a regression model (OLS). The beta's are presented. Indicators for hydrogen knowledge and our five worldviews are used to explain support to see which explains support for hydrogen technology better.

From the table it can be seen that, as known from earlier studies, the young, the higher educated and males are more supportive of hydrogen technology. Furthermore it can be seen that those with higher levels of income are less supportive of hydrogen technology, although it must be noted that this effect is rather small and on the edge of statistical significance.

Concerning our cultural worldviews, from Table 3, the conclusion must be drawn that trust in technology and environmental concern as associated with support for hydrogen technology most strongly. Those who trust technology and those who are very concerned with the environment are more

Table 3 – The measurement of knowledge about hydrogen technology.

Hydrogen knowledge	Correct?	% Correct	Factor loading
Emissions of hydrogen cars are less polluting than those of cars on regular fuels	Y	83.8	.68
The use of hydrogen improves the local quality of the air, for instance in cities	Y	73.6	.69
Hydrogen can be used in buses	Y	71.3	.67
Hydrogen cell emissions do not contain any unwanted rest products like carbon dioxide	Y	63.3	.71
Hydrogen is odorless	Y	61.8	.72
Emission of a hydrogen care is water vapor	Y	59.7	.73
How clean hydrogen is depends on the way the energy is obtained	Y	53.3	.65
Hydrogen is not an energy source but a carrier of energy	Y	52.0	.65
Emission of a hydrogen car is carbon dioxide	N	48.0	.67
The storage of hydrogen is (still) not without problems	Y	43.6	.55
Hydrogen is liquid at room temperature	N	33.3	.63
Hydrogen has a colorless flame and is hard to see	Y	32.8	.51
Hydrogen is lighter than air at room temperature	Y	32.2	.59
The costs of hydrogen storage are higher than for fuel	Y	31.9	.44
Hydrogen cells make less noise than normal fuel motors	Y	30.2	.40
Hydrogen can be used in airplanes	N	21.3	.32
Hydrogen can be used to store solar- or wind energy	Y	20.8	.45
Hydrogen can be used in zeppelins	N	18.4	.36
Hydrogen is an inexhaustible natural resource	N	15.5	.24
Global warming will decline as more people will start to use hydrogen	N	14.8	.31
Hydrogen definitely does not cause any harmful effects to health	N	11.2	.21
Eigenvalue			6.53
R^2			.31

Table 4 – Explaining support for hydrogen technology (OLS regression analysis, method = enter).

	Beta M0
Hydrogen knowledge	.11**
Cultural worldviews	
Environmental concern	.14**
Trust in technology	.26**
Mastery over nature orientation	.03ns
Stewardship	.08**
Holistic spiritualism	.04*
Controls	
Age	−.11**
Education	.04*
Income	−.04*
Gender (=female)	−.14**
R^2	.14
N	1880

*$p < 0.05$; **$p < 0.01$; ns: not statistically significant (two-tailed test for significance).

supportive of hydrogen technology. Also, we find that spiritual holism and stewardship are positively associated with support for hydrogen technology.

Controlled for the effects described above, we find that there is a positive, significant effect of knowledge about hydrogen technology and the support for this technology – yet it must be noted that the strength of this relationship is only modest and it outweighed by one's trust in technology and environmental concern. Given these results, we accept the first hypothesis: knowledge does lead people to positively appreciate hydrogen technology, but other cultural worldviews are more important.

4.2. *Is there a multiplicative effect of knowledge and predispositions?*

As the second set of hypotheses predicts that the strength of the associations between cultural predispositions and hydrogen support varies with the extent to which people have more knowledge of hydrogen technology, we need to test five interaction effects. We calculated the products of hydrogen knowledge with each of the five cultural predispositions and entered them into the multiple regression model shown above. To avoid problems of multicollinearity, for each interaction effect we estimated a new model extending Model 0 presented in Table 4. Below, in Table 5 we show the interaction effects and their statistical significance – for reasons of brevity, we did not include all main effects.

From Table 5 it becomes clear that two interaction effects did not prove to be statistically significant, this means that the degree to which holistic spiritualism and mastery over nature orientations lead to support for hydrogen technology does not depend on the knowledge one has of this technology. In other words, there are few differences between people think they are allowed to use nature to their advantage and know very much about hydrogen technology and those who don't think that they are to use nature to their advantage and know equally much about hydrogen. The same conclusion must be drawn for those scoring high and low on spiritual holism.[2]

Table 5 – Explaining support for hydrogen technology: do the effects of cultural predispositions increase or decrease with knowledge of hydrogen technology? (OLS regression analysis, method = enter, extensions of M0, Table 3, beta's presented).

	M1	M2	M3	M4	M5
Hydrogen knowledge multiplied with					
• Environmental concern	.30**				
• Trust in technology		.37**			
• Stewardship			.32**		
• Holistic spiritualism				.11ns	
• Mastery over nature orientation					.01ns
R^2	.16	.17	.16	.15	.14
N	1880	1880	1880	1880	1880

**$p < 0.01$; ns: not statistically significant (two-tailed test for significance).

The findings elaborated above do not mean that both hypothesis 2a and 2b need to be totally rejected based on the results obtained from Table 5 however. After all, the other three interaction effects have proven to be statistically significant – demonstrating that the degree tow which one has adequate knowledge of hydrogen technology does play a role for the way in which cultural predispositions are translated into a favorable opinion about hydrogen technology. As can be seen from the positive signs of each of the three effects we can conclude that as the general level of knowledge of hydrogen increases the public's support will be determined more by the way they trust technology, whether they are environmentally concerned or not and score high on Christian stewardship or not. For easier interpretation of these interaction effects we construed three figures depicting the mean levels of support for hydrogen technology for various categories of people based on their cultural predispositions – split on the median – and their level of knowledge – split into three equally sized groups.

Fig. 1 shows the differing way in which people who are highly concerned with the environment translate knowledge about hydrogen technology into support as compared to the way people who are not concerned with the environment. As can be seen from the lowest line which increases only slightly, for people who are not concerned with the environment it does not matter how much they know about hydrogen technology – they just aren't very supportive of hydrogen technology. For people who are very concerned with the environment the degree to which they are adequately informed does matter a lot for their support for hydrogen technology – more knowledge leads for them to more support

[2] Although it must be noted that this effect is rather strong and hinges on statistical significance. A less strict test for significance (one-sided test) reveals that this interaction effect is significant when only an increasing effect was to be expected. Given the fact that Hypothesis 2a expects a negative effect, we can not conclude that this interaction effect is significant. If one would treat this effect as significant, comparable results as those presented ahead would be obtained.

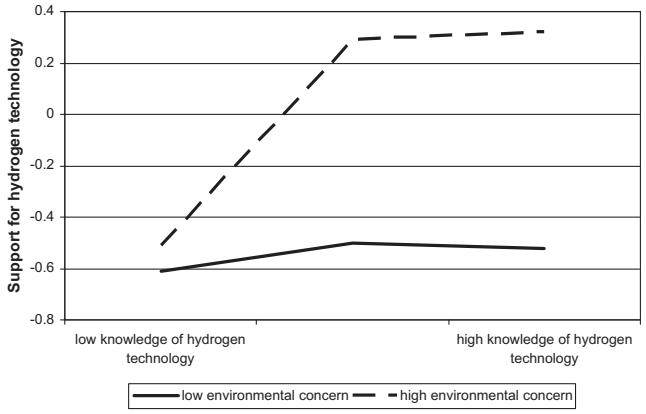

Fig. 1 – The conditioning effect of knowledge of hydrogen technology the way environmental concern leads to support for hydrogen technology.

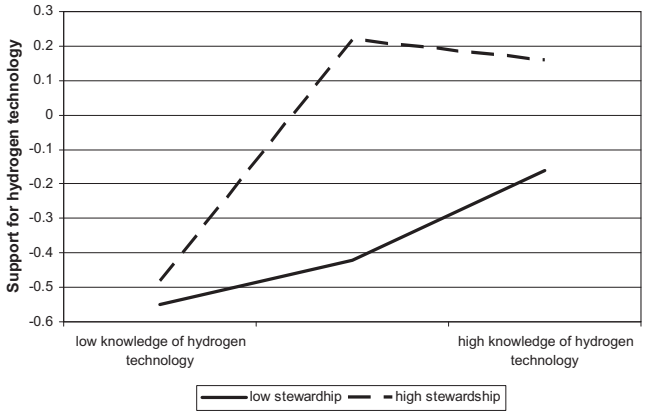

Fig. 3 – The conditioning effect of knowledge of hydrogen technology the way stewardship leads to support for hydrogen technology.

for hydrogen technology. The final result is that differences in support between those high and low on environmental concern are greatest for those who are very adequately informed about hydrogen technology.

For the other two interaction effects found, similar results are shown in Figs. 2 and 3, depicting the way in which trust in technology (Fig. 2) and stewardship (Fig. 3) is translated into support for hydrogen technology for people with little and for those with ample knowledge of hydrogen technology. It is, again, shown that for those culturally predisposed to favor hydrogen technology anyway, the addition of adequate knowledge does lead to more favorable judgments of hydrogen technology. For those culturally not predisposed to favor hydrogen (because they do not trust technology and because they score low on stewardship) more knowledge much less leads to support for hydrogen technology. Put differently – only when people have ample levels of knowledge, these two figures tell us, their trust in technology and their ideals of stewardship will lead to more favorable views of hydrogen technology.

Given the evidence presented above we find no empirical support for Hypothesis 2a which is inspired by the idea that cultural predispositions become important especially when levels of knowledge are low. On the contrary – if anything we find empirical confirmation for Hypothesis 2b: Cultural predispositions become important for people who are more knowledgeable of new technologies such as hydrogen technology. Once they know something about hydrogen technology, their trust in technology, environmental concern and their orientation towards stewardship will lead to more support for hydrogen.

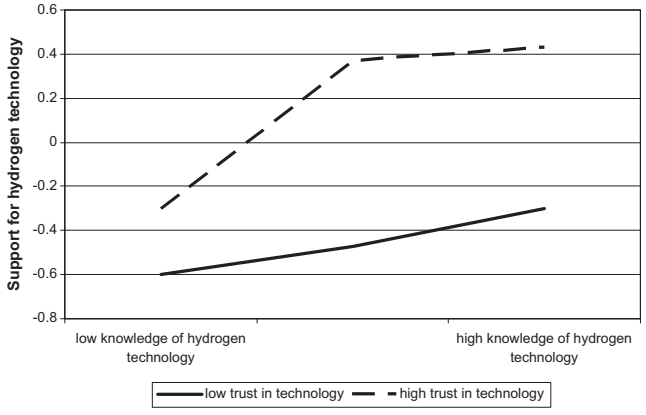

Fig. 2 – The conditioning effect of knowledge of hydrogen technology the way trust in technology leads to support for hydrogen technology.

5. Conclusion and discussion

5.1. *Conclusion*

William Gamson once wrote: 'The mystery is…how people manage to have opinions about matters about which they lack the most elementary understanding' ([40]: 5). In this article we have tried to find out how people make up their minds about hydrogen technology – a new technology that the public is relatively unknowledgeable about [6,3,7]. Building on notions of low-information rationality it was hypothesized that people tend to lean on their wider cultural predispositions when they are to judge so-called difficult issues they know only little about. Relying on a recent survey of the Dutch population we have demonstrated that people who are better able to answer all kinds of questions about hydrogen technology are more supportive of this kind of technology. Yet, we also demonstrated that one's cultural predispositions are more important for the way people tend to lend their support to hydrogen technology – giving credence to the idea that for 'difficult' issues such as hydrogen technology people tend to weigh heavily on their cultural predispositions, especially trust in technology and environmental concern and to a lesser extent orientation towards stewardship. People with strong trust in technology will be very supportive of hydrogen technology. The same can be said for people who are very concerned about the environment, and for those strongly believing that they should take good care for the planet for the generations to come. This means that people who do not trust technology (as much), are not concerned with the environment (as much) and do not

believe in Christian stewardship (as much) will not be inclined to support hydrogen technology.

Next, we investigated whether and how actual knowledge of hydrogen technology together with the aforementioned cultural predispositions are jointly determining how people think of hydrogen technology. Two ideas have been tested. The first idea, that cultural predispositions become more important for people who know less about hydrogen technology, has proven to be empirically uncorroborated. The second idea, that one needs some information about this technology to use their cultural predispositions more effectively in their final judgments, is empirically sustained. We found that irrespective of their cultural predispositions, people who know very little about hydrogen technology tend to be unsupportive of hydrogen technology. Then, pending on whether people are culturally predisposed to support hydrogen technology, adding knowledge has differential effects. For those not really predisposed to favor hydrogen technology more knowledge about it does not (or very meagerly) lead to more support. For those already inclined to support hydrogen technology, because of their environmental concern, trust in technology and Christian stewardship, more knowledge has a surplus effect – these people are extra motivated to support hydrogen.

The conclusion that more knowledge does not automatically lead to more support for hydrogen technology has serious consequences for those aiming at raising the level of support for hydrogen technology as a means to enable a transition towards a sustainable hydrogen economy. People who do not trust technology, who do not feel the need to take care of nature and are not concerned about the environment, will generally not tend to support hydrogen technology, and for these people campaigns educating the public about the use of hydrogen will expectedly have no strong positive effects.

5.2. *Discussion*

Some people within the political and public domain claim that providing people with adequate information will more or less automatically ensure more positive evaluations of emerging technologies. 'One-way' provision of information to the public at large can however be criticized harshly ([41] pp. 10). Based on our findings, three objections can be made against this kind of reasoning. First, the empirical evidence for a relationship between scientific knowledge and supportive ideas about technology is not that overwhelming. Allum et al. studied the way in which the level of knowledge leads to more positive evaluations of several technologies in 193 nationally representative surveys and found only a small relationship between the two [15]. Our findings point out that the same can be said for having adequate hydrogen knowledge and supporting hydrogen technology. Raising the general knowledge about hydrogen technology expectedly will not lead to a strong raise in support for this technology.

Second, in several other studies it is frequently found that the way in which people evaluate various technologies is embedded in a broad range of cultural predispositions. Lee et al. for instance find that trust in scientists effectively ensures more support for nanotechnology [42]. Siegrist et al. find trust in governmental agencies is strongly related to the way in which people evaluate nanotechnology [43]. There is also research reporting strong relationships between support for genetic modification of food and a more general trust in governance [44,45]. Nisbet and Goidel find that the way in which people support stemcell research is embedded in Christian values [46]. Based on their ethnographic research Cherryman et al. recently showed that environmental concerns do play a role in one's ideas about hydrogen energy [26]. In this paper in addition to one's knowledge of hydrogen technology we also included some cultural predispositions such as environmental concern in order to explain support for hydrogen technology. From our analyses it can be inferred that cultural predispositions which are related to one's religious outlook are less important than trust in technology and environmental concern. Nevertheless, the cultural predispositions employed in this study still outweigh actual knowledge about hydrogen technology in determining one's support for hydrogen technology.

Third, as ethnographic research Grove-White et al points out: 'Present methods of 'one-way' information provision are wholly inadequate for the task of addressing the human tensions and social dynamics likely to emerge in relation to new technologies and products over the coming decades' ([41]: pp.6). This conclusion resonates in studies concerning stem cell research and nanotechnology – there it is found that a strong religious predisposition inhibits adequate information to be translated into support for stem cell research [9] and nanotechnology [20]. Just giving more information will not result in more support for these strongly religious people. From our analysis of support for hydrogen technology we can draw similar conclusions. In some cases we found that knowledge about hydrogen sometimes does work out positive for one's support for hydrogen technology. For those culturally predisposed to trust technology, be environmentally concerned, and feel the need to take care of nature, more knowledge will lead to more support. The irony is, of course, that adding knowledge works out for those who, based on their cultural predispositions are already more inclined to favor hydrogen technology anyway. For their counterparts – those without trust in technology, with no environmental concern, and those who do not feel the need to take care of nature – more information will not lead to a more positive evaluation of hydrogen technology. Still, future research should explore how support for hydrogen technology could be raised for these people.

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