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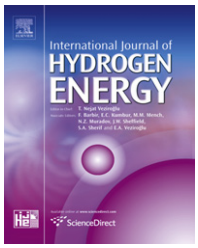

Analysis of South Carolina hydrogen and fuel cell workers views and opinion leadership behavior: A waiting opportunity?

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ABSTRACT

The current study uses quantitative survey results to explore what a near census of hydrogen and fuel cell (HFC) workers in South Carolina ($n = 70$) say about their HFC experiences and the degree to which these workers can be expected to act as opinion leaders for the field. In general, these workers say they are positive about the environmental, national security, and economic potential of HFC technologies. They further see HFC technologies as having small and manageable levels of risk. A number of these workers exhibit characteristics associated with both issue-specific and general opinion leadership. Issue-specific leadership and positive views about HFC technology were associated with higher levels of self-reported technology-related interpersonal discussion. The study concludes that the existence of workers with positive HFC experiences and a demonstrated interest in telling others about their experiences may represent an opportunity for those charged with promoting HFC development and adoption. Future efforts should explore how HFC workers could be effectively integrated into such efforts as a means of reaching difficult to reach audiences.

1. Introduction

The state of South Carolina has identified the hydrogen and fuel cell (HFC) technology sectors as an area of significant economic opportunity given the growing desire for environmental protection and energy security. Federal, state, and local governmental leaders, as well as academic, non-governmental and private actors, are therefore working together in a range of areas to develop and bring HFC technologies to market. The current study takes advantage of the introduction of HFC applications into a range of workplaces in South Carolina to study workers who have been tasked by their employers to use the technologies on a regular basis.

The goal of the current study is to assess South Carolina HFC workers' views about HFC technologies with a specific focus on the degree to which such workers are telling other people within their social networks about their views and experiences. The focus on interpersonal discussion, and specifically opinion leadership (which is defined in detail below), is a response to a renewed recognition in the field of science communication that within-social-network communication is a key mechanism through which individuals

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develop their views about scientific public issues [1,2]. Ultimately, the hope is to assess the degree to which the South Carolina HFC worker community includes individuals who are leading opinions in their social networks on the topic of HFC technologies. Highlighting the presence of such individuals, as well as correlates of being such an individual, is meant to enable those who may wish to foster a change in the level or pace of HFC technology adoption. The focus on fuel-cell workers, not managers or other individuals who might have the responsibility for choosing to deploy HFC technologies, reflects a concern about the difficulty of reaching non-expert audiences in science communication efforts.

The chosen focus reflects the view that, as with most new technologies, rapid public acceptance of HFC technology cannot be assumed based only on experts' perceptions of a technology's technical merits [3–5]. For example, in the United States, substantial recent research has focused on public perceptions of nanotechnology as a partial response to experiences with public opposition to biotechnology, including the perception that such technologies were introduced in undemocratic ways [6,7]. While energy research has not received as much attention in this discussion, questions about public perception of energy have often been a focus of academic and applied interest [8,9].

Below, we first outline relevant research on perceptions of HFC technologies and introduce theoretical discussions from the risk communication literature related to opinion leadership. Additional information is also provided on the specific context underlying the current study. Substantial writing [10–12] has previously addressed the political, economic, and environmental rationales for the development of HFC technologies, as well as the field's challenges; these will not be restated here.

1.1. *Views about hydrogen and fuel cell technologies*

Concerted attention to opinion about hydrogen-related technologies remains a relatively recent phenomenon. One recent review of the hydrogen-focused opinion research [13] divides this work into studies focused on awareness and knowledge, perceptions and acceptance, views about fueling stations, the public's willingness to pay additional costs, and mental imagery of the technologies. In most cases, studies touch on several of these topics. Most of the research have involved quantitative survey techniques, though qualitative research has sometimes been used alongside a survey [14–16] or in the context of exploratory work [17,18]. And, while much of the cited work has appeared in peer-reviewed journals, a number of frequently cited studies have appeared as industry- or government-sponsored reports. Zachariah-Wolf and Hemmes [19] are one of the few studies to include an experimental component. Most studies are focused on European or British samples, reflecting European Commission support for such work. Only a small number of studies [20–22] include North American respondents. The current study is therefore somewhat unique in focusing on an American population.

With regard to awareness and knowledge, the general finding from the previous work is that most people know little about HFC technologies. This was the finding of initial work by Atlmann and Graesel [23] and, while respondents were often aware of specific projects [24,25], low knowledge continues to be the case whether the focus is on members of the public asked about the acceptability of specific fuel-cell applications such as buses [20,26,27] and storage facilities [28], or on potential operators of HFC technologies such as taxi [15] or bus drivers. Both random samples of the general public [19,22] and samples from specific relevant populations [16,18] all point to relatively low HFC knowledge. The only study where there were relatively high levels of knowledge was a German study of BMW workers that found high levels of acceptance and an emphasis on the environmental and personal benefits [18].

Despite low levels of knowledge, most studies find relatively little concern about HFC technology risk, high levels of acceptance, and some willingness to pay a small additional cost for access to HFC technologies [13]. Such results are consistent with work in the area of science and risk communication that cautions about expecting a substantial relationship between knowledge and technology acceptance [29–32]. Rather, as several recent hydrogen-focused studies have pointed out [14–18], the risk communication literature emphasizes the role that variables such as trust in key decision-makers, rather than science literacy, play in technological acceptance [33,34]. The main study in which risk perceptions were a key factor in views about hydrogen focused on a hydrogen refueling facility where there had been previous disagreements between government decision-makers and local residents. Those charged with operating the technology focused less on safety and more on technical concerns about performance [15,25]. Consistent with the experimental work of Zacharias-Wolf and Hemmes [19] and contemporary work on social perception of nanotechnology [35–37], Yetano Roche et al. [38] caution that almost all current studies involve respondents with very limited direct or mediated experience with HFC technologies.

The current study is unlike most previous work in that, while it includes consideration of knowledge and risk perceptions, the workers surveyed were using HFC technologies in their day-to-day work. While trust is not explicitly addressed in the current study, the focus here on interpersonal discussion reflects an expectation that everyday talk among family, friends, colleagues, and others, makes an important contribution to the process of building and destroying trust. This is important because, while trust is difficult to foster, one factor underlying trust is a sense of shared values [33]. There is also the hope that well-executed public engagement involving fair procedures and respect for participants can help build a sense of shared identity and, ultimately, trust [4,39]. The focus on interpersonal discussion is also a unique aspect of this study.

1.2. *Opinion leadership and interpersonal discussion*

In this regard, drawing on classic [40] work from political communication, Nisbet has argued that those who wish to foster societal support for addressing climate change need to take advantage of opinion leaders in society to foster desired perspectives (positive views about HFC technologies, in the current context) within-social-networks [1]. The original concept of the 'two-step-flow' focused on how self-selected individuals characterized by higher levels of media use and

knowledge pass on their perspectives to others. By operating within existing social networks, opinion leaders can be expected to have relatively higher levels of communicative credibility. Childers [41] has emphasized the concept of issue-specific opinion leaders, while Weimann and his colleagues have argued in favor of searching for "influentials" based on measures of personality strength [42–44]. Keller and Berry [45] have also described the work of the polling firm Roper ASW on influentials over more than half a century, and an enormous body of literature has described the role of early adopters in the "diffusion of innovation" [46].

While early adopters do not *necessarily* share their views with other [1,47], Kelly [48] explicitly recognizes diffusion of innovation as the grounding for his work aimed at identifying opinion leaders in the gay community and using them in campaigns to reduce risky sexual behavior. Attempts to replicate this type of campaign in the UK were not successful [49], but the underlying concept of taking advantage of opinion leaders is at the heart of Nisbet's [50] proposal. Besley [51], for example, explored the degree to which citizens who took part in engagement activities around both nanotechnology and HFC technologies reported speaking to others about their experiences. More generally, Southwell and his colleagues [2,52] have reviewed and explicated the role of intended and unintended interpersonal discussion in the context of media campaigns, and interpersonal discussion has recently been the focus on a range of studies related to public engagement. The current study draws on this work by exploring the degree to which Childers' issue-specific opinion leaders [41] and Weimann's [42] personality-based general opinion leaders are present in the South Carolina HFC worker community. It then assesses the role of these variables as predictors of interpersonal discussion.

1.3. *Summary of key literature*

In summary, as with previous research, the current study seeks to understand a specific population's perceptions of HFC technologies' risks and benefits. However, the current study also includes additional consideration of interpersonal communication based on opinion leadership literature that identifies such behavior as a key to how people develop views about new subjects. The focus below is therefore on first using descriptive statistics to highlight key variables related to both technology perceptions and communication and then using standard multivariate methods to explore the degree to which the technology-oriented and opinion leadership oriented variables predict communication behavior. In other words, the goal is to assess the HFC technology workers views and determine how these views are associated with a specific behavior that the literature suggests may be central to future technology adoption. The final models therefore address both the predictors of opinion leadership behavior and, ultimately, interpersonal discussion.

1.4. *South Carolina context*

As noted, a range of actors in South Carolina have made the development of a regional HFC technology industry a strategic priority. At the time of this research, several organizations had begun to integrate such technologies into their regular activities and the workers at these organizations represent the population of interest for the current work. The largest of these organizations is a factory that is using fuel-cell-powered forklifts, but fuel cells are also in use in smaller application across the state. Specifically, the University of South Carolina is using fuel cells to heat water in a residence complex and to power the baseball stadium scoreboard. A local TV stations are using fuel cell-powered cameras. A city facility has installed equipment for refueling hydrogen fuel-cell buses. A large military base and mobile telephone company have both installed fuel cell-powered backup generators for critical equipment. And, finally, local police officers are using a fuel-cell-powered Segway Human Transporter.

In total, the South Carolina Hydrogen and Fuel-Cell Alliance (SCHFCA) identified approximately 100 non-managerial workers using HFC technologies as part of their jobs over the previous year (about two-thirds of these individuals were using the fuel-cell forklifts). This means that, in contrast to previous studies where many participants had only limited experience with hydrogen power, South Carolina has a unique population of individuals with substantial, real-world experience. The focus was placed on non-managerial workers because of a desire to focus primarily on individuals for whom exposure to HFC technologies was a by-product of their position, rather than something they necessarily chose for themselves.

2. Methods

2.1. *Research goal and analysis method*

As suggested above, the goal below is to use descriptive statistics to highlight key attributes of HFC technology workers in South Carolina and to then use the underlying data to present an assessment of the degree to which the variables described are associated with interpersonal discussion.

In addition to exploring the frequencies for the key variables (explicated below), the normal distribution of the variables enables the use of an ordinary least squares regression [54] model to predict interpersonal discussion. Equivalent models are also provided for issue-specific and general opinion leadership to help put the interpersonal discussion model in context. The independent variables used to predict opinion leadership will be demographics, perceived investment potential, media use, risk/safety perceptions, views about the environment, and views about the need to reduce reliance on foreign oil imports. The same independent variables, as well as the opinion leadership measures, are used to predict interpersonal discussion. While the opinion leadership measures come from the research described above, the variables focused on specific views about HFC technologies (e.g., views about environment or foreign oil) were drawn from the general literature on the rationale for HFC technology development [10–12] and of the key aspects of the argument that the SCHFCA uses in its technology promotion work. The interpersonal discussion model is central because it highlights who is currently most likely to disseminate views about HFC technologies to others

Table 1 – Demographics of SC HFC respondents.

Average Age	41 (*SD* = 8.67)
Gender	84% male
Race	79% white
Less than college degree	63%
Bachelors degree	29%
University education (including graduate)	7%

$n = 70$.

and who technology proponents might therefore work with for technology promotion purposes.

2.2. Survey implementation

The population for this study was all regular non-managerial workers in South Carolina that are required to operate HFC technologies in their everyday activities. The SCHFCA identified workplaces with relevant technology and made contact with onsite managers to identify workers. In August 2009, an SCHFCA employee then either traveled to the workplace to distribute the three-page survey or mailed it directly to the identified workers. The SCHFCA's position within the South Carolina HFC community enabled high levels of cooperation from managers.

To ensure participant privacy, satisfy human subject protection requirements and limit respondents' sense that they needed to provide certain answers (demand effects), most respondents were asked not to put their name or workplace on the survey and were given a sealable, postage-paid envelope within which to place the survey once it was complete. The workers could then either give it back to the SCHFCA representative or mail it directly to the university-based first author. The survey identified the principal investigator as a university-based researcher who was collaborating with the SCHFCA but who would handle all data independently to ensure confidentiality. When the first author received the surveys, these were entered into a spreadsheet and any information that could be used to identify participants was erased. Caution was used in handling the data because some of the questions on the survey asked participants to assess the viability of the application. As such, to avoid potentially identifying specific individuals, some data (e.g., education and workplace) are not segmented below as much as the data would technically allow.

In the end, 70 of the approximately 100 individuals the SCHFCA believes use HFC technologies in their workplace replied. The research involves an attempted census and it is not, therefore, appropriate to report statistics related to sampling error. Rather, the main sources of potential error in the current study are measurement and non-response error, both of which are also present in sampling-based studies. An attempt was made to reduce measurement error through the use of multiple measures for key constructs (i.e., issue-specific opinion leadership) as well as through the use of measures adapted from previous studies. We attempted to minimize non-response error by ensuring that respondents could respond freely and at their own leisure. Further, it is difficult to know the exact population or to imagine that, even if the population were known, to obtain full participation. Although we have no reason to think they are systematically biased in one direction or another, these limitations suggest that the exact numbers presented should be read with caution, given the focus on a single state, caution should also be made when attempt to interpret the results for other locales. Finally, while we report significance levels below as though we had a conducted random sample survey, the census-based approach to data collection means that all of the relationships are technically significant.

2.3. Participant demographics

Most of the participants in the survey did not attend university or college and were male and white. Participants were not asked for their income. According to the U.S. Census Bureau,

Table 2 – Risk perceptions of SC HFC respondents.

	2	1	−1	−2	
Perceptions of HFC Risk					
I DO NOT WORRY about the safety of hydrogen and fuel-cell technology	33%	30%	25%	12%	I WORRY about the safety of hydrogen and fuel-cell technology
If an accident were to happen with hydrogen and fuel-cell technology, the results would NOT likely be FATAL	12%	36%	28%	25%	If an accident were to happen with hydrogen and fuel-cell technology, the results would likely be FATAL
Any risks associated with hydrogen and fuel-cell technology are WITHIN MY CONTROL	18%	50%	21%	12%	Any risks associated with hydrogen and fuel-cell technology are BEYOND MY CONTROL
Perceptions of HFC Related Risks					
I DO NOT WORRY about the impact of global climate change	17%	17%	31%	31%	I WORRY about the impact of global climate change
I DO NOT WORRY about the impact of air pollution on health and the environment	10%	17%	30%	40%	I WORRY about the impact of air pollution on health and the environment
I DO NOT WORRY about America's dependence on foreign oil	13%	4%	20%	59%	I WORRY about America's dependence on foreign oil

$n = 68$.

Table 3 – Experience with HFC Technologies (Since I started working with hydrogen and fuel cells I have become…).

	−2	−1	Same	1	2	
LESS positive about the safety of the technology	1%	7%	33%	31%	27%	MORE positive about the safety of the technology
LESS positive about the value of the technology for U.S. energy independence	1%	1%	26%	37%	34%	MORE positive about the value of the technology for U.S. energy independence
LESS positive about the value of the technology for economic development	3%	6%	23%	44%	24%	MORE positive about the value of the technology for economic development
LESS positive about the environmental value of the technology	1%	6%	23%	39%	31%	MORE positive about the environmental value of the technology

$n = 69$.

about 74% of South Carolinians are white and 27% have a bachelor's degree or higher. This means that survey participants are slightly more likely to be white and slightly more educated than the average South Carolinian. Table 1 provides a summary of key characteristics.

2.4. *Measures*

Multiple measures of key concepts were used whenever possible. Also, when meaningful, response options were numbered from −2 to +2 with such that the middle point (if provided) would represent a neutral opinion. Scales were created by a simple arithmetic summation of the underlying questions (i.e., they were not differentially weighted). Cronbach's *alpha* is reported below as a measure of each scale's internal reliability [53], but exploratory factor analyses were also conducted to ensure that questions reported as scales were indeed measuring a single construct.

The survey included three questions to assess risk perceptions based on Slovic's [55] division of risk perceptions into dimensions of worry (2 questions) and concerns about control/uncertainty (1 question). A four-point semantic differential scale was used with values between '2' for a positive assessment and '-2' for a negative assessment. While traditionally the two dimensions are unique, they all appeared to measure a single construct in this study. They are therefore added together to create a single scale ($M = -0.36$, $SD = 3.59$, $alpha = 0.78$, $n = 69$). In addition, three separate questions asked about the degree to which respondents worried about climate change ($M = 0.44$, $SD = 1.53$, $n = 68$), air pollution ($M = 0.75$, $SD = 1.42$, $n = 68$), and U.S. dependence of foreign oil ($M = 1.12$, $SD = 1.42$, $n = 67$). Table 2 contains the frequency for each of these variables. The variables for climate change and air pollution are highly correlated ($r = 0.87$, $p < 0.00$) so these are combined for the analysis below ($M = 1.19$, $SD = 2.85$, $n = 68$).

Self-reported experience with HFC technologies was measured in a way similar to the issue-specific worry questions and included a focus on the degree to which respondents said they had become more or less positive about the safety, value in achieving energy independence, economic potential, and environmental potential of HFC technologies. While each question had a different focus, their overall emphasis on experience led these to be highly correlated and they were therefore combined into a single experience scale ($M = 3.51$, $SD = 3.27$, $alpha = 0.88$, $n = 70$).

Perceived investment potential was assessed with a series of semantic differential questions that each addressed a different actor, including federal, state, and local government, and business, as well as an overall question about perceived future promise of HFC technologies. These are highly correlated and therefore added together to create a single measure of perceived investment potential ($M = 5.06$, $SD = 5.94$, $alpha = 0.95$, $n = 68$).

Media use, a key predictor of opinion leadership behavior, was measured using a simple exposure assessment (measured in minutes) for seven different types of content. The most common form of (reported) media use was television news, with about 1 h of daily exposure per worker. Respondents also indicated that they read the local newspapers about 45 min per day and national newspapers about 25 min per day. Respondents reported about 30 min each of exposure to more specific types of media (and these could potentially overlap with other

Table 4 – SC HFC Respondents' perceived investment potential.

	−2	−1	1	2	
Hydrogen and fuel-cell technology is a BAD investment for the federal government	10%	11%	26%	51%	Hydrogen and fuel-cell technology is a GOOD investment for the federal government
Hydrogen and fuel-cell technology is a BAD investment for state government	7%	11%	31%	49%	Hydrogen and fuel-cell technology is a GOOD investment for state government
Hydrogen and fuel-cell technology is a BAD investment for local government	7%	13%	31%	47%	Hydrogen and fuel-cell technology is a GOOD investment for local government
Hydrogen and fuel-cell technology is a BAD investment for businesses	7%	11%	31%	49%	Hydrogen and fuel-cell technology is a GOOD investment for businesses
Hydrogen and fuel-cell technology shows LITTLE promise for the near future	10%	11%	26%	51%	Hydrogen and fuel-cell technology shows GREAT promise for the near future

$n = 69$.

Table 5 – Media exposure.

	Minutes	SD
1. Reading local news (including online)?	43.81	36.25
2. Reading national newspaper (including online)?	26.06	28.79
3 Watching television news (including online)?	59.68	68.02
4. Watching or reading news about science and technology?	35.58	54.37
5. Watching or reading news about then environment?	23.96	32.41
6. Watching or reading news about economics or business	30.04	31.78
7. Watching or reading news about national security issues	29.36	41.75

$n = 69$.

types of media use). All of the media use variables were combined into a single measure of media exposure ($M = 248.49$, $SD = 220.65$, *alpha* $= 0.84$, $n = 68$). Because this measure may give additional weight to issue-specific media use, it should not be viewed as a measure of total minutes using media. The strategic priority given to HFC technology development in the state of South Carolina may have made HFC coverage more common than in other locales but no research has attempted to assess this hypothesis or to evaluate the tone or content of the available coverage (Table 5).

Issue-specific opinion leadership was measured with several statements adapted from the work of Childers [41]. Six statements were provided and were highly correlated ($M = -0.49$, $SD = 4.48$, *alpha* $= 0.88$, $n = 70$). General opinion leadership was measured with three additional questions adapted from Weimann [42]. These were also combined into a single measure of issue-specific opinion leadership with acceptable reliability ($M = 1.92$, $SD = 1.98$, *alpha* $= 0.74$, $n = 69$) (Table 6).

Interpersonal discussion was measured by asking about how often respondents had talked to four different types of people about HFC technologies during the past six months. This variable was initially recorded as an ordinal variable but, for the purposes of analysis, it was recoded based on the category mid-point (with 10 + equal to 12) to create a continuous variable with the unit of measurement being the number of people with whom the respondent indicated they had talked about HFC technologies. Recoding also enabled adding the four talk variables together for a single measure of interpersonal discussion ($M = 11.17$, $SD = 11.85$, alpha $= 0.85$. $n = 70$) (Table 7).

3. Results

3.1. *Views about the technology*

A number of interesting patterns emerge in the frequency distributions for the different question blocks.

With regard to risks (Table 2), on average, respondents felt that HFC technologies were safely manageable. While 51% thought accidents would be fatal, only about one-third of respondents expressed either worry or a sense that the risks were beyond the individual's control. Respondents further reported that their experiences with HFC technologies made them feel more positive about safety (Table 3).

Respondents also said they saw the potential for substantial benefits from HFC technologies. The survey showed that about two-thirds of workers said they worried about climate change, air pollution, and U.S. dependence on foreign oil (Table 2). The survey also, however, showed that respondents said that their experiences were making them more positive about HFC technologies' potential to help solve environmental

Table 6 – SC HFC respondents' issue-specific and general opinion leadership self-reports.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Issue-specific opinion leadership					
When I talk to others about HFC technology, I provide a great deal of information.	4%	17%	53%	21%	4%
My friends often use me as a source of knowledge in discussions about HFC technology.	14%	34%	40%	7%	4%
In a discussion about HFC technology, I would be the most likely to convince others of my views	4%	19%	44%	29%	4%
People I know are more likely to ask me about HFC technology than others.	13%	30%	35%	19%	3%
I tell others more about HFC technology than they tell me.	4%	14%	31%	43%	7%
Overall, I am a source of advice about HFC technology to others.	6%	31%	41%	17%	4%
Mean (*SD*)	8% (5%)	26% (9%)	38% (5%)	23% (14%)	4% (2%)
General personality-based opinion leadership					
I enjoy convincing others of my opinions.	3%	9%	46%	34%	7%
I often give advice and suggestions.	0%	6%	28%	55%	12%
I like to assume responsibility.	0%	4%	30%	41%	25%
Mean (*SD*)	1% (1%)	6% (3%)	35% (10%)	43% (11%)	15% (9%)

$N = 69$.

Table 7 – SC HFC respondents' self-reported interpersonal discussion.

	None	1 or 2 People	3–5 People	6–9 People	10 + People
Colleagues at work who do not directly use hydrogen or fuel-cell technologies in their job	21%	39%	26%	9%	6%
Family members	27%	39%	26%	3%	6%
Friends and neighbors	36%	20%	16%	11%	17%
Other people in your community (e.g., fellow church members, or people who are part of any type of local organization that you in which you participate)	64%	17%	4%	6%	9%

$n = 70$.

problems, and decrease U.S. energy dependence. They also saw the potential for HFC technologies to provide economic opportunity (Table 3). Additional questions specifically focused on economic potential (Table 4) suggest that the surveyed workers overwhelmingly saw investment in HFC technologies by a range of actors as a good idea.

3.2. *Opinion leadership behavior*

The overall mean for issue-specific opinion leadership was less than zero, suggesting that the majority of respondents do not see themselves as leaders when it comes to HFC communication. There were, however, some specific areas where respondents indicated relatively high levels of the behaviors associated with opinion leadership. About 50% of respondents indicated that they were likely to be a source of HFC information ("tell others"). Also, a third of respondents indicated that they thought they could convince others to adopt their views about HFC technologies, and about a quarter indicated that that they provide a great deal of information about HFC technology in their conversations. Overall, an average of about 27% of workers agreed or strongly agreed with the questions used to assess issue-specific opinion leadership, though only about 4% of workers strongly agreed with these measures.

Higher percentages expressed views consistent with general opinion leadership as personality strength, with more than half of the respondents indicating that they like to give

Table 8 – OLS regression for opinion leadership and interpersonal discussion.

	Issue-specific Opinion Leadership			Opinion Leadership as Personality Strength			Interpersonal Discussion		
	r	B	SE	r	B	SE	r	B	SE
Intercept		−4.365	3.325		1.724	1.528	0.128	−3.933	8.508
Age	0.002	−0.013	0.067	0.031	−0.011	.031	0.256*	0.266	0.167#
Gender (male = 1)	0.095	0.504	1.59	0.090	−.071	0.729	−0.052	3.633	3.943
Race (white = 1)	0.132	2.004	1.47	−0.037	−0.182	.677	−0.114	2.797	3.724
Education (high school = 1)	0.099	0.387	1.14	0.017	−0.108	.522	−0.032	−0.193	2.825
Media Use	0.266*	0.006	.003**	.175#	0.002	0.001*	0.233*	0.007	0.007
Perceived risk of HFC tech.	−0.53	0.048	.171	−.167#	−0.067	0.078	−.180#	−0.446	0.427
Concern about environment	0.047	−0.065	0.224	−0.121	−0.170	0.103#	0.105	1.017	0.568#
Concern about foreign oil	−0.059	0.226	0.454	0.002	−.049	0.209	0.166#	1.963	1.131*
HFC tech. invest. potential	−0.053	−0.143	0.115	0.189#	0.037	0.053	0.132	0.592	0.290*
HFC tech. experience	0.224*	0.462	0.221*	0.198*	0.104	0.102	−0.114	−1.628	0.572**
Issue-specific opinion leader.		–		0.203*	–		0.199*	0.626	0.335*
General opinion leader.	0.203*	–			–		0.137	0.562	0.730
	$R^2 = 0.196$; Adj-$R^2 = .052$ $F(10, 66) = 1.362$, $p < .222$[a]			$R^2 = 0.144$; Adj-$R^2 = -.009$ $F(10, 66) = .940$, $p < .504$[a]			$R^2 = 0.327$; Adj-$R^2 = 0.178$ $F(12, 66) = 2.191$, $p < .025$		

#$p < .10$; *$p < .05$; **$p < .01$ (one-tailed test), pairwise deletion, $n = 68–70$.

a Reduced models that include only the variables that showed a significant relationship with the dependent variable have significant F-tests ($F[2, 68] = 4.640$, $p < .013$, adj-$R^2 = .097$, and $F[5, 66] = 1.975$, $p < .095$, adj-$R^2 = .069$).

advice and to assume responsibility. On average, 58% agreed or strongly agreed with these statements, though again, the portion strongly agreeing was much smaller (15%).

When it came to actual talk behavior, the average level of talk suggests that each person has talked to more than 10 people about HFC technologies over the past six months. The frequency table shows, however, that there is a broad range in the level of interpersonal discussion with some people talking quite a lot but more people talking very little. Overall, it appears that about one-third of respondents talked to 11 individuals or more, while another third talked to less than 4 (meaning a third talked to between 5 and 10 individuals).

3.3. *Multivariate analysis of opinion leadership and interpersonal discussion*

The two models for opinion leadership, which provide context to the final model for interpersonal discussion, suggest that opinion leadership behavior exists relatively independently of specific views about HFC technology. In this regard, the model for issue-specific opinion leadership explains only 5.2% of the overall variance with only the variables for media use and a positive experience with the technology providing any explanatory power after controls. In contrast, media use and relatively lower level of concern about the environment predicts general opinion leadership as personality strength. Demographic variables are not significant correlates of opinion leadership in this population.

In contrast, the interpersonal discussion appears to be predicted by HFC technology variables as well as opinion leadership variables with the overall model explaining 17.8% of the variance. The model suggests that age, concern about the environment, concern about foreign oil imports, perceptions of the value of HFC technology investment, positive experience with HFC technologies, and issue-specific opinion leadership are all predictors of interpersonal discussion behavior (Table 8).

4. Discussion and conclusions

The current assessment of HFC workers in South Carolina clearly indicates that those who are working with HFC technologies are having positive experiences. The data presented on risk perceptions indicate that most respondents see little to no fear in HFC technologies and, perhaps more importantly, the respondents indicated that their experience was making them more positive across a range of areas. When asked to assess whether investing in HFC technologies remains a good idea, they were overwhelmingly positive.

On their own, the opinion leadership measures suggest that a number of South Carolina's HFC workers could be considered both issue-specific and general opinion leaders (personality-based). While most respondents reported neutral or negative views, substantial numbers also reported positive views. The fact that only a small portion of respondents strongly agreed with most of the opinion leadership measures highlights that, as would be expected, such behavior is far from universal. However, the presence of opinion leaders within the HFC worker population also means that, while many workers might be willing to talk about their experiences with HFC technologies if asked, there is also a group of individuals who might relish the opportunity. The fact that opinion leadership is unevenly distributed is also represented in the assessment of interpersonal discussion. Some individuals, whether by dint of opportunity or personality, are already out in their communities telling people about HFC technologies.

The multivariate analyses show that opinion leadership characteristics, particularly issue-specific leadership characteristics, are predicted by both media use and positive experiences. General opinion leadership was also predicted by media use but the failure for this variable to predict interpersonal talk suggests it may be less important to those interested in fostering HFC talk than the more targeted, issue-specific measure. The importance of media use in predicting discussion is not particularly surprising as such behavior is often considered characteristic of opinion leaders [1]. However, the relationship between positive HFC technology experience and issue-specific opinion leadership should reassure those interested in fostering broader use of HFC technologies that they are on the right track. The fact that these models do not explain a substantial amount of variance may not be particularly surprising as the characteristics relevant to opinion leadership are somewhat distal to specific views about technology. The real value of these variables, however, is revealed in their relative relationship to interpersonal discussion.

In this regard, the interpersonal discussion model shows that those who are talking about HFC technologies are doing so because of both HFC-specific and non-HFC-specific reasons. As the literature on opinion leadership suggests, issue-specific opinion leadership characteristics are one such factor. The other is that those who discuss HFC technology are also more likely to have concerns about issues such as the environmental or the country's energy-supply. In other words, other things being equal, those who are already talking about HFC technologies tend to be the kind of people who have concerns about environmental and energy issues but have had good experiences with HFC technologies. They also tend to be older and see the investment potential of these technologies. The hope for those charged with fostering wider adoption of HFC technology is that the types of individuals identified by the model for interpersonal discussion can be harnessed.

Indeed, such proponents may be able to use the results reported here for several purposes. First, if speaking with potential HFC technology adopters, they can emphasize that workers, many of whom have personal environmental and political concerns about traditional energy technologies, appear eager to accept HFC technologies in the workplace. It is noteworthy, in this regard, that most of the workers in the current study had not gone to college and received only limited training related to HFC technologies. Second, the fact that people are having good HFC technology experiences and that these experiences are associated with interpersonal discussion could be used to reassure funding organizations that support for demonstration projects can result in positive outcomes for participants. Third, proponents could draw on

the results to argue for the potential value of providing existing opinion leaders within the workforce with the resources to enhance the dissemination of positive messages about HFC technologies. Doing so might expand the impact of these issue-specific opinion leaders.

Future research needs to test the degree to which interpersonal discussion has impact on discussion partners' perceptions of both HFC technologies and views about decision-makers (e.g., trust). Such work is at the heart most risk communication work and should include both additional quantitative work as well as qualitative work aimed at delving into the factors that may contribute to opinion leadership on HFC issues.

Ironically, the fact that HFC technologies appear to have been integrated into the workplace with relatively few problems (and almost no training) may limit the scope of potential conversation topics. In other words, inasmuch as people like to talk about things that *have* happened, the unproblematic arrival of fuel cells in the workplace may limit the depth or amount of interpersonal discussion. Nevertheless, it may also be interesting to explore the degree to which participants felt they had a voice in the decision to use HFC technologies and the degree to which such attitudes affect views about HFC technologies. Past experience in the field of emerging technology communication (i.e., the referenced work on biotechnology and nanotechnology) clearly shows that the potential value of a technology is not the only factor that determines whether a technology will be successful. Ultimately, those who believe HFC technologies have the potential to provide useful services – as well as those that may have concerns about such technologies – should ensure that they consider the interpersonal dynamics at the heart of opinion leadership research.

REFERENCES

[1] Nisbet MC, Kotcher JE. A two-step flow of influence? Opinion-leader campaigns on climate change. Sci Commun 2009;30:328–54.

[2] Southwell BG, Yzer MC. The roles of interpersonal communication in mass media campaigns. Commun Yearbook 2007;31:420–62.

[3] Joss S, Belluci S, editors. Participatory technology assessment: European perspectives. Gateshead: Athenaeum Press/Centre for the Study of Democracy; 2002.

[4] Stern PC, Fineberg HV, editors. Understanding risk: informing decisions in a Democratic society. Washington, DC: National Research Council/National Academy Press; 1996.

[5] Dietz T, Stern PC, editors. Public participation in environmental assessment and decision making. Washington, DC: National Research Council/National Academy Press; 2008.

[6] Einsiedel EF, Goldenberg L. Dwarfing the social? Nanotechnology lessons from the biotechnology front. In: Hunt G, Mehta M, editors. Nanotechnology: risk, ethics, and law. London, UK: Earthscan; 2006. p. 213–21.

[7] Center for Nanotechnology in Society. RTTA Program 3: deliberation and participation, http://cns.asu.edu/program/rtta3.htm; 2005 [accessed 24.03.08]Available from.

[8] Bolsen TF, Cook L. The polls-trends: public opinion on energy policy: 1974–2006. Public Opin Q 2008;72:364–88.

[9] Smith ERAN. Energy, the environment, and public opinion. Lanham: Rowman & Littlefield Publishers; 2002.

[10] United States Department of Energy and United States Department of Transportation. Hydrogen posture plan: an integrated, development, and demonstration plan. Available from: http://www.hydrogen.energy.gov/pdfs/hydrogen_posture_plan_dec06.pdf; 2006 [accessed 11.04.10].

[11] Rand DAJ, Dell R. Hydrogen energy: challenges and prospects. Cambridge: RSC Publishing; 2008.

[12] High Level Group for Hydrogen and Fuel Cell Technologies. Hydrogen energy and fuel cells: a vision for our future. Directorate-General for Research, Directorate-General for Energy and Transport. Available from: http://ec.europa.eu/research/fch/pdf/hlg_vision_report_en.pdf; 2003 [accessed 11.04.10].

[13] Ricci M, Bellaby P, Flynn R. What do we know about public perceptions and acceptance of hydrogen? A critical review and new case study evidence. Int J Hydrogen Energy 2008;33:5868–80.

[14] Sherry-Brennan F., Devine-Wright H, Devine-Wright P. Public understanding of hydrogen energy: a theoretical approach, Energy Policy, in press, doi:10.1016/j.enpol.2009.03.037.

[15] Mourato S, Saynor B, Hart D. Greening London's black cabs: a study of driver's preferences for fuel cell taxis. Energy Policy 2004;32:685–95.

[16] LBST. The acceptance of hydrogen technologies: a study carried about by Ludwig-Bolkow-Systemtechnik GmbH (LBST) in cooperation with Ludgwig-Maximilians university of Munich. Available from: http://www.hydrogen.org/accepth2/execsumm.html; 1997 [accessed 28.05.10].

[17] Ricci M, Bellaby P, Flynn R. Engaging the public on paths to sustainable energy: Who has to trust whom? Energy Policy 2010;38:2633–40.

[18] Schulte I, Hart D, van der Vorst R. Issues affecting the acceptance of hydrogen fuel. Int J Hydrogen Energy 2004;29:677–85.

[19] Zachariah-Wolff J, Hemmes LK. Public acceptance of hydrogen in the Netherlands: two surveys that demystify public views on a hydrogen economy. Bull Sci Technol Soc 2006;26:339–45.

[20] Hickson A, Phillips A, Morales G. Public perception related to a hydrogen hybrid internal combustion engine transit bus demonstration and hydrogen fuel. Energy Policy 2007;35:2249–55.

[21] Martin E, Shaheen SA, Lipman TE, Lidicker JR. Behavioral response to hydrogen fuel cell vehicles and refueling: results of California drive clinics. Int J Hydrogen Energy 2009;34:8670–80.

[22] Cooper C. Hydrogen knowledge and opinions survey. Available from:. Washington, DC: U.S. Department of Energy Hydrogen Energy Program, Department of Energy http://www1.eere.energy.gov/hydrogenandfuelcells/hydrogen_publications.html; 2004 [accessed 8.01.10].

[23] Altmann M, Graesel C. The acceptance of hydrogen technologies. Available from:. The Euroepean Commission http://www.hydrogen.org/accepth2/study.html; 1998 [accessed 8.01.10].

[24] Heinz B, Erdmann G. Dynamic effects on the acceptance of hydrogen technologies: an international comparison. Int J Hydrogen Energy 2008;33:3004–8.

[25] Saxe M, Folkesson A, Alvfors P. A follow-up and conclusive report on the attitude towards hydrogen fuel cell buses in the CUTE project: from passengers in Stockholm to bus operators in Europe. Int J Hydrogen Energy 2007;32:4295–305.

[26] O'Garra T, Mourato S, Pearson P. Analysing awareness and acceptability of hydrogen vehicles: a London case study. Int J Hydrogen Energy 2005;30:649–59.

[27] O'Garra T, Mourato T, S, Garrity L, Schmidt P, Beerenwinkel A, Altmann M, et al. Is the public willing to pay for hydrogen buses? A comparative study of preferences in four cities. Energy Policy 2007;35:3630–42.

[28] O'Garra T, Mourato T, S, Pearson P. Investigating attitudes to hydrogen refueling facilities and the social cost to local residents. Energy Policy 2008;36:2074–85.
[29] Bauer MW, Allum N, Miller S. What can we learn from 25 years of PUS survey research? Liberating and expanding the agenda. Public Underst Sci 2007;16:79–95.
[30] Sturgis PN, Allum N. Science in society: re-evaluating the deficit model of public attitudes. Public Underst Sci 2004;13: 55–74.
[31] Wynne B. Public understanding of science research: new horizons or hall of mirrors? Public Underst Sci 1992;1:37–43.
[32] Nisbet MC, Goidel RK. Understanding citizen perceptions of science controversy: bridging the ethnographic-survey research divide. Public Underst Sci 2007;16:421–40.
[33] Earle TC, Siegrist M, Gutscher H. Trust, risk perception and the TCC model of cooperation. In: Siegrist M, Earle TC, Gutscher H, editors. Trust in cooperative risk management: uncertainty and scepticism in the public mind. London: Earthscan; 2007. p. 1–50.
[34] Poortinga WN, Pidgeon F. Prior attitudes, salient value similarity, and dimensionality: toward an integrative model of trust in risk regulation. J Appl Soc Psychol 2006;36:1674–700.
[35] Lee CJ, Scheufele DA, Lewenstein BV. Public attitudes toward emerging technologies: examining the interactive effects of cognitions and affect on public attitudes toward nanotechnology. Sci Commun 2005;27:240–67.
[36] Macoubrie J. Nanotechnology: public concerns, reasoning and trust in government. Public Underst Sci 2006;15:221–41.
[37] Brossard D, Scheufele DA, Kim E, Lewenstein BV. Religiosity as a perceptual filter: examining processes of opinion formation about nanotechnology. Public Underst Sci 2009;18:546–58.
[38] Yetano Roche M, Mourato S, Fischedick M, Pietzner K, Viebahn P. Public attitudes towards and demand for hydrogen and fuel cell vehicles: a review of the evidence and methodological implications, Energy Policy, in press, doi:10.1016/j.enpol.2009.03.029.
[39] Besley JC. Focusing on fairness in science and risk communication. In: Kahlor L, Stout P, editors. Communicating science: new agendas in science communication. Thousand Oaks, CA: Sage; 2009. p. 68–87.
[40] Lazarsfeld PF, Berelson B, Gaudet H. The people's choice: how the Voter makes up his mind in a Presidential campaign. New York, NY: Duell; 1944.
[41] Childers TL. Assessment of the psychometric properties of an opinion leadership scale. J Mark Res 1986;23:184–8.
[42] Weimann G. The influentials: back to the concept of opinion leaders? Public Opin. Q 1991;55:267–79.
[43] Weimann G. The influentials: people who influence people. Albany: State University of New York Press; 1994.
[44] Weimann G, Tustin DH, van Vuuren D, Joubert JPR. Looking for opinion leaders: traditional vs. modern measures in traditional societies. Int J Public Opin Res 2007;19:173–90.
[45] Keller EB, Berry JL. The influentials. New York: Free Press; 2003.
[46] Rogers EM. The diffusion of innovation. 5th ed. New York: Free Press; 2003.
[47] M.P. Venkatraman, Opinion leaders, adopters, and communicative adopters: a role analysis. Psychol Mark. 6 (189) 51–68.
[48] Kelly JA. Popular opinion leaders and HIV prevention peer education: resolving discrepant findings, and implications for the development of effective community programmes. AIDS Care 2004;16:139–50.
[49] Elford J, Bolding G, Sherr L. Popular opinion leaders in London: a response to Kelly. AIDS Care 2004;16:151–8.
[50] Nisbet MC. Communicating climate change: why frames matter for public engagement. Environment 2009;51:12–23.
[51] Besley JC, Kramer VL, Yao Q, Toumey CP. Interpersonal discussion following citizen engagement on emerging technology. Sci Commun 2008;30:209–35.
[52] Southwell BG, Torres A. Connecting interpersonal and mass communication: science news exposure, perceived ability to understand science, and conversation. Commun Mono 2006; 73:334–50.
[53] DeVellis RF. Scale development: theory and applications. 2nd ed. Thousand Oaks: Sage; 2003.
[54] Cohen J, Cohen P, West SG, Aiken LS. Applied multiple regression/correlation analysis for the behavioral sciences. 3rd ed. Mahwah: Lawrence Erlbaum Associates; 2003.
[55] Slovic P. Perception of risk. Science 1987;236:280–5.