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## Under high tension

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# CHAPTER

# 6

## “These power lines make me ill”: A typology of residents’ responses

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**Submitted**

## ABSTRACT

### Background

Little attention has been devoted to the potential diversity in residents' health responses when exposed to an uncertain environmental health risk. The present study explores whether subgroups of residents respond differently to a new high-voltage power line (HVPL) being put into operation.

### Methods

We used a quasi-experimental prospective field study design with two pretests during the construction of a new HVPL, and two posttests after it was put into operation. Residents living nearby (0-300m, n = 229) filled out questionnaires about their health and their perception of the environment. We applied latent class growth models to investigate heterogeneity in the belief that health complaints were caused by a power line. Classes were compared on a wide range of variables relating to negative oriented personality traits, perceived physical and mental health, and perceptions of the environment.

### Results

We identified five distinct classes of residents, where the largest class (49%) could be described as emotionally stable and healthy residents with weak responses to the introduction of a new power line. A considerable minority (9%) with good perceived health before the power line was put into operation responded more strongly to the new line being activated. Residents in this class had heard more about the health effects of power lines beforehand, were more aware of the activation of the new line, and reported a decrease in perceived health afterwards.

### Conclusions

There is considerable heterogeneity in health responses to a new HVPL. The perceived health risks of exposure appeared to play an important role in this typology which has implications for risk management.

## INTRODUCTION

Exposure to an uncertain environmental health risk can have a profound impact on an individual and societal level. Well-known cases such as the Three Mile Island accident, or Love Canal, demonstrate how health concerns of those exposed play a crucial role in societal outcomes (see [1-3]). Impacts can be profound, even if in hindsight the health risks of exposure are proved to be small according to toxicological experts. The social amplification of risk framework (SARF, [4,5]) explains such findings by illustrating that an individuals' interpretation of, and responses to a risk event, takes place within a complex social context and may eventually lead to societal impacts such as protests, financial losses, organizational changes and litigation. The present paper aims to provide insight into the multifaceted nature of risk events through profiling residents' health responses to an uncertain environmental health risk in a prospective field study.

The specific case of an uncertain environmental health risk that we investigate is the construction of new high-voltage power lines (HVPLs). Due to increasing demands for reliable and renewable energy supplies many governments deem it necessary to build new HVPLs [6]. Proposals to build new power lines in residential areas are often met with fierce local opposition [7,8]. The potential health risks of exposure to extremely low-frequency electromagnetic fields (ELF-EMF) emitted by HVPLs play an important role in the public debate regarding new HVPLs [9-12]. Pooled analyses of epidemiological studies suggest an association between magnetic field exposure from HVPLs and childhood leukemia [13-15], and single studies have suggested a relationship between ELF-EMF exposure and Alzheimer's disease [16], and headaches [17].

In contrast to high frequency ionizing radiation (e.g. X-rays) there is no known plausible biophysical mechanism that might explain these findings. Some experts consider the health risks of exposure under the current exposure limits as non-existent [18], where others do see reason for some concern based on the epidemiological evidence [19,20]. As a result some countries apply the precautionary principle and try to avoid building new lines close to people's homes, which comes with considerable financial costs. Home-owners in the Netherlands who live within the projected magnetic field zone associated with the higher relative risk of childhood leukemia, for instance, get an offer to sell their house to the government and lower voltage (50/110/150 kV) overhead lines in residential areas are being undergrounded. If there is a causal relationship between ELF-EMF and childhood leukemia, this operation could potentially prevent one case of childhood leukemia to occur in the Netherlands in every two years [21]. The costs of this operation are estimated to be around 580 million euros [22].

Despite, or because of the inconclusive evidence for health effects, 70% of the European population believes that HVPLs affect their health to at least some extent [23]. For residents living close to HVPLs these health beliefs are particularly strong [24-26] and some expect to develop non-specific health complaints such as headaches and concentration problems when exposed to EMF from HVPLs [27,28]. In previous work we demonstrated the negative impact of a new HVPL on health perceptions of

nearby residents [38]. When compared to a control group of residents living farther away, residents living within 300 meters showed a larger increase in reported non-specific health complaints and thought it more likely that their health complaints were caused by a power line after the new line was put into operation. Hence, the potential impact of new HVPLs on societies as well as on individuals should be an area of concern.

Given the complexity of factors involved, surprisingly little attention has been devoted to the potential diversity in residents' health responses when exposed to an uncertain environmental health risk such as ELF-EMF from HVPLs. Risk events unfold over time and subgroups of residents might respond at different moments and in different directions. Even though not much is known about the existence of distinct response patterns, risk factors have been identified for attributing health complaints to environmental factors in general. These factors include a negative oriented personality (NOP traits, see [29]), high concern about the effects of environmental exposures on health [26,30,31], demographic characteristics like gender or age [32-34] and pre-existing physical and mental distress [35-37]. The introduction of new HVPLs offers the rare opportunity to study heterogeneity in health responses of residents in a prospective manner, and investigate whether these responses match a psychosocial profile based on these potential risk factors.

The present study has two aims. First, we investigate whether we can identify subgroups of residents living close to the introduction of a new HVPL based on different developmental trajectories of the belief that a power line caused health complaints. For this group of residents as a whole (< 300 m of the new line) we previously found that the strength of causal belief was already higher during construction of the line and increased after it had been put into operation [38]. If subgroups of residents respond in qualitatively different ways to such events this has important implications for research and practice. Second, we explore whether this typology of residents' responses can be characterized by a distinct pattern of socio-demographic and psychological factors. As we are the first to profile these responses our study is explorative and meant to provide new hypotheses for future research and to inform policy makers involved in risk governance.

## METHODS

### Participants and procedure

The sample consisted of residents living within 0-300 m (n = 229) of a newly introduced HVPL in the Netherlands. Participants were on average 52 years old (SD = 10.5) and 46.3 % were male. The majority of the participants have had higher education (54.4 %), 31.6 middle and 14 % lower. Participants completed questionnaires two times before the new line was put into operation (T1, T2) and two times afterwards (T3, T4). The first measurement (T1) took place during construction of the new power line, and the second (T2) 5 months later when major construction work was finished, but still 5 months before the line was put into operation. The last two measurements took place respectively 2 (T3) and 7 months (T4) after the line was put into operation. The moment that the line would be put

into operation was communicated by the electricity grid operator through postal mail and over the internet.

All residents living within 0-300 m were invited by postal mail to participate in a longitudinal environmental health study. To reduce the potential for response bias and demand characteristics, power lines were not mentioned in the invitation letter and the questionnaires contained questions about a wide range of environmental factors (e.g. wind turbines, busy roads, railway lines). Participants filled out questionnaires digitally (or on request on paper) and received a maximum of three reminders. Residents who did not respond to our invitation at T1, again received an invitation at T2. After the new power line was put into operation (T3, T4) only residents who had participated at T1 and/or T2 were invited. Full details about the study design and inclusion are given elsewhere [39].

## Measures

### *Causal belief*

To assess health responses to the new HVPL we measured the strength of the belief that an overhead power line had caused health complaints. We asked participants to indicate on a 5-point scale (from 1 = certainly not, to 5 = certainly and 6 = not applicable) whether they believed that their health complaints during the previous week were caused or worsened by an overhead power line (amongst 10 other environmental factors; e.g. wind turbines and mobile phone base stations). All scores of participants who did not report any health complaints were recoded to a missing value. For participants who did report health complaints the not applicable score was recoded to 1 (certainly not).

### *Potential risk factors*

We measured several potential risk factors for attributing health complaints to environmental factors. These are divided into socio-demographic variables, negative-oriented personality traits, perceived physical and mental health, and perceptions of the environment.

### *Socio-demographic variables*

Socio-demographic characteristics assessed included age, sex, education, marital and occupational status, homeownership and years of residency at current address.

### *Negative-oriented personality traits*

Two types of negative oriented personality traits were assessed. Neuroticism was assessed with the 12-item neuroticism subscale of the NEO Five-Factor Inventory (NEO-FFI, [40]) which intends to measure a tendency to experience negative distressing emotions and to possess associated behavioral and cognitive traits [41]. A perceived lack of mastery, which might be seen as a negative oriented personality characteristic indicative of a lack of psychological resources, was measured with the 5-item Mastery scale [42]. For both scales participants needed to indicate on a 5-point Likert scale to what extent they agree with statements describing themselves. A sum score was calculated for both scales and a higher score reflects a more negative oriented personality.

### *Perceived physical and mental health*

Several questions and scales were used to assess perceived physical and mental health at baseline. As a general indicator of perceived health, participants were asked to rate their health in general on a 5-point scale (ranging from 1 = excellent, to 5 = poor; general health item, SF-12, [43]). Additionally, participants indicated whether their health status interfered with their daily activities during the previous week on a 3-point scale (ranging from 1 = no problems, to 3 = unable to perform usual activities; usual activities item from EQ-5D, [44]). To assess the experience of somatic symptoms the 16-item somatization scale of the 4DSQ [45] was used, and the experience of cognitive symptoms was assessed with the 6-item MOS Cognitive Functioning Scale [46]. For somatic symptoms, participants indicated on a 5-point scale whether they were bothered by a broad range of symptoms (headaches, dizziness, low back pain, etc.) during the previous week (ranging from 1 = no, through to 5 = constantly), while cognitive symptoms (e.g. forgetfulness, difficulty concentrating, trouble maintaining attention) were rated on a 6-point scale (1 = all of the time, to 6 = none of the time). Following instructions [47] the somatic symptom scores were trichotomized and summed and for cognitive symptoms scores were recoded and an average was calculated.

The extent to which participants were concerned about their health was measured with the 4-item health concern scale of the RAND General Health Perceptions Questionnaire [48]. On a 5-point scale (1 = definitely true, 5 = definitely false) participants indicated whether statements regarding health concerns corresponded to their own view and a sum score was calculated. After the power line was put into operation a global rating of change scale ranging from -3 (deteriorated) to +3 (improved) was used to measure to what extent one's health had changed in the previous six months. Perceived mental health at baseline was assessed with the 14-item Hospital Anxiety and Depression Scale (HADS, [49]). This scale contains 7 items assessing the experience of anxiety-related feelings during the past week, as well as 7 items assessing depressive feelings. Sum scores were calculated. For all questions regarding perceived physical or mental health, higher scores indicate more negative perceptions.

### *Perceptions of the environment*

Different beliefs regarding a list of 11 environmental factors, including overhead power lines (see Appendix 1 for all factors), were measured using 5-point scales with verbal descriptors. One item assessed perceived proximity to an overhead power line (1 = very far, to 5 = very close). Another item referred to how often during the previous three months participants had heard or read about the health effects of an overhead power line (1 = never, to 5 = very often) as indicator of the perceived saliency of environmental health risk information. To assess negative health expectations of overhead power lines, participants were asked whether they considered this environmental factor to be a health risk in general for those living in the vicinity (1 = certainly not, to 5 = certainly), and whether they think they would get health complaints themselves if they lived near the factor (1 = certainly not, to 5 = certainly). Finally, participants were asked to indicate how concerned they were about the effects



of an overhead power line on their own personal health (1 = no concern, to 5 = extreme concern).

After the new power line was put into operation (T3, T4) we asked for the same list of 11 environmental factors whether they perceived any change in their living environment concerning these factors in the previous six months in a yes/no format. In the case of a yes response, respondents could type in what exactly had changed. We combined these two questions as an indication that a participant was aware that the new power line was put into operation (0 = not aware of a change and/or did not mention activation of the new line at T3 and/or T4; 1 = aware of a change and mentioned activation of the new line at T3 and/or T4).

### Statistical analyses

To investigate heterogeneity of residents' health responses to the new power line, we conducted latent class growth model (LCGM) analyses (see [50]) using robust full-information maximum likelihood estimation (Mplus version 6.12 was used for all analyses) on the strength of the belief that an overhead power line had caused health complaints. LCGM is an extension of latent growth curve models where one intercept (initial value) and one slope (change) is estimated to describe overall growth in a sample. In contrast, LCGM allows to estimate separate intercepts and slopes for a number of unobserved classes. The goal of LCGM analyses is to identify different clusters in such a way that homogeneity is maximized within classes and heterogeneity between classes [51].

In these analyses we specified the slope as T1 (0), T2 (0), T3 (1), T4 (1), representing change in the strength of causal belief after the line was put into operation. We compared 1- to 6-class models and used conventional criteria to assess the relative statistical fit of these models (BIC, AIC, Entropy, LMR-LRT and BLRT, see [52]). We plotted the log-likelihood values of these different models to further guide the decision of the best fitting model. Model selection should however not just be based on statistical fit. We plotted the average strength of the causal belief against time-point (T1 till T4) and most likely class-membership based on posterior probabilities of the different class models. Based on the interpretability of these plots, as well as the statistical fit of the different models, we selected one model to further explore the typology of health responses to a new power line. To check whether class membership was uniquely associated with a response to the new power line, we also plotted the average strength of causal beliefs of all other environmental factors (e.g. wind turbines, mobile phone base stations, etc.) according to class membership.

Characteristics of residents in the different classes as measured before the new line was put into operation, as well as the perceived change in general health and the awareness of the activation after the line was put into operation, were compared using ANOVA's for continuous measures, and chi-square tests for categorical measures. Significant differences ( $p < .05$ ) should be interpreted as exploratory results and are merely displayed for descriptive purposes (see [53]).



## RESULTS

### Participant characteristics

The last column in Table 1 displays characteristics of participants living within 300 meters of the new power line. Participants with missing values on causal beliefs at all measurements occasions were excluded from further analyses ( $n = 16$ ). Of the remaining 213 participants, 46.9% participated at all four measurement waves, 27.7% at three, 14.6% at two and 10.8% at one. The majority of participants (78.9%) started participating at T1, while the remaining participants joined the cohort at T2.

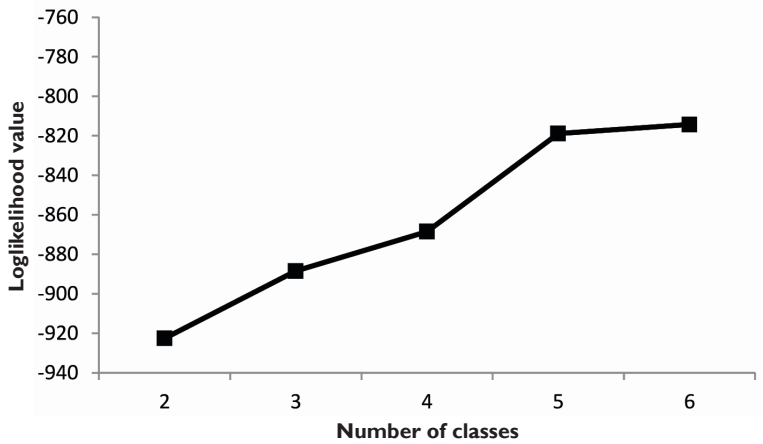
### Causal belief trajectories

Table 2 displays fit indices of the 1- to 6-class LCGM for the strength of the belief that a power line caused or worsened experienced health complaints. The BIC and AIC values indicate that model fit improved up to a 5-class model, which is in line with the bootstrapped LRT being non-significant for the 6-class model. Figure 1 shows the log-likelihood values of the different models. This plot clearly shows that the log-likelihood increased substantially when moving from a 4- to a 5-class model, while the line flattens out with a 6-class model. In addition to superior statistical fit of the 5-class model, the trajectories were also theoretically more defensible than the 3- or 4-class trajectories. The posterior class probabilities for the 5-class model varied from 0.70 to 0.93 and classification based on these probabilities lead to classes varying in size from 9 to 49%, which suggests that a 5-class model met the minimal requirements for further interpretation.

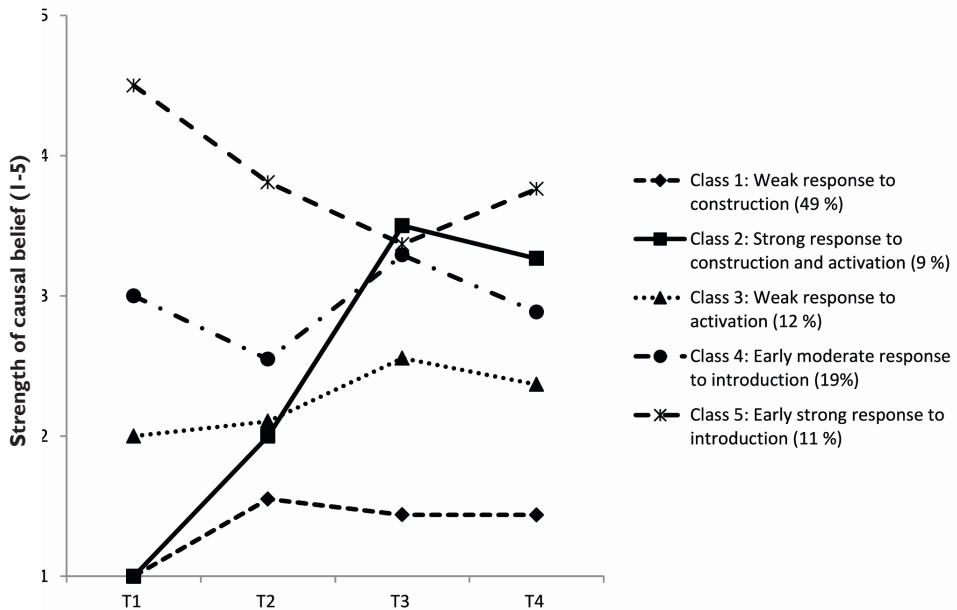
**Table 2.** Fit indices for the 1- to 6-class latent growth models.

Class	BIC	AIC	Entropy	p value	
				LMR LRT	Boostrapped LRT
1	2041.20	2021.03	-	-	-
2	1893.44	1863.19	0.735	0.262	< 0.001
3	1841.27	1800.93	0.772	0.005	< 0.001
4	1817.45	1767.03	0.773	0.062	< 0.001
5	1734.25	1673.75	0.795	0.057	< 0.001
6	1741.13	1670.54	0.789	0.260	0.076

Figure 2 shows the average strength of the causal belief for each class of residents before (T1, T2) and after the power line was put into operation (T3, T4). The largest class (49%, Class 1) consisted of residents who were very certain that their health complaints were not caused by a power line during construction at T1, but they found it a little less unlikely after the major construction work was finished at T2. They did not appear to respond to the moment the power line was put into operation. A second much smaller class (9%, Class 2) consisted of residents who were also certain that their health complaints were not caused by a power line during construction at T1, but showed a different pattern of a strong response after major construction work was finished at T2, as well as when the new power line was put into operation at T3. The



**Figure 1.** Loglikelihood values for the 2- to 6-class latent growth models.



**Figure 2.** Trajectories of the strength of the belief that a power line has caused experienced health complaints. **T1** = During major construction work, 10 months before activation of HVPL; **T2** = During minor construction work, 5 months before activation of HVPL; **T3** = 2 months after activation HVPL; **T4** = 7 months after activation HVPL.

third class of residents (12%, Class 3) did not show a response after major construction work was finished at T2, but demonstrated a small response when the line was put into operation at T3. Residents in the fourth class (19%, Class 4) fluctuated around the mid-point of the scale, indicating that they considered power lines as a potential cause for their health complaints during as well as after

**Table 1.** Characteristics of residents living in the vicinity (0-300m) of a new HVPL in general and according to class membership.

	<b>Class 1:</b> <b>Weak response to construction (n = 105)</b>	<b>Class 2:</b> <b>Strong response to construction and activation (n = 20)</b>	<b>Class 3:</b> <b>Weak response to activation (n = 25)</b>	<b>Class 4:</b> <b>Early moderate response to introduction (n = 40)</b>	<b>Class 5:</b> <b>Early strong response to introduction (n = 23)</b>	<b>Total (n = 213)</b>
<b>Socio-demographics</b>						
Age (M ± SD)	51.69 ± 10.33	50.85 ± 9.21	48.04 ± 9.04	55.05 ± 10.86	53.26 ± 12.20	51.98 ± 10.50
Gender (% female)	46.7	55	<b>72.0*</b>	62.5	52.2	54.0
Education level (% higher education)	51.9	65.0	<b>76.0*</b>	52.5	43.5	55.2
Marital status (% not married or living together)	11.4	20.0	12.0	12.5	13.0	12.7
Occupational status (% not working)	28.6	31.6	20.8	30.6	47.8	30.4
Residency before plans new HVPL (% yes)	85.3	90.0	68.0	87.5	77.3	83.3
House owner (% yes)	97.6	100	94.7	93.5	90.5	95.9
<b>Negative oriented personality traits</b>						
Neuroticism; 12-60 (M ± SD)	23.75 ± 8.08	27.26 ± 9.15	26.58 ± 10.05	<b>27.23* ± 6.97</b>	<b>30.82*** ± 8.40</b>	25.95 ± 8.54
Lack of mastery; 5-25 (M ± SD)	9.14 ± 3.47	<b>11.26* ± 4.48</b>	10.11 ± 3.40	9.68 ± 3.26	<b>11.05* ± 3.57</b>	9.81 ± 3.61
<b>Perceived physical and mental health</b>						
General perceived health; 1-5 (M ± SD)	1.90 ± 0.57	2.10 ± 0.72	2.04 ± 0.61	<b>2.25** ± 0.71</b>	<b>2.30** ± 0.76</b>	2.04 ± 0.65
Daily functioning (% some problems with daily activities)	16.2	20.0	24.0	<b>35.0*</b>	26.1	22.1
Somatic symptom reports; 0-32 (M ± SD)	3.06 ± 3.28	4.00 ± 2.94	4.24 ± 3.67	<b>5.80** ± 4.29</b>	<b>6.52** ± 5.45</b>	4.17 ± 3.97
Cognitive symptom reports; 1-6 (M ± SD)	1.55 ± 0.60	1.61 ± 0.52	<b>1.98** ± 0.61</b>	<b>1.85* ± 0.78</b>	<b>2.09*** ± 0.92</b>	1.72 ± 0.69
Perceived change in health <sup>a</sup> ; -3--3 (M ± SD)	0.03 ± 0.76	<b>-0.53* ± 0.83</b>	-0.38 ± 0.86	<b>-0.56** ± 0.85</b>	<b>-0.81** ± 1.25</b>	-0.30 ± 0.92

General health concern; 4-20 (M ± SD)	9.88 ± 2.70	10.55 ± 2.58	10.84 ± 3.94	<b>11.53** ± 3.45</b>	<b>12.83*** ± 2.59</b>	10.69 ± 3.13
State anxiety; 0-21 (M ± SD)	3.46 ± 2.56	<b>4.95* ± 3.26</b>	<b>5.12* ± 3.75</b>	<b>4.85* ± 2.87</b>	<b>6.35*** ± 3.47</b>	4.38 ± 3.08
State depression; 0-21 (M ± SD)	2.68 ± 2.73	3.84 ± 2.67	<b>4.28* ± 3.66</b>	<b>3.93* ± 2.92</b>	<b>5.65*** ± 3.96</b>	3.54 ± 3.16
<b>Perceptions of the environment</b>						
General dissatisfaction with living environment; 1-5 (M ± SD)	1.61 ± 0.66	1.70 ± 0.73	1.76 ± 1.01	1.70 ± 0.56	<b>2.45** ± 1.14</b>	1.74 ± 0.80
Perceived proximity of an overhead HVPL; 1-5 (M ± SD)	4.13 ± 1.11	4.25 ± 1.07	4.44 ± 0.77	<b>4.78*** ± 0.58</b>	<b>4.82*** ± 0.50</b>	4.37 ± 0.97
Perceived saliency of overhead HVPL health risk information; 1-5 (M ± SD)	2.81 ± 1.33	<b>3.80** ± 1.06</b>	2.95 ± 1.26	<b>3.45** ± 1.40</b>	<b>3.95*** ± 1.21</b>	3.16 ± 1.36
Negative personal health expectations of overhead HVPLs; 1-5 (M ± SD)	3.18 ± 1.25	<b>4.10** ± 1.07</b>	3.56 ± 1.08	<b>3.93*** ± 0.97</b>	<b>4.64*** ± 0.58</b>	3.61 ± 1.20
Negative general health expectations of overhead HVPLs; 1-5 (M ± SD)	3.76 ± 1.12	<b>4.42** ± 0.61</b>	3.84 ± 1.12	<b>4.26** ± 0.63</b>	<b>4.82** ± 0.40</b>	4.06 ± 1.00
Concern about effects of overhead HVPLs on personal health <sup>a</sup> ; 1-5 (M ± SD)	3.16 ± 1.32	<b>4.00** ± 0.88</b>	3.37 ± 1.42	<b>3.81** ± 0.98</b>	<b>4.55*** ± 0.86</b>	3.57 ± 1.27
Awareness of activation new HVPL <sup>c</sup> (% Yes)	26.2	<b>55.6*</b>	20.0	39.3	45.5	33.1

\* p < .05 compared to reference Class I

\*\* p < .01 compared to reference Class I

\*\*\* p < .001 compared to Class I

<sup>a</sup> Measured at T2.

<sup>b</sup> Measured at T4, question regarded a perceived change in health during the past half year.

<sup>c</sup> Measured at T3 and T4; if mentioned at one or both of these occasions this was coded as a yes response.

construction. Residents in the fifth class (11%, Class 5) already thought it very likely that their health complaints were caused by a power line during construction of the new line at T1. Although their causal belief decreased after major construction work was finished, it stayed strong throughout all measurement occasions.

For all classes the causal belief regarding overhead power lines clearly stood out from the other environmental factors (see Appendix 1). However, in most classes (3 till 5) causal beliefs regarding high traffic roads and/or mobile phone base stations resembled the longitudinal pattern of overhead power lines. The strength of these beliefs were much lower though.

### **Differences between classes in baseline characteristics**

Table 1 shows characteristics of residents recorded at baseline (unless otherwise stated) according to class membership. There were distinct differences between the classes in negative oriented personality, perceived physical and mental health, and perceptions of the environment. The largest class of residents (Class 1, weak response to construction) can be characterized by emotionally stable (low NOP scores, low state anxiety and depression scores) individuals with good perceived general health (low scores on physical health measures) who did not perceive the health risks of power lines as particularly high or salient (low scores on all power lines health risk variables) and did not perceive a change in their health after the new line was put into operation. In the subsequent analyses we compared the other smaller classes with this dominant class to see if we could identify differences in characteristics.

#### *Responders to activation of the new line*

Residents in Class 2 (strong response to construction and activation) scored higher on one NOP trait (lack of mastery) and were more anxious, but they did not perceive their physical health as worse than residents in the reference class. After the line was put into operation they reported a deterioration in general health and they were more aware of the activation of the new line. They also scored higher on health risk perceptions of power lines before the line was put into operation. The other class of residents who responded to the activation of the new line (Class 3, weak response to activation) consisted of more women and more highly educated residents than the reference class. They experienced more negative affect and reported more cognitive symptoms before the line was put into operation. They did not show higher scores on power line related perceptions.

#### *Early responders to the introduction of the new line*

The two classes who responded more strongly to the construction of the line instead of the activation (Class 4, early moderate response to introduction; Class 5, early strong response to introduction) differed considerably from reference Class 1 on several factors. Not only did they score higher on NOP traits (except for lack of mastery for Class 4), they perceived their mental and physical health as worse, were more concerned about their health, reported a larger deterioration in general health after the line was put into operation and scored higher on all power line perceptions before the line was put into operation. The differences with the reference class on

these variables were particularly large for residents showing a strong early response to the introduction of the new line (Class 5). A notable difference between the two classes, besides the size of the differences with the reference class, is the much higher general dissatisfaction with the living environment of residents in Class 5 during construction of the new line, and the higher reporting of problems with daily activities due to health of residents in Class 4.

## DISCUSSION

In the present study we found support for diversity in residents' health responses when a potential environmental risk event occurred, namely the introduction of a new HVPL in the direct vicinity. Subgroups of residents responded to the new line at different moments in time and could be characterized by differences in personality, perceived physical and mental health, and perceptions of the environment. These findings indicate that subgroups of residents interpret an environmental risk event in different ways. While the largest subgroup of residents showed little response to the construction of a new HVPL near their home, a small subgroup of residents responded strongly to the new line being activated. The latter group of residents evaluated the health effects of power lines more negatively and they were more aware of the moment when the new line was put into operation. Such a focus on potential environmental hazards appeared to be associated with a lack of perceived control over life and having heard more about the health effects of the exposure. Based on our findings, we hypothesize that a strong focus on the negative health effects of potential environmental hazards in the vicinity, is an important risk factor to develop health responses to these potential environmental risks.

We also identified a subgroup of residents who appeared to respond to the introduction of the new HVPL as a whole. During construction of the new line they already attributed health complaints to an overhead power line and remained doing so after the new line was put into operation. We found that this subgroup of residents scored higher on all previously identified risk factors for attributing health complaints to the environment (i.e. NOP traits, perceived physical and mental health, and environmental risk perceptions) and they were the only group of residents who were more dissatisfied about their living environment in general before the line was put into operation. Previous research has shown that the potential health risks of ELF-EMF are not the only burden for residents living near HVPLs. Other burdens such as the visual intrusion, disruption of the landscape, and fear for lower property values, are also important negative externalities [54,55] and these burdens interact and can amplify each other [11,28]. Based on our findings we hypothesize that such an amplification between different burdens and a more broad interpretation of a risk event, is more likely to occur in residents with a more negative orientation towards their physical and mental health, and a focus on potential health risks in their environment.

Contrary to what one would expect based on the literature, pre-existing health problems did not appear to be a risk factor for responding to increased exposure in our study. However, in line with previous work [30], we did find a prospective

association between beliefs about the negative health effects pre-exposure and attribution of health complaints post-exposure. Combined with the experienced deterioration in general health, this fits the profile of a nocebo response, where people experience more health complaints after exposure to an inert treatment due to negative expectations of the treatment (see [56]). Interestingly, these beliefs regarding the negative health effects of power lines were also stronger in the subgroups of residents showing an earlier response during construction of the line. This suggests that the crucial factor to be affected by an uncertain risk event may lie more in negative expectations about environmental exposures than the experience of health complaints before exposure.

The specific content of negative health expectations could differ between the identified subgroups of residents. In a qualitative study we found that the majority of residents had more abstract negative health expectations of living next to a power line, while a smaller group had specific concrete expectations regarding the development of non-specific health complaints which they associate with exposure to EMF from several sources [28]. The latter type of expectations might have been more prevalent in the only subgroup of residents who responded strongly to the activation of the new line. Especially because a similar, but less strong, developmental pattern could be seen for causal beliefs regarding another EMF source (mobile phone base stations) in this subgroup of residents. This suggests that a response to one environmental risk event may generalize to other similar events, which has been suggested before in the context of different stages of development of self-reported electromagnetic hypersensitivity [37]. Future research should focus on potential differences in the mental models (see [57]) of power lines in these different groups of residents to better attend to residents' specific concerns.

The most important limitation of this study is the explorative character. We used an exploratory data-driven analytic strategy (LCGM) which might lead to spurious findings [58-60]. The developmental pattern we observed for some subgroups could partly reflect regression to the mean, instead of a meaningful response pattern. In addition, the posterior probabilities for some classes only met the minimal requirements suggesting that not all derived classes might be as distinct from each other. We were able, on the other hand, to interpret most classes on the basis of residents' characteristics which suggests that our findings do not just reflect a spurious result. In line with experts' opinions we would like to point out that the result of any LCGM analysis should not be interpreted as direct evidence for the existence of distinct homogenous subpopulations [61]. At best, it serves as an approximation of a more complex reality. Future research with other power lines, and other environmental risk events, is needed to further investigate the hypotheses this study generated.

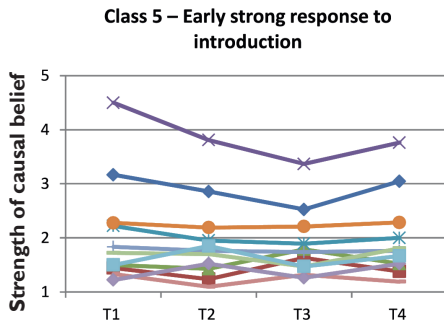
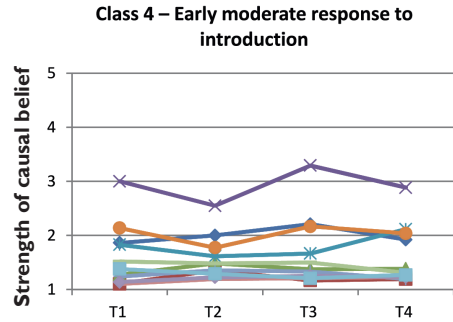
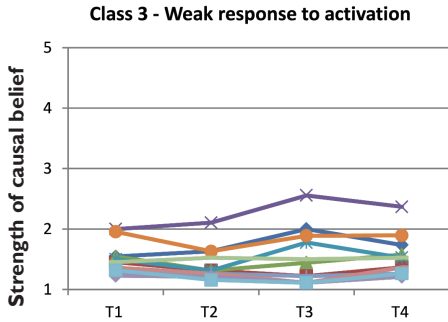
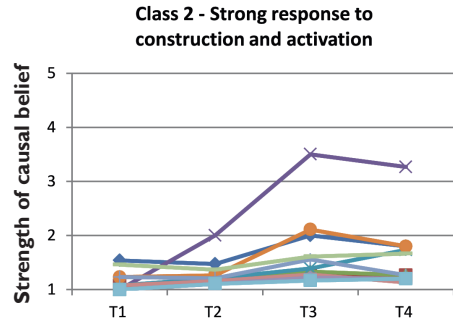
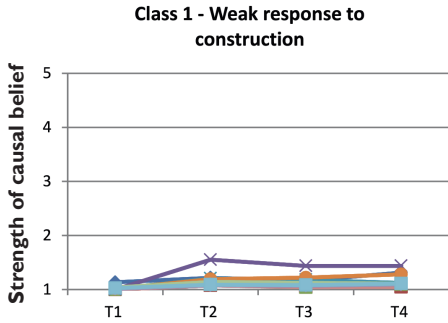
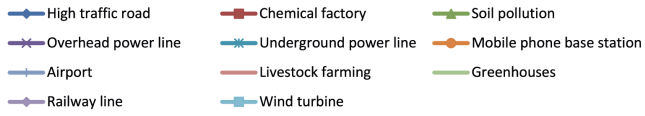
An important strength of this study is the prospective investigation of health responses to an uncertain environmental health risk and the use of comprehensive measures encompassing a wide variety of environmental and health related perceptions. This approach led to new hypotheses regarding the multifaceted nature of environmental risk events and identified potential individual characteristics involved in responding differently to such events. Our findings suggest that residents respond



differently depending on a specific constellation of beliefs regarding environmental exposures, their own health, and how they deal with distressing emotions. For risk managers and other involved stakeholders this presents a challenge when risk events unfold. Listening carefully to the different kinds of concerns of involved residents and adapt the content and timing of communications accordingly is the best possible advice we can give based on our findings.

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**Appendix I.** Longitudinal development of causal beliefs regarding environmental factors plotted against class membership.

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