

# Public participation in genomics research in the Netherlands: Validating a measurement scale

Anne M. Dijkstra<sup>1</sup>, Jan M. Gutteling<sup>1</sup>,  
Jac. A. A. Swart<sup>2</sup>, Nicolien F. Wieringa<sup>2</sup>,  
Henny J. van der Windt<sup>2</sup> and Erwin R. Seydel<sup>1</sup>

<sup>1</sup>University of Twente, The Netherlands

<sup>2</sup>University of Groningen, The Netherlands

## Abstract

Nowadays, new technologies, like genomics, cannot be developed without the support of the public. However, although interested, the public does not always actively participate in science issues when offered the opportunity via public participation activities. In a study aimed at validating a measurement scale, first, we investigated if public participation existed, and, secondly, we investigated how levels of public participation in genomics research varied among groups. Finally, we studied which factors predicted public participation. Results were based on a questionnaire with four subsamples. Results confirmed, first of all, the internal consistency of the measurement scale to assess levels of public participation. Secondly, the groups differed significantly with regard to their levels of participation in genomics research. Finally, the findings revealed that information-seeking behaviour, knowledge and education were main predictors of public participation, while interest, social involvement, and trust and influence had some influence together with age and gender.

## Keywords

biotechnology, genomics, measurement scale, public participation, science–society relationship

## 1. Introduction

It is widely understood that genomics cannot be developed without the support of the public. Politicians as well as researchers agree that the introduction of new technologies, such as genomics or nanotechnology, requires public acceptance, in particular when it concerns issues of health and food. This is the lesson learned from the emergence of biotechnology in the 1980s and 1990s (Gaskell and Bauer, 2001). In fact, the public itself generally demands to play a role when it comes to the development of science and technology (Leshner, 2005; Te Molder and Gutteling,

---

### Corresponding author:

Anne M. Dijkstra, University of Twente, Faculty of Behavioural Sciences, Institute ELAN, Science Communication, Postbus 217, 7500 AE Enschede, The Netherlands

Email: a.m.dijkstra@utwente.nl

2003), and biotechnology in particular (De Jong et al., 2000). The public finds itself interested in science and technology, yet considers itself often poorly informed. Additionally, and even more strikingly, the public demands a role in making decisions on science issues, but does not participate on a large scale when offered an opportunity (Gottweis, 2002; Leshner, 2005; Te Molder and Gutteling, 2003). In this paper, we investigated this seemingly inconsistent behaviour of the public – being interested, but not participating when offered the opportunity – by studying public participation behaviour in relation to genomics research. In the study we designed a five-item scale to measure public participation, and tested this scale in various groups in the Netherlands for consistency and validity. Finally, we looked at determinants of public participation. Results of this validation study may help us to understand what to expect when organising public participation activities.

Public participation is often seen as the ideal solution for the growing gap between science and society; it fits into the idea of “upstream engagement” – engaging the public in science issues from the stage of agenda-setting onwards – and it has become the favourite communication instrument of governments (Gibbons, 1999; Pidgeon et al., 2009; Rogers-Hayden and Pidgeon, 2007; Wilsdon and Willis, 2004). It is seen by them as the way to create acceptance and to restore trust in experts (Hagendijk, 2004). Thus, participation has been a concept that attracted wide political interest and the urge for participation is underlined by many authors (cf. Hagendijk et al., 2005; Rowe and Frewer, 2005; Wilsdon and Willis, 2004). Bauer, Allum and Miller (2007: 80) place participation and deliberation in the line of development from a science literacy paradigm, to a public understanding paradigm, to a science and society paradigm (Von Grote and Dierkes, 2000; Weigold, 2001; Wynne, 1991). It is in this latest phase that participation and deliberation are most important (see also Einsiedel and Thorne, 1999; Logan, 2001; Rogers-Hayden and Pidgeon, 2007).

Conceptually, participation is closely connected to the concept of empowerment (Hansen, 2005). Participation is one of the strategies for enhancing empowerment; it is a prerequisite for empowerment and it is an element of psychological (individual) and community empowerment (Jacobs et al., 2005; Zimmerman, 2000). Both concepts are closely related to other concepts like trust and knowledge, and to the way communication and risks are regarded. According to Zimmerman (2000), “empowering processes at the individual level of analysis include experiences to exert control by participation in decision making or problem solving in one’s immediate environment. This may be achieved through participation in community organizations or activities” (p. 47). He considered participation as one of the critical aspects of the multilevel construct that empowerment is (Zimmerman, 2000). And, public participation in decision making has been a way to gain control at the individual, psychological level of empowerment (Zimmerman, 2000; see also Gurabardhi, 2005).

Therefore, public participation may also be considered as a continuous scale where the *level of participation* varies with the level of public involvement and public consultation in decision making. Early on, Arnstein (1969: 217) described levels of participation in her often used “ladder of citizens’ participation.” Many of the later models can be traced back to this ladder (Jacobs et al., 2005). In Arnstein’s view the ladder represents a continuous scale ranging from a situation where experts are in full control of all aspects of decision making to a situation where the public holds this position of full control. Each rung of the ladder corresponds to the degree of power citizens have in determining the end product. At the bottom level, two rungs, 1) *Manipulation* and 2) *Therapy*, describe “levels of non-participation.” In these rungs participants do not actually participate, but the decision makers’ objective is to educate or cure the participating member of the public. The next three rungs described what Arnstein (1969) called “levels of tokenism”: 3) *Informing*, 4) *Consultation* and 5) *Placation*. Informing is aimed at one-way communication from experts or

decision makers to the public, while, at the level of consultation, participating citizens provide experts with relevant information on the issues involved. In the process of consultation, citizens may be heard, but they lack the power to make sure that something is done with the views they express. There is no follow-up on the activity of providing information. The rung of placation is restricted to the situation in which participants can give advice, but the decision makers still can choose whether or not to take the advice into account. The three top rungs, 6) *Partnership*, 7) *Delegated Power* and 8) *Citizen Control*, Arnstein (1969) labelled “levels of citizen power.” The higher on the ladder, the more power participants gain to decide about the issues involved. At the level of partnership, the public can negotiate and engage with the experts or decision makers, while at the levels of delegated power and citizen control the public has a majority vote or is in full control. With regard to the communication involved, the lower levels involve top-down communication and a one-way flow of information, while at the highest levels dialogue and two-way flow of information are involved (Rowe and Frewer, 2000).

Furthermore, mechanisms of public participation have been reviewed by various authors (e.g., Chess and Purcell, 1999; Fiorino, 1989; Hanssen et al., 2002; Rowe and Frewer, 2000, 2004, 2005). Chess and Purcell (1999) stressed that a great variation in the criteria for success exists. Rowe and Frewer (2000) concluded that contextual and situational factors influence the effect that a certain mechanism of public participation can achieve. In later studies they evaluated effects of various public participation mechanisms (Rowe and Frewer, 2004, 2005), and described a typology of participation mechanisms. Furthermore, they discerned three levels of public engagement: public communication, public consultation, and public participation. Only in the third level will there be some degree of dialogue in the process that takes place. In their typology, communication refers to one-way communication and consultation is the possibility of the public to react upon decision making without an interactive process (Rowe and Frewer, 2005).

Our study is also aimed at providing more insight into the multidimensional aspects of participation. However, in contrast to studies that investigate participation mechanisms, we focused on public participation in gene research by taking the perspective of the individual. In this study we add to the work of Barnett et al. (2007) and Sturgis et al. (2004), who found fairly low attentiveness to issues about genes and genetics investigated by means of a hierarchical order and based on results from the British Social Attitudes Survey. We developed and validated a measurement scale based on the application of Arnstein’s and others’ ideas about a hierarchy of public participation and factors influencing public participation. As far as we know, regarding genomics, no similar study has been conducted. In the following section we describe methodological issues related to the study.

## 2. Method

### *Participants and procedure*

In the winter of 2006/2007, 6266 persons, between 18 and 65 years old who were representative of the Dutch population, were approached via an Internet panel of a professional marketing research agency.<sup>1</sup> In total, 1380 people started the online questionnaire and 1056 respondents completed it (response rate = 17%). From this group, we excluded respondents who indicated having experience with genomics research through their work or education ( $N = 29$ ). Next, the remaining group of respondents was divided into two subsamples: a general public sample ( $N = 986$ ) and a sample of respondents with experience in genomics research as a patient ( $N = 41$ ).

Additionally, members of two “natural” groups were asked to partake in the survey. First, members of the celiac disease patients’ association were asked to fill out the questionnaire by a call for

participation and a link to the online questionnaire on the association's website.<sup>2</sup> Of the 294 people that visited the website, 68 respondents completed the questionnaire (response rate = 23%). Second, experts in genomics research were recruited by sending an email with the link to the questionnaire to each expert's contact person at the national research program of the National Science Foundation (NWO-MCG). Experts who joined one of the Centres of Excellence of the National Genomics Initiative in the Netherlands were included. A total of 49 experts completed the questionnaire. Experts who indicated that they did not have experience with genomics research were excluded from the sample, resulting in a group of 45 experts.

In sum, a total of 1140 questionnaires were used for the analysis. These 1140 questionnaires consisted of surveys from 986 members of the public (I – general public), 41 members of the public with experience in genomics research as a patient (II – patients in general public), 68 celiac disease patients (III – celiac disease patients), and 45 experts (IV – experts).

### Questionnaire

Our survey questionnaire consisted of measures indicating people's level of *public participation*. Furthermore, concepts playing a role in the public–science relationship and influencing public participation as described in the section above were included. A section on demographics, i.e., gender, level of education, and age, completed the survey questionnaire. We derived measures from the literature that were based on results from previous studies within the larger research project (Dijkstra, 2008), or newly constructed. A pilot study including students ( $N = 70$ ) preceded the survey and guided the construction of the measures to be used in the final analysis. Unless otherwise reported, we rated each item on a 5-point Likert-type scale. To ensure that respondents understood what was meant by “genomics research” we gave a short explanation at the start of the questionnaire. We used only the Dutch term “genenonderzoek” when referring to genomics research.

All measures were explored by means of reliability analysis to test if the items in the scale consistently reflect the construct that is measured, and factor analysis to identify clusters of variables. For public participation a Guttman scale was created in which agreement with an item implies agreement with preceding items. Items were analysed and rank-ordered to discriminate between more passive and more active forms of participation. Additionally, data were analysed using univariate analysis of variance (ANOVA) supplemented by post hoc tests to test whether the four groups differed regarding their levels of participation.

*Public participation* was based on five items in which respondents could indicate their participation in genomics research. For this validation study, we derived the items from Arnstein's (1969) ladder of participation. Respondents could indicate if they had participated in genomics research by means of reading about, talking about, or searching for information on genomics research, or by attending public meetings or by participating actively in discussions about genomics. They could specify their answers on a 4-point Likert-type scale ranging from 1 – “no, never” to 4 – “yes, often.” Reliability analysis indicated good internal consistency for public participation, while factor analysis revealed one scale.

Other measurements included *social involvement*, which refers to the respondents' involvement in societal and political issues and is captured in two items, societal involvement and political involvement. Correlation between the two items was high.

*Attitude towards citizens' participation* is based on a scale of the respondents' judgement of citizens' general participation in the GM Nation Debate in Poortinga et al.'s (2003) study and adapted to the Dutch case. The construct consisted of five items in which respondents could indicate levels

of approval of government efforts to involve citizens in decision making about the limits of genomics research (e.g., “Involving citizens in decision making about limits of genomics research influences governmental decisions with regard to this issue”). Two negatively phrased items were reverse-coded, thus higher scores indicated higher agreement. However, factor analysis showed one conflicting item and this item was therefore excluded from the analysis. Reliability analysis indicated good internal consistency.

*Interest in genomics issues* indicated respondents’ interest in genomics research. This measure was based on previous Dutch work on this type of research (Pin et al., 2009) and was adapted to the current situation. In total six items measured *interest in genomics issues* (e.g., “I am very interested in genetic tests to determine hereditary diseases”). Factor analysis revealed one single factor. Reliability analysis indicated high internal consistency.

*Perception of genomics issues* is based on previous Dutch research with regard to genomics research (Pin et al., 2009) and was adapted to the current study in order to measure respondents’ perceptions. Six items measured *perception of genomics issues*. We asked respondents to indicate their positive or negative judgement of genomics research developments (e.g., “The use of genomics research to make plants and food products healthier for human beings”). Factor analysis revealed one single factor. Reliability analysis indicated high internal consistency.

*Information need* and *information-seeking behaviour* were included as indicators of communication processes and were measured by asking respondents how they behave with regard to information on genomics research. We developed two scales based on the literature on information sufficiency and information-seeking and information-processing behaviour (Griffin et al., 1999; Grunig, 1989; Ter Huurne et al., 2009). We adapted these scales. Three items in the scale *information need* assessed the need for information on genomics research (e.g., “In order to develop my opinion on genomics research, I need much information”). Three items in the scale *information-seeking behaviour* assessed the information-seeking behaviour dimension (e.g., “In cases of societal debate regarding genomics research I search for information on the issue”). Factor analysis revealed single factors. Reliability analysis indicated good internal consistency for both scales.

*Relative knowledge* indicated respondents’ self-reported knowledge of genomics research and was measured by three 3-point scale items with potential responses ranging from 1 – “know more” to 3 – “know less” (e.g., “In comparison with other people in my surroundings, I am inclined to think that regarding genomics research I ...”). The items were recoded, thus a higher score indicated more self-reported knowledge. Factor analysis revealed one single factor. Reliability analysis indicated good internal consistency.

*Trust* has been conceptualised in other studies as consisting of several dimensions, such as social trust and institutional trust (Earle and Cvetkovich, 1995; Sztompka, 1999). We measured both dimensions of trust. We asked respondents in which situations they trusted organisations or groups of people in general (*general trust*, five items, e.g., “I trust organisations or groups of people, when they make clear which interests they have in genomics research”). Factor analysis revealed one factor. Reliability analysis indicated high internal consistency.

As a second dimension, termed *trust and influence*, we asked about institutional trust as well. From a democratic rationale it is expected that citizens place great importance on being able to influence decision making. As Arnstein (1969), and more recently Poortinga and Pidgeon (2003) indicated, public participation is related to power, such as influence on the decision-making processes, which is also related to trust. Therefore, we asked respondents to indicate how much they trusted six types of organisations or groups of people to be honest about genomics research and we asked their opinion on how much influence these groups should have in determining the limits of genomics research. A total of six items measured *trust in persons or organisations* and six other

**Table 1.** Reliability of measured scales (in Cronbach's alpha), means and standard deviation per group

	Total sample (N = 1140)		
	# items (min-max)	$\alpha$	M (SD)
Level of public participation	5 (1-4)	.84 <sup>b</sup>	1.46 (.51)
<i>Before you filled out this questionnaire, did you ever</i>			
- read information on gene research			2.02 (.78)
- talk to someone about gene research			1.63 (.76)
- search for information in the library or on the Internet			1.41 (.74)
- attend a public meeting on gene research			1.14 (.51)
- participate actively in discussions about gene research			1.10 (.41)
Social involvement	2 (1-5) <sup>a</sup>	.34 <sup>**</sup>	2.60 (.85)
Attitude towards citizens' participation	4 (1-5)	.72	3.37 (.82)
Interest in genomics issues	6 (1-5)	.94	3.53 (1.06)
Perception of genomics issues	6 (1-5)	.88	3.52 (.91)
Information need	3 (1-5)	.78	4.16 (.79)
Information-seeking behaviour	3 (1-5)	.75	3.34 (.93)
Relative knowledge	3 (1-3)	.70	2.08 (.45)
General trust in organisations	5 (1-5)	.92	3.51 (.80)
Trust in and influence of <i>private</i> persons or organisations	4 (1-5)	.70	2.50 (.68)
Trust in and influence of <i>public</i> persons or organisations	6 (1-5)	.77	3.43 (.67)

<sup>a</sup> Correlation coefficients (Spearman's rho) are reported when scales consist of two items.

<sup>b</sup> Reliability analysis indicates good internal consistency when Cronbach's  $\alpha > .7$ .

\* $p < 0.5$ ; \*\* $p < 0.1$ .

items measured *influence of persons or organisations*. Factor analysis showed for both the trust and the influence items one conflicting item and these items were excluded from the analysis. Thereupon, factor analysis revealed two factors which indicated a division in persons or organisations operating in the private domain or in the public domain. Therefore, we constructed a scale with the trust and influence items regarding *private* persons or organisations (four items). Reliability analysis indicated good internal consistency. Factor analysis showed one factor. We applied the same procedure for items of trust in and influence of *public* persons or organisations (six items). Again, reliability analysis indicated good internal consistency and factor analysis showed one factor.

Table 1 shows the reliability analysis of the measured scales for the total sample, reported in Cronbach's alpha, as well as the mean scores, the standard deviation and the series of items used to measure public participation.

### 3. Results

#### *Characteristics of the samples*

The socio-demographic characteristics of the four samples in the study are summarised in Table 2.

The two groups derived from the public sample (I – general public, and II – patients in general public) are representative of the Dutch population in terms of gender but are slightly higher educated and less often from a single-person household (*Statistisch Jaarboek CBS, 2007*). As one might have expected because of their composition, the participants from the two “natural” groups are younger and more highly educated than the general public and the Dutch population as a whole.



**Table 2.** Characteristics of the samples

	Dutch population <sup>a</sup>	General public sample		Natural samples	
		I – General public (N = 986)	II – Patients in general public (N = 41)	III – Celiac disease patients (N = 68)	IV – Experts (N = 45)
	%	%	%	%	%
<i>Gender</i>					
Male	49.5	48.4	41.5	8.8	82.2
Female	50.5	51.6	58.5	91.2	17.8
<i>Education</i>					
Lower	33.4	19.0	17.1	1.5	0.0
Intermediate	41.0	47.1	41.5	32.4	0.0
Higher	25.1	34.0	41.5	66.2	100.0
<i>Age</i>					
< 20 years	24.3	2.2	–	1.5	–
20–39	26.9	26.7	26.8	50.0	44.4
40–64	34.5	71.1	73.2	45.6	55.6
65–80	10.7	–	–	2.9	–
> 80 years	3.6	–	–	–	–

<sup>a</sup> Taken from *Statistisch Jaarboek 2007*: CBS Statistics Netherlands (2007).

Participants from the group of celiac disease patients are predominantly female, whereas experts are mostly male. However, we decided not to correct for gender or educational level since the groups were considered to be naturally formed groups, and it would undermine the basic research question for this study to correct for these differences.

### *Consistency and validity of public participation*

The Guttman analysis revealed one scale for public participation varying from a low level of participation (passive participation) to a high level of participation (active participation). The items *read*, *talk* and *search* rank on the lower end of the continuum, while the items *attend a meeting* and *participate* are ranked on the higher end of the continuum. The coefficient of reproducibility indicates good quality ( $\lambda = .84$ ). Thereupon, we found large and significant differences in the total group for public participation ( $F(3, 1136) = 331.40, p < .001, \omega = .68$ ).<sup>3</sup> In addition, post hoc tests showed that publics with different backgrounds participate differently in genomics research.<sup>4</sup> The level of public participation was lowest within the general public group (I) and highest in the expert group (IV) while the two patient groups (II, III) ranked in between and were not significantly different from each other ( $I < II, III < IV$ ). Thus the experts, who were the most experienced in gene research, are the most active in participating. Both the two patient groups participate at an intermediate level, while the general public are the most passive group (see also Table 3).

### *Determinants of public participation*

The final goal of the study was to examine which factors contributed to public participation. First, we conducted a correlation analysis of the data on the total group (data not shown). Public participation was significantly correlated to all included prediction variables but age. We included all

**Table 3.** Public participation for the total sample, percentages for each item

Before you filled out this questionnaire, did you ever	No, never (%)	Yes, sometimes (%)	Yes, regularly and yes, often (%)
- read information on gene research	24.2	54.1	21.7
- talk to someone about gene research	51.1	38.6	10.3
- search for information in the library or on the Internet	71.4	19.6	9.0
- attend a public meeting on gene research	91.4	6.7	3.3
- participate actively in discussions about gene research	92.9	4.7	2.4

variables in a hierarchical multiple regression analysis in order to predict public participation. The results are shown in Table 4.

The proposed final model (model 5) for public participation explained 41% of the variance. These results suggested that the factors most predictive of public participation were respondents' *relative knowledge of genomics research*, their *information-seeking behaviour*, and their *level of education*. *Interest in genomics issues* delivered a contribution to public participation, as well as, *age, gender, social involvement*, and both *trust–influence scales*. In sum, these results indicate that persons who have a higher score for public participation are more knowledgeable, seek more information and are higher educated. They have more interest in genomics issues. Men are somewhat more active in participating than women and the more active people are younger and are more societally and politically engaged. Finally, trust in and influence of persons and organisations from the private and the public domain have opposite effects.

#### 4. Discussion and conclusions

First of all, in this study we created a scale for public participation. A low score on the scale indicates a more passive participation while a higher score indicates a more active participation in genomics research. The results support the idea of a hierarchy of public participation. Secondly, the natural groups are ordered along this passive–active continuum in the way as expected, that is publics in their roles of general public, patients or experts, vary in their level of public participation in genomics research. The general public may be regarded as a more *passive public*; experts are the most active participants in genomics research and, hence, they can be considered a more *active public*. Patients show intermediate participation levels. Finally, we can conclude that information seeking and having knowledge are motives influencing public participation, while some influence can be ascribed to other concepts included in the analysis such as interest, social involvement, and trust and influence.

To the best of our knowledge, this study is the first quantitative study that validates a scale of public participation, and, therefore, illustrates that people's public participation in genomics research varies with their roles. The findings give more insight into the relationship between publics and science. First of all, groups in society are only active in small numbers, when the urge to be active is there, i.e., as a patient, or, as a scientist who is in his expert role actively participating in genomics research. According to Felt (2000), a public adopts different roles depending on the particular functions it has to fulfil in relation to the way science is seen. Partly, the level of participation for the various groups could also be explained by the idea of "issue specialization" (Gaskell



**Table 4.** Hierarchical regression analysis (final model) with public participation as dependent variable (standardised)

	Independent construct	Final model $\beta$	t-value <sup>a</sup>	R <sup>2</sup>	F change	Significance F change (df)
	<i>Constant</i>		-1.12			
<i>Model 1</i>	<i>Model 1</i>					
	Age	-.06	<b>-2.40</b>			
	Education	.15	<b>6.03</b>			
	Gender	-.07	<b>-2.79</b>	.112	547.90	*** (1136)
<i>Model 2</i>	<i>Model 1 +</i>					
	Social involvement	.05	<b>2.07</b>			
	Attitude towards citizens' participation	.01	.34	.138	36.20	*** (1134)
<i>Model 3</i>	<i>Model 2 +</i>					
	Interest in genomics issues	.10	<b>3.07</b>			
	Perception of genomics issues	.05	1.57	.207	42.16	*** (1132)
<i>Model 4</i>	<i>Model 3 +</i>					
	Information need	-.04	-1.48			
	Information-seeking behaviour	.20	<b>6.70</b>			
	Relative knowledge	.42	<b>16.41</b>	.406	77.24	*** (1129)
<i>Model 5</i>	<i>Model 4 +</i>					
	General trust	.03	.97			
	Trust in and influence of <i>private</i> persons or organisations	.08	<b>3.09</b>			
	Trust in and influence of <i>public</i> persons or organisations	-.10	<b>-2.97</b>	.414	61.09	*** (1126)

<sup>a</sup> Based on two-tailed tests: for t-values > 1.96,  $p < .05$ ; for t-values > 2.58,  $p < .01$ . Significant coefficients are in bold.

and Bauer, 2001: 63). That is, publics – both the general public as well as the experts – are interested in science issues but can only specialise in a few issues. However, more research is needed to investigate the idea of issue specialisation in relationship to participation.

Regarding the predictors of public participation, the two main predictors “information-seeking behaviour” and “relative knowledge” confirm research by Grunig (1989), who found that the most active publics are most likely to communicate actively about the issues, are more knowledgeable about these issues, and engage actively in participation activities. Education contributes to public participation as well, meaning that higher educated people are more inclined to participate in genomics research. People who exhibit more *interest in genomics issues* are more active participants in genomics research and are more socially involved. Demographic variables, such as age and gender, have some influence as well. Of interest is the influence of *trust in and influence of persons or organisations*. The private and the public domain do have opposite influences.

In final conclusion, publics fulfil different roles with different levels of participation in genomics research. The wider public is a passive public, and although it is interested in genomics research, it does not participate in large numbers in public participation activities. Meanwhile, active publics are small groups of people who develop, for example, more expert knowledge about the issue. They need more information and search for information actively, but they also participate more often when offered the opportunity. Therefore, when roles change, for example, when people become patients, we can conclude that this affects the urgency for information and their public participation. Thus, governments should take into account more pluralistic models of the public–science relationship and should acknowledge the diversity of publics when organising public participation activities (cf. Hagendijk et al., 2005).

By studying public participation and its predictors, this study shows various dimensions of this construct, and provides more insight into the public–science relationship. But, some considerations should also be acknowledged. First of all, the survey method gives a certain perspective on the matter and provides one understanding of public participation in the public–science relationship. However, comparing the various naturally formed groups provides a clearer insight into the hierarchy of public participation. Second, the empirical data investigated the publics' participation in *genomics research*. Caution is in order here since it is known that publics respond differently to various science issues (cf. Gaskell and Bauer, 2006).

A better scientific understanding of the public–science relationship is a prerequisite for understanding people's participating behaviour. Too often it is assumed that the public will participate when offered the opportunity. Our study shows, this is not the case. Some suggestions can be formulated for future research and future efforts of public participation. Regarding future research, more attention should be directed towards the roles people play, and consider the question of when, how and why publics participate in science issues. Publics, in some roles, want information to be available, while, in other roles, publics want to get involved in decision-making processes (Kerr et al., 1998). Although, currently, only some publics are actively involved in science issues, the composition of a given public may change. Future research could identify these moments of changing roles (e.g., when a person becomes a patient), and could provide insight about wishes to participate and about more effective and useful communication. Thus, with regard to efforts of public participation, a pro-active role of policymakers and researchers in the participation and communication process regarding genomics research is recommended, while they should take into account that people participate in science issues differently.

### Acknowledgements

We gratefully acknowledge the suggestions of two anonymous reviewers. The study described in this paper was financially supported by the Dutch Research Organization in particular by the programme Societal and Ethical Aspects of Genomics (050-32-007 and 050-32-016).

### Notes

1. This agency is called Motivaction. The Internet panel consists of members representative of the Dutch population who partake in surveys a few times per year.
2. The celiac disease patients' association is involved in several genomics research projects intended to gain a deeper understanding of the disease.
3. Effect size measure  $\omega$  (omega) can be compared to Pearson's  $r$ , but the measure makes an adjustment for the fact that the effect size  $r$  is estimated (Field, 2005).
4. Since measurements of homogeneity were broken, Welch F statistics and Games-Howell post hoc analysis are reported.

## References

- Arnstein SR (1969) A ladder of citizen participation. *Journal of the American Institute of Planners* 35(4): 216–224.
- Barnett J, Cooper H, and Senior V (2007) Belief in public efficacy, trust, and attitudes toward modern genetic science. *Risk Analysis* 27: 921–933.
- Bauer MW, Allum N, and Miller S (2007) What can we learn from 25 years of PUS survey research? Liberating and expanding the agenda. *Public Understanding of Science* 16(1): 79–95.
- Chess C and Purcell K (1999) Public participation and the environment: Do we know what works? *Environmental Science and Technology* 33(16): 2685–2692.
- De Jong JM, Gutteling JM, Koopman BR, and Seydel ER (2000) Genetische manipulatie: Maatschappelijke reacties en communicatieprocessen [Genetic manipulation: Societal reactions and communication processes]. *Tijdschrift voor Communicatiewetenschap* 28(2): 165–180.
- Dijkstra AM (2008) *Of Publics and Science: How Publics Engage with Biotechnology and Genomics*. Enschede: University of Twente.
- Earle TC and Cvetkovich GT (1995) *Social Trust: Toward a Cosmopolitan Society*, 1st edn. Westport, CT and London: Praeger.
- Einsiedel E and Thorne B (1999) Public responses to uncertainty. In: Friedman SM, Dunwoody S, and Rogers CL (eds) *Communicating Uncertainty: Media Coverage of New and Controversial Science*. London: Lawrence Erlbaum, 43–57.
- Felt U (2000) Why should the public “understand” science? A historical perspective. In: Dierkes M and Von Grote C (eds) *Between Understanding and Trust: The Public, Science and Technology*. London: Routledge, 7–38.
- Field A (2005) *Discovering Statistics Using SPSS*, 2nd edn. London: SAGE.
- Fiorino DJ (1989) Technical and democratic values in risk analysis. *Risk Analysis* 9(3): 293–299.
- Gaskell G and Bauer MW (eds) (2001) *Biotechnology 1996–2000: The Years of Controversy*. London: Science Museum.
- Gaskell G and Bauer MW (eds) (2006) *Genomics and Society: Legal, Ethical and Social Dimensions*. London and Sterling, VA: Earthscan.
- Gibbons M (1999) Science’s new social contract with society. *Nature* 402(2 December): C81–C84.
- Gottweis H (2002) Gene therapy and the public: A matter of trust. *Gene Therapy* 9(11): 667–669.
- Griffin RJ, Dunwoody S, and Neuwirth K (1999) Proposed model of the relationship of risk information seeking and processing to the development of preventive behaviors. *Environmental Research* 80(2 Pt II): S230–S245.
- Grunig JE (1989) Sierra Club study shows who become activists. *Public Relations Review* 15(3): 3–24.
- Gurabardhi Z (2005) *A Journey into Risk Communication: Findings and Reflections on Organizations’ Risk Communication with Stakeholders*. Enschede: University of Twente.
- Hagendijk RP (2004) The public understanding of science and public participation in regulated worlds. *Minerva: A Review of Science, Learning and Policy* 42(1): 41–59.
- Hagendijk R, Healey P, Horst M, and Irwin A (2005) *Science, Technology and Governance in Europe: Challenges of Public Engagement. STAGE (HPSE-CT2001-50003) Final Report – February 2005*.
- Hansen J (2005) *Framing the Public: Three Case Studies in Public Participation in the Governance of Agricultural Biotechnology*. European University Institute, Florence.
- Hanssen L, Van Est R, and Enzing C (2002) *Het Participatieve Gen. Participatieve instrumenten in het omgaan met maatschappelijke vraagstukken over ontwikkelingen in voedingsgenomics*. The Hague: NWO.
- Jacobs G, Braakman M, and Houweling J (2005) *Op eigen kracht naar gezond leven. Empowerment in de gezondheidsbevordering: concepten, werkwijzen en onderzoeksmethoden*. Utrecht: University for Humanistics.

- Kerr A, Cunningham-Burley S, and Amos A (1998) The new genetics and health: Mobilizing lay expertise. *Public Understanding of Science* 7(1): 41–60.
- Leshner AI (2005) Where science meets society. *Science* 307(5711): 815.
- Logan RA (2001) Science mass communication: Its conceptual history. *Science Communication* 23(2): 135–163.
- Pidgeon N, Harthorn BH, Bryant K, and Rogers-Hayden T (2009) Deliberating the risks of nanotechnologies for energy and health applications in the United States and United Kingdom. *Nature Nanotechnology* 4(2): 95–98.
- Pin RR, Gutteling JM, and Kuttischreuter M (2009) Determinants of reactions to gene technology: A generic approach. *New Genetics and Society* 28(1): 51–65.
- Poortinga W and Pidgeon NF (2003) Exploring the dimensionality of trust in risk regulation. *Risk Analysis* 23(5): 961–972.
- Poortinga W, Pidgeon N, Bickerstaff K, Langford I, Niewöhner J, O’Riordan T, et al. (2003) *Public Perceptions of Risk, Science and Governance: Main findings of a British Survey of Five Risk Cases* (No. RSK990021/L144250037), January. Norwich: Centre for Environmental Risk, University of East Anglia.
- Rogers-Hayden T and Pidgeon N (2007) Moving engagement “upstream”? Nanotechnologies and the Royal Society and Royal Academy of Engineering’s inquiry. *Public Understanding of Science* 16(3): 345–364.
- Rowe G and Frewer LJ (2000) Public participation methods: A framework for evaluation. *Science, Technology & Human Values* 25(1): 3–29.
- Rowe G and Frewer LJ (2004) Evaluating public-participation exercises: A research agenda. *Science Technology & Human Values* 29(4): 512–557.
- Rowe G and Frewer LJ (2005) A typology of public engagement mechanisms. *Science Technology & Human Values* 30(2): 251–290.
- Statistisch Jaarboek CBS* (2007) The Hague: CBS Statistics Netherlands.
- Sturgis P, Cooper H, Fife-Schaw C, and Shepherd R (2004) Genomic science: Emerging public opinion. In: Park A, Curtice J, Thomson K, et al. (eds) *British Social Attitudes: The 21st Report*. London: SAGE, 119–147.
- Sztompka P (1999) *Trust: A Sociological Theory*. Cambridge: Cambridge University Press.
- Te Molder H and Gutteling J (2003) The issue of food genomics: About reluctant citizens and united experts. In: Van Est R, Hanssen L, and Crapels O (eds) *Genes for Your Food – Food for Your Genes: Societal Issues and Dilemmas in Food Genomics*. The Hague: Rathenau Institute, 117–131.
- Ter Huurne EFJ, Griffin RJ, and Gutteling JM (2009) Risk information seeking among U.S. and Dutch residents: An application of the model of risk information seeking and processing. *Science Communication* 31: 215–237.
- Von Grote C and Dierkes M (2000) Public understanding of science and technology: State of the art and consequences for future research. In: Dierkes M and Von Grote C (eds) *Between Understanding and Trust: The Public, Science and Technology*. Amsterdam: Harwood, 341–361.
- Weigold MF (2001) Communicating science: A review of the literature. *Science Communication* 23(2): 164–193.
- Wilsdon J and Willis R (2004) *See-through Science: Why Public Engagement Needs to Move Upstream*. London: Demos.
- Wynne B (1991) Knowledges in context. *Science, Technology & Human Values* 16(1): 111–121.
- Zimmerman MA (2000) Empowerment theory: Psychological, organizational and community levels of analysis. In: Rappaport J and Seidman E (eds) *Handbook of Community Psychology*. New York: Kluwer Academic/Plenum Publishers, 43–63.

## Author Biographies

Anne M. Dijkstra is an assistant professor at the University of Twente, Faculty of Behavioural Sciences. She studies the relationship between science, technology and society from a communication perspective. Her research focuses on risk and science communication and public participation regarding biotechnology, genomics, human enhancement and nanotechnology.

Jan M. Gutteling is an associate professor of crisis and risk communication at the University of Twente and the research centre for Conflict, Risk and Safety Perception (iCRiSP). His research focuses on the understanding of risk perception and the application of this understanding in crisis and risk communication. Recent themes are environmental risks and physical safety issues, modern biotechnology and genomics, and water safety management (flood risks).

Jac. A. A. Swart is associate professor at the Science and Society Group of the Energy and Sustainability Research Institute Groningen. His research focuses on ethics, visions, and social aspects of the life sciences, in particular with respect to restoration and conservation of nature, animal experimentation, biotechnology, and food sciences.

Nicolien F. Wieringa has specialised in the field of social pharmacy. Her research interests include the development and social implications of new medical and food technologies.

Henny J. van der Windt is associate professor at the Science and Society Group of the Energy and Sustainability Research Institute Groningen. His research interests include science and technology studies, in particular the role of civil society organisations in science and technology, and environmental history.

Erwin R. Seydel is professor of Applied Communication Studies at the University of Twente and Scientific Director of the Institute of Behavioural Research at this university. His research interests include the study of communication in relation to social change strategies, and new technologies.