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ARTICLE

Place attachment, distress, risk perception and coping in a case of earthquakes in the Netherlands

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Abstract
In the Netherlands, the extraction of natural gas from the ground has led to soil subsidence and the occurrence of earthquakes. These earthquakes cause physical damage to buildings and give rise to psychological distress. Research on the impact of natural hazards, such as earthquakes, has shown that there is a complicated relationship between place attachment, perceived risk and coping strategies. The current study, performed in the earthquake area, provides further insight into this relationship, with a focus on place attachment. The study examines whether place attachment is related to (1) the damage intensity of the neighbourhood, (2) socio-demographic characteristics, (3) cognitive and emotional characteristics and (4) coping strategies. The results show that stronger place attachment is related to higher age, lower education and place of origin in the region. Furthermore, respondents with strong place attachment more frequently indicated to be frightened by the multiple earthquakes and to expect damage to their dwelling as a consequence of future earthquakes. Nevertheless, these respondents less frequently intended to relocate than respondents with weaker place attachment. This result indicates that strong place attachment might diminish the chances of moving out despite the awareness of risk and the emotional response to the earthquake hazard.

Keywords Place attachment · Risk perception · Psychological distress · Earthquakes · Intention to move

1 Introduction

The extraction of natural gas in the province of Groningen, the Netherlands, has led to soil subsidence and, consequently, to the occurrence of earthquakes. The Dutch Petroleum Company (NAM) reports on its website 1320 earthquakes between January 1986 and May

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2019.[1] The strongest earthquake occurred in 2012 and was 3.6 on the Richter scale. This earthquake was unexpectedly strong and it raised the national awareness of the severity of the consequences of gas extraction (Kutlaca et al. 2019; van der Voort and Vanclay 2015). The combination of the shallow depth at which the earthquakes occur, the special composition of the ground and the fact that the constructions are not earthquake-resistant makes the buildings vulnerable to damage (van Elk et al. 2017). The cumulative earthquakes cause damage to houses, e.g., wall tiles that become loose, cracks in walls and damage to roofs (van der Voort and Vanclay 2015). Owner-occupiers can submit a claim to be compensated for the damage to their dwelling. To provide an idea of the width of the problem, about 80,000 damage claims have been submitted of which 53,000 have been granted so far (Kuipers and Tjepkema 2017). However, the process of claiming has turned out to be a very lengthy and complicated one. Residents feel that policy has failed and no longer trust the national government (van der Voort and Vanclay 2015; Kuipers and Tjepkema 2017; Boelhouwer and van der Heijden 2018). Previous research has shown that people are generally strongly attached to their homes and can experience severe distress if these homes are damaged or destroyed (Tapsell and Tunstall 2008). Important stressors that emerged in the earthquake area are: damage to property, decline in house prices, fears about the dykes breaking, insecurity, health issues, distrust and anger (van der Voort and Vanclay 2015).

The earthquakes can be viewed as a disruption to place. A disruption to place evolves over time as individuals try to make sense of what has happened or what might happen, and attempt to cope accordingly to alleviate the threat and/or negative feelings following it (Brown and Perkins 1992; Devine-Wright 2009; Fresque-Baxter and Armitage 2012). How do residents cope with the physical and psychological consequences of past and future earthquakes? Before going into more details, first some definitions of important concepts as well as their relationships will be discussed.

Risk perception concerns the intuitive risk judgments concerning natural or technological hazards (Slovic 1987). Risk perception is mediated by social influences (e.g., friends, family), whether or not an activity is voluntarily and by mental strategies (heuristics) that people use to structure their view of the world (Slovic 1987). Risk perception can also be influenced by the situation that people face, individual characteristics (Lopez-Vazquez and Marvan 2003) and previous experience (Tversky and Kahneman 1973; Whitmarsh 2008; Peters et al. 2012). Raaijmakers et al. (2008) make a distinction between the following three aspects of risk perception: awareness (of the risky situation), worrying about this situation and preparedness.

Place attachment can be broadly defined as a positive affective bond between people and specific places, which is characterized by the desire to maintain closeness to the object of attachment (Hidalgo and Hernandez 2001). Affect, emotion and feeling are central to the concept, but it also includes behavioural and cognitive components (Brown and Perkins 1992; Low and Altman 1992; Fried 2000; Billig 2006; Scannell and Gifford 2010). Usually, two dimensions are discerned: an emotional dimension (often called place identity) and a functional dimension (often called place dependency) (Mishra et al. 2010; Raymond et al. 2010; Cheng and Chou 2015; Westin 2016; Anton and Lawrence 2016). Place dependency concerns the functional bonds that people have with a place. The more the place meets a person's needs and goals, the better it will be evaluated and the more the person becomes dependent upon the place (Anton and Lawrence 2016). Place identity refers to the symbolic

[1] https://www.nam.nl/feiten-en-cijfers/aardbevingen.html#iframe=L2VtYmVkL2NvbXBvbmVudC8_aWQ9YWFyZGJldmluZ2Vu.

meaning of a place. (Shared) memories, ideas and feelings associated with a place become part of a broader self-identity (Anton and Lawrence 2016). Another important aspect of place attachment concerns the relationships with others (Low and Altman 1992). Scannell and Gifford (2010) introduced a three-dimensional "person–process–place" framework in which the person (who is attached?), the process (how are affect, cognition and behaviour manifested?) and the place (what is the object of attachment?) together form the framework upon which the concept of place attachment is built.

Coping can be defined as a person's cognitive and behavioural efforts to manage the demands of a stressful person-environment relationship (Folkman et al. 1986). In the context of the threat of earthquakes one can think of various strategies, such as fortifying one's house, accepting the situation, denying the situation, blaming the government, seeking information, becoming depressed, seeking social support and moving house. Which coping strategie(s) will be applied depends upon the situation, personal characteristics and other processes, such as risk perception (Lopez-Vazquez 2001).

Bonaiuto et al. (2016) performed a review study concerning natural hazards. Among other topics, the authors examined the relationship between place attachment and risk perception. The authors report on eight studies that showed that stronger place attachment was related to a higher awareness of the occurrence of a natural disaster, e.g., a volcanic eruption, hurricanes and earthquakes and mudslides. People who live in threatened places are known to report stronger place attachment, possibly because the threat of losing the place might remind residents of their attachment to it (Anton and Lawrence 2014; Cheng and Chou 2015). Bonaiuto et al. (2016) also report on four studies that showed a negative relationship. Stronger place attachment was related to lower risk perception in cases of seismic risk exposure, volcano risk and beach pollution threat. This result suggests that strongly attached residents might feel safe in their homes and this could lead to neglect or denial of the potential hazard, thus to underestimation of potential risk (De Dominicis et al. 2015; Bonaiuto et al. 2016). Lindell and Perry (2000) argue that residents might fail to personalize seismic risk; they do believe that they might experience an earthquake but do not think that they will be personally harmed by it. The 'optimism bias' might apply: individuals think that a disaster 'will not happen to them', is more likely to occur elsewhere, or with other people (Spittal et al. 2008; De Dominicis et al. 2015; Bonaiuto et al. 2016). The review study by Bonaiuto et al. (2016) suggested that place attachment can act as a barrier to the perception and action of natural occurring risks. For example, closer proximity to a risk source turned out to be related to stronger place attachment; the latter was related to lower risk perception.

Bonaiuto et al. (2016) also report on relationships between place attachment and coping activities. Both positive and negative relationships have been reported. This varying result can be explained because it concerns different types of coping with risky situations. The positive relationships generally showed that stronger place attachment was related to place-protective and pro-environmental behaviours (e.g., recycling and cleaning up beaches). Lindell and Perry (2000) also report on studies that found positive correlations between risk perception and seismic adjustment, such as purchasing insurance and storing food and water. The reported negative relationships mostly concerned the relationship between place attachment and moving from a risky area. Strongly attached individuals are generally less willing to relocate and are more likely to return to risky areas after a natural environmental disaster (Bonaiuto et al. 2016). De Dominicis et al. (2015) suggested that, when the perceived risk is high, place attachment could function as a barrier for enacting preventive behaviours to cope with an environmental risk of flooding.

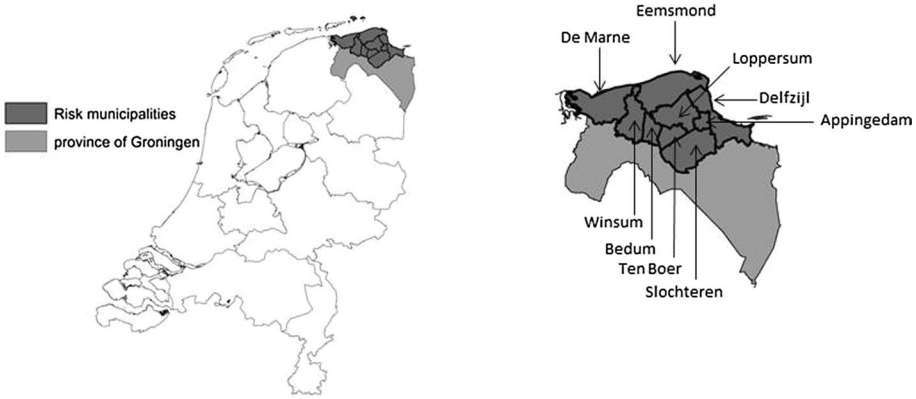

Fig. 1 The earthquake region in the province of Groningen in the Northeast of the Netherlands (adapted from Boelhouwer and van der Heijden 2018)

As described above, the relationships between place attachment, risk perception and coping strategies can be quite complicated. There is a lack of knowledge with regard to systematic scientific attention to the relationships between these concepts (Anton and Lawrence 2014; De Dominicis et al. 2015; Bonaiuto et al. 2016). For this reason, the current paper will focus on these concepts and especially on the role of place attachment. Furthermore, the situation in the earthquake area seems quite relevant to study the relationships between risk perception, coping and place attachment. Relatively weak earthquakes occur regularly in this region. Besides from that, other earthquake-related problems play a role, like the delay in the disbursement of damage claims and the request of residents to turn down the gas supply. Such topics are often discussed in the (national) media; almost on a daily basis. Consequently, residents are constantly reminded of the earthquake problem, they probably have thought about their earthquake-related risk and most of them will actually be in the process of coping with the situation. What this study also adds to the existing literature is the focus on the attachment for the region. Most research has been performed on the level of the neighborhood and only few on the level of the region (Hidalgo and Hernandez 2001; Lewicka 2010).

The following research questions were formulated:

1. What is the strength of place attachment and does it differ between residents living in areas with different damage intensity?
2. Is place attachment related to socio-demographic characteristics?
3. Is place attachment related to cognitive and emotional characteristics, such as personal experience of earthquakes, emotional response, risk perception and psychological distress?
4. Is place attachment related to coping strategies, i.e. the intention to move and the acceptance of the situation?

2 Methods

2.1 The earthquake region in the Netherlands

The Groningen gas field is located in the province of Groningen in the northeast of the Netherlands, near the municipality of Loppersum. The risk area consists of nine municipalities with about 96,500 inhabitants aged 18 years or older (Appingedam, Bedum, De Marne, Delfzijl, Eemsmond, Loppersum, Slochteren, Ten Boer, Winsum). Figure 1 shows the location of the risk area in the northeast of the Netherlands as well as the nine municipalities.

The risk area is a rural area with mainly agriculture and some farming. The landscape shows many natural as well as artificial watercourses. The municipalities of De Marne, Eemsmond and Delfzijl are located near the Wadden sea. The region has many dikes and houses built on mounds because of the past risk of flooding. The landscape is characterized by (monumental) detached buildings, like scattered farmhouses, churches, mills, monasteries and historical town centres. The region experiences serious population decline and has problems with an ageing population and decreasing liveability and employment opportunities (de Vries and Bresser 2015).

More than 19,000 residents in the risk area were invited by letter to take part in an internet survey. Residents were selected by having the nine municipalities take a random sample from their registry. The selection was partly stratified to obtain a sufficient number of respondents from smaller villages within the municipalities. The response rate was 23% (n = 4363, of which 4.260 were valid) (Hoekstra 2016).

2.2 Variables included in the study

The variables that are used in the study are summarized in Appendix 1.

2.2.1 Place attachment

Place attachment can be measured on different geographical levels, from a room in a house to the world (Scannell and Gifford 2010). In the current study, place attachment was operationalized with a question into the degree to which the respondent felt attached to the region. In Dutch, the word "streek" was used, which refers to the wider neighbourhood or region. A study by Lewicka (2010) showed that inhabitants of rural areas tend to identify more with the country region and relatively less with their village or town than residents of big cities. For this reason, reference to the "streek" seemed most suitable.

2.2.2 Damage intensity of the neighbourhood

Different parts of the earthquake risk area are not affected to the same extent. The "damage intensity of the neighbourhood" is calculated on the basis of damage claims from residents. Each damage claim that has been officially acknowledged by the NAM between August 2012 and August 2015 was registered. Using this information, the percentage of houses for which damage has been claimed and granted within each of the 173 zip code areas can be calculated. This variable ranges between 0% (no damaged dwellings within a zip code area) to 100%, which actually occurred for two very small zip code areas (10 and 30 dwellings) (Boelhouwer et al. 2016). The variable has been divided into four damage intensity

classes, based on the frequency distribution graph: < 5% (hardly any damage); 5–38.9% (lower intermediate); 39–60% (higher intermediate) and > 60% (substantial damage) (Boelhouwer et al. 2016; Boelhouwer and van der Heijden 2018). Areas with the highest level of neighbourhood damage intensity can be found mostly in the municipalities of Loppersum and Slochteren. The municipalities of Eemsmond and Bedum show mostly higher intermediate damage intensity areas. De Marne mostly shows the lower intermediate and lowest level of damage intensity areas. The other municipalities are somewhere in between.

2.2.3 Socio-demographic characteristics

The socio-demographic data collected include: age, education, household type, number of persons in the household, municipality, gender, monthly net household income, tenure, length of residence in the current dwelling and place of origin (in the region, or not).

2.2.4 Cognitive and emotional characteristics

Note that there are two important aspects with regard to the operationalization of the questions that measure the cognitive and emotional characteristics and the coping strategies. The first is that the questions had to be tailored to fit the Groningen situation. The second is that the results from the study needed to be comparable to previous research in the Groningen area. This concerns a study into the effect of earthquakes on housing wellbeing among the members of the Groninger Panel, performed by the Sociaal Planbureau Groningen (2014) and a study by de Kam and Raemakers (2014) in the Groningen earthquake area. Most of the questions were copied from these studies.

Two questions enquire about the personal experience of respondents with earthquakes in this area in Groningen and about personal experience with damage to their own dwelling as a consequence of the earthquakes. Furthermore, the respondents answered four questions about the emotional effect of the multitude of earthquakes: does it make them more and more emotionally distressed, are they less and less concerned about these earthquakes or does it have no effect? As explained above, the region is afflicted by many, mostly weak, earthquakes. The four statements cannot be simply combined into one scale as the answering categories are not unidimensional (more and more; no change; less and less; don't know). The emotional responses are therefore included separately in the regression analysis.

As stated in the Introduction, three aspects of risk perception can be discerned: awareness of the risky situation, worrying about this situation and preparedness for the situation (Raaijmakers et al. 2008). Our study includes two of these dimensions. Awareness of the risky situation is defined as knowledge or consciousness of the risk that an individual or a group of individuals is exposed to (Raaijmakers et al. 2008). In the earthquake situation in Groningen it is not expected that many people will be injured from the earthquakes directly (Van der Voort and Vanclay 2015). The most important risk is the potential damage to the dwelling. Therefore, an item was included about the expectation of (further) damage to the dwelling as a consequence of future earthquakes. A second aspect of risk perception concerns worrying about the situation. According to Raaijmakers et al. (2008), worry, or fear, depends on the awareness of the frequency of occurrence of the particular hazard and the expected severity of the consequences. The current study measured risk worry using four statements on feelings of unsafety and insecurity. The four statements were rated by respondents on a 5-point Likert scale. The

items were combined into one scale "risk worry", with good reliability (α=0.91, n=3565). Higher scores indicate more perceived risk worry.

Finally, psychological distress was determined with the use of a statement about the personal experience of psychological problems as a consequence of the earthquakes.

2.2.5 Coping strategies

The last variables concern the coping strategies. There are many different coping strategies, which can be both behavioural and cognitive. Which coping strategie(s) will be applied depends upon the situation and personal characteristics. In the current study, two possible coping strategies have been selected: the intention to move within two years and the acceptance of the earthquake situation. The use of the first coping mechanism is highly important because it might determine migration out of the earthquake region. The second coping strategy is interesting because not much research has been performed into this topic. Some research has been done into the relationship between place attachment and the acceptance of evacuation plans or relocation offers (reported in, for example, Bonaiuto et al. 2016), but not into the relationship with just accepting the actual situation. Would residents with stronger place attachment accept the situation more easily, for example because the place has many other benefits? Alternatively, would they have more difficulties with accepting the situation, for example because they are more emotionally engaged in the place?

2.3 Statistical methods

For answering the research questions, a hierarchical multinomial logistic regression was used to compare respondents with "(very) strong place attachment" against those with "moderate" and "weak/no place attachment". In the first model, the damage intensity of the neighbourhood variable was included. In the second model, the socio-demographic characteristics were included. In each additional model, a subsequent set of predictors was included. To obtain a parsimonious model, non-significant predictors were eliminated one-by-one (backward elimination-by-hand) in each step. Before performing the multinomial logistic regression all bivariate relationships (place attachment versus all predictors) were examined using the Chi^2 test.

3 Results

Table 1 reports the socio-demographic characteristics of the respondents and the population (residents of the nine risk municipalities), where available. The information on the population was calculated from data obtained from Statistics Netherlands for 2014. A comparison of the respondent group to the population showed that older residents and couples without children were overrepresented and singles were underrepresented in the current study. Furthermore, residents living in Loppersum were somewhat more frequently presented and residents living in Appingedam somewhat less frequently.

Table 1 Socio-demographic characteristics

	Respondent group n = 4260		Population n ≈ 95,000
	n	%	%
Age			
=< 45	724	17	38
46–55	874	21	20
56–65	1230	29	19
> 65	1394	33	23
Education			
Unknown	138	3	
Lower	1292	30	
Middle	1347	32	
Higher	1483	35	
Household type			
Single	760	18	31
Couple	2217	52	34
Couple with kids	1127	27	28
Single with kids	128	3	7
Number of persons in household			
1	753	18	
2	2319	55	
3	461	11	
4	500	12	
5 or more	210	5	
Municipality			
Appingedam	224	5	10
Bedum	410	10	9
De Marne	366	9	9
Delfzijl	833	20	22
Eemsmond	543	13	13
Loppersum	586	14	8
Slochteren	542	13	13
Ten Boer	305	7	6
Winsum	451	11	11
Gender			
Male	2139	50	
Female	2121	50	
Monthly net household income			
Unknown	1194	28	
Low (≤ €2000)	1026	24	
Middle (€2001–€3000)	991	23	
High (> €3000)	1049	25	
Tenure			
Owner-occupied	3722	87	
Rental	538	13	

Table 1 (continued)

	Respondent group n = 4260		Population n ≈ 95,000
	n	%	%
Length of residence			
< 6 years	561	13	
6–10 years	542	13	
> 10 years	3122	74	
Place of origin			
Has always lived in the region	2416	57	
Has mostly lived in the region	551	13	
Born and raised elsewhere	1271	30	
Place attachment			
Very strong	1244	30	
Strong	1604	38	
Moderate	1052	25	
Weak/not attached	300	7	

3.1 What is the strength of place attachment and does it differ between residents living in areas with different damage intensity of the neighbourhood?

Almost one third of respondents (30%) indicate to be very strongly attached to the region, 38% is strongly attached, 25% is moderately attached and 7% reports to be weakly or not attached. The multinomial regression analysis including the damage intensity indicator shows that place attachment is not dependent upon the level of damage intensity ($\chi^2_{(6)} = 3.72$, $p = 0.71$). This means that place attachment is not related to the reported percentage of damaged dwellings in the neighbourhood.

3.2 Is place attachment related to socio-demographic characteristics, cognitive and emotional characteristics and coping strategies?

All the bivariate results for the nominal variables are presented in Appendix 2. The Chi^2 test shows a statistically significant relationship between place attachment and age, education, household type, number of persons in the household, municipality, length of residence, place of origin, personal experience of earthquakes and of damage to the dwelling, all four emotional responses, risk awareness, psychological problems, the intention to move and the acceptance of the situation.

The interpretation of the statistically significant results is primarily based on cells in the matrix with standardized residuals > |2| (Field 2018, p. 857), indicated in bold in the Appendix. Stronger place attachment is generally related to higher age, living in the municipality of Winsum, always have lived in the region, having personal experience of earthquakes and of having damage to the dwelling, expecting future damage to the house (risk awareness) and a lower intention of moving. In contrast, weaker place attachment has a relationship with having an unknown education, being part of a single-parent household or large household, living in the municipality of Delfzijl, having a

medium length of residence (6–10 years), being born and raised elsewhere and being unsure with regard to the emotional responses following the recurring earthquakes, to having psychological problems and about accepting the situation.

Risk worry is a numerical variable and has been analysed by means of an analysis of variance. The bivariate result shows that risk worry does not differ between respondents with weaker or stronger place attachment ($F_{(2)} = 1.96$, $p = 0.14$).

At first, the regression model only includes the socio-demographic characteristics. Age, education, municipality and the place of origin turn out to be statistically significant predictors of place attachment. Thus, household type, number of persons in the household and length of residence are not statistically significant predictors of place attachment in the multivariate case. Next, the cognitive and emotional characteristics are added. The personal experience of earthquakes and of having damage to the dwelling turn out not to be related to place attachment. One of the four items reflecting the emotional response is statistically significant ("It frightens me"), but not the other items. Finally, the expectation of future damage (risk awareness) and having psychological problems are related to place attachment in the multivariate analysis. In the last model, the intention to move and the acceptance of the situation are also included in the model. Both are statistically significantly related to place attachment. However, having psychological problems now no longer is statistically significant and is omitted from the final model.

The final model is presented in Table 2 ($\chi^2_{(52)} = 505.10$, $p < 0.01$, Nagelkerke $R^2 = 0.15$). The interpretation of the results is merely based on the statistically significant relationships, indicated in bold in Table 2. The results show that place attachment increases with higher age. This is especially noticeable in the comparison between the respondents who are (very) strongly attached and those who are not or only weakly attached. For education, the group with the unknown education stands out; they are about 2.3 and 2.7 times less likely to be (very) strongly attached when compared to respondents with higher education. Furthermore, respondents with lower education are somewhat weaker attached when compared to respondents with higher education, but this only applies to the comparison between (very) strongly and moderately attached respondents. Next, various results are observed for municipality. In general, respondents living in Winsum have the highest degree of attachment. This can be seen from the fact that Winsum acts as the reference and all other municipalities (except for Appingedam) have odds ratios above 1. The place of origin is an important predictor of place attachment. Respondents who have always lived in the region are about 3 times more likely to be (very) strongly attached than respondents who have been born and raised elsewhere. Similarly, respondents who have mostly lived in the region are about 2 times more likely to be (very) strongly attached. "It frightens me" is the only emotional response that reaches statistical significance in the multivariate analysis. Respondents who report that they feel more and more frightened by the recurring earthquakes are generally stronger attached. With regard to risk awareness, respondents who expect damage to their dwelling as a consequence of future earthquakes are more likely to be stronger attached. The intention to move is also an important predictor of place attachment. Respondents who do not intent to move are more likely to report (very) strong place attachment than respondents who intend to move or who consider moving. Finally, the acceptance of the situation is a relatively unimportant predictor of place attachment ($p = 0.03$). The only statistically significant result is found between respondents who do and who do not accept the situation, in the comparison between the (very) strongly and the not or only weakly attached respondents. Respondents who do not accept the situation are more frequently very strongly attached than respondents who accept the situation.

Table 2 Statistically significant predictors of place attachment (n = 4064)

	(Very) strong versus moderate				(Very) strong versus weak/not attached			
	b	SE	*p*	OR	b	SE	*p*	OR
Constant	− 1.36	0.18			− 3.02	0.33		
Age**								
> 65	0.18	0.12	0.16	1.19	− 0.60	0.20	< **0.01**	0.55
56–65	0.08	0.12	0.52	1.08	− 0.46	0.19	**0.02**	0.63
46–55	0.14	0.13	0.27	1.15	0.07	0.19	0.71	1.07
≤ 45 (reference)	–	–	–	–	–	–	–	–
Education**								
Unknown	0.83	0.23	< **0.01**	2.30	1.00	0.36	< **0.01**	2.72
Lower	0.22	0.10	**0.04**	1.24	0.23	0.18	0.19	1.26
Middle	0.10	0.10	0.30	1.11	0.07	0.16	0.65	1.07
Higher (reference)	–	–	–	–	–	–	–	–
Municipality**								
Appingedam	0.06	0.21	0.76	1.07	− 0.03	0.43	0.95	0.97
Bedum	0.29	0.17	0.09	1.33	0.77	0.31	**0.01**	2.17
De Marne	0.09	0.17	0.62	1.09	− 0.13	0.36	0.73	0.88
Delfzijl	0.20	0.15	0.18	1.22	0.76	0.28	< **0.01**	2.13
Eemsmond	0.11	0.16	0.49	1.12	0.59	0.30	**0.05**	1.81
Loppersum	0.10	0.16	0.51	1.11	0.27	0.31	0.38	1.31
Slochteren	0.36	0.16	**0.02**	1.43	1.00	0.29	< **0.01**	2.72
Ten Boer	0.38	0.18	**0.03**	1.47	0.78	0.33	**0.02**	2.19
Winsum	–	–	–	–	–	–	–	–
Place of origin**								
Has always lived in the region	− 1.05	0.09	< **0.01**	0.35	− 1.25	0.15	< **0.01**	0.29
Has mostly lived in the region	− 0.45	0.12	< **0.01**	0.63	− 0.86	0.21	< **0.01**	0.42
Born and raised elsewhere	–	–	–	–	–	–	–	–
"It frightens me"**								
Don't know	0.39	0.12	< **0.01**	1.48	0.66	0.20	< **0.01**	1.93
Less and less	0.32	0.12	< **0.01**	1.37	0.27	0.22	0.21	1.31
To the same amount	0.19	0.10	**0.05**	1.21	0.41	0.17	**0.01**	1.50
More and more (reference)	–	–	–	–	–	–	–	–
Risk awareness (expect damage)**								
I don't know	0.32	0.14	**0.02**	1.38	0.58	0.23	**0.01**	1.79
Maybe/no	0.30	0.09	< **0.01**	1.35	0.39	0.15	**0.01**	1.47
Yes (reference)	–	–	–	–	–	–	–	–
Intention to move within 2 years**								
Yes	0.75	0.13	< **0.01**	2.11	2.09	0.18	< **0.01**	8.12
Maybe	0.64	0.09	< **0.01**	1.89	1.34	0.15	< **0.01**	3.81
No (reference)	–	–	–	–	–	–	–	–
Accept the situation*								
Don't know	0.26	0.18	0.15	1.30	0.53	0.28	0.06	1.71
Disagree	− 0.05	0.09	0.55	0.95	− 0.37	0.16	**0.02**	0.69
Neutral	0.13	0.11	0.23	1.14	− 0.06	0.19	0.74	0.94
Agree	–	–	–	–	–	–	–	–

b = coefficient; SE = standard error; *p* = *p* value; OR = odds ratio

$^{**}p < 0.01$, $^{*}p < 0.05$

In summary, stronger place attachment is predicted by higher age, living in Winsum, place of origin in the region, an increase in fear by the recurrent earthquakes, expecting future damage to the dwelling (risk awareness), a lower intention of moving and not accepting the situation. These results have an independent relationship with place attachment. In conclusion, respondents with (very) strong place attachment do feel more frightened and do perceive a higher risk of damage to the dwelling than respondents with weaker place attachment. Nevertheless, respondents with (very) strong place attachment also more frequently do not have the intention to move.

4 Discussion

This study examined the relationships between place attachment on the one side and neighbourhood damage intensity, socio-demographic characteristics, cognitive and emotional characteristics and two types of coping strategies on the other side in respondents living in a region with a recent history of earthquakes. For interpreting the results of the study note that the respondents were asked for the strength of their place attachment with regard to the wider neighbourhood or region ("streek" in Dutch). Most studies into place attachment have been performed on the level of the neighborhood and almost none on the level of the region (Hidalgo and Hernandez 2001; Lewicka 2010). The results of the current study are compared against those of other studies and for this reason these studies are mentioned here with the object of place attachment between brackets: Anton and Lawrence (2014) (attachment to home and local area); Billig (2006) (attachment to home and region); Bonaiuto et al. (1999) (attachment to neighbourhood); Brown et al. (2003) (attachment to house and block/neighbourhood); Hidalgo and Hernandez (2001) (attachment to house, neighbourhood and city); Lewicka (2010) (attachment to apartment, building, neighbourhood, city district and city); Lewicka (2011a) (attachment to neighbourhood, city/town/village and country region); von Wirth et al. (2016) (attachment to city).

4.1 What is the strength of place attachment and does it differ between residents living in areas with different damage intensity?

Sixty-eight percent of respondents indicated to be (very) strongly attached to the region in which they lived. Another 25% reported a moderate level of attachment. These percentages seem quite high. For example, Hidalgo and Hernandez (2001) report, based on three different studies, a percentage of 40–65% of residents being attached to their neighbourhoods. The relatively high level of attachment found in the current study could be explained by a number of reasons. First, Hidalgo and Hernandez (2001) and Lewicka (2010) report that the relationship between attachment and geographical scale generally has an u-form with the lowest attachment for the neighbourhood and somewhat higher attachment to lower and higher spatial levels such as the house, the city, or the region. Second, people who live in threatened places are known to report stronger place attachment, possibly because the threat of losing the place might remind residents of their attachment to it (Anton and Lawrence 2014; Cheng and Chou 2015). Bonaiuto et al. (2016) argue that threatening stimuli activate proximity-seeking to valued places. In other words, a risky situation might increase the bond between resident and place. If this effect plays a role in the current situation, then perhaps a positive relationship between place attachment and neighbourhood

damage intensity would have been expected. The higher the percentage of dwellings in the zip code for which damage has been claimed and granted, the larger the threat of losing the place and the stronger the degree of place attachment? Neighbourhood damage intensity is an administrative variable and is not known to residents. Nevertheless, residents will be aware of whether or not there are (m)any damaged dwellings in their nearby residential environment. Apparently, this did not influence their place attachment, which makes the aforementioned potential reason for the relatively strong place attachment less likely. The third potential explanation for the relatively strong place attachment concerns the potential influence of place and age. The earthquake area is a rural area and the respondents are relatively old. Both aspects have been found to be related to stronger place attachment (Anton and Lawrence 2014; Hidalgo and Hernandez 2001; Lewicka 2011a, b). Elderly residents are often strongly attached to their neighbourhood because of limited mobility, the loss of close family members and friends, retirement from work and a decrease in social contacts (Oh 2003). A fourth reason is that the region in northeast Groningen has experienced serious population decline even before the earthquake problems became apparent (Haartsen and Venhorst 2010). Problems linked to population decline are housing price depreciation (Glaeser and Gyourko 2005), uninhabited houses, a decrease in the supply of facilities and services and decreasing liveability of the area (Haartsen and Venhorst 2010). Residents with stronger place attachment might stay, whereas residents with weaker place attachment might already have moved out for work-related, educational or other reasons. Finally, the earthquake threat in itself could strengthen the mutual bond between residents (Mishra et al. 2010). When asked, almost 40% of respondents indicated that they believe that the bonding between residents in the area increases as a consequence of the earthquake issues (Hoekstra 2016). Social relationships have been found to be an important aspect of place attachment (Fried 2000; Hidalgo and Hernandez 2001; Lewicka 2010).

4.2 Is place attachment related to socio-demographic characteristics?

The second research question examined whether place attachment is related to socio-demographic characteristics. The results of our study showed that place attachment was positively related to age. This result complies with general findings (Lewicka 2010, 2011a). Place attachment was not related to tenure and length of residency. These results contradict some other research. Owner-occupiers have generally been found to experience stronger place attachment than renters (Anton and Lawrence 2014; Brown et al. 2003; Lewicka 2011b; von Wirth et al. 2016). Similarly, length of residency has generally been shown to be positively correlated to place attachment (Bonaiuto et al. 1999; Brown et al. 2003; Billig 2006; Lewicka 2011b; Anton and Lawrence 2014; von Wirth et al. 2016). Homeowners usually have a longer length of residency, invest more money in housing, know more neighbours and participate more in community groups (Brown et al. 2003). The shorter the length of stay in a specific place, the less someone has invested in and becomes attached to that locality (Speare 1974; Mesch and Manor 1998; Böheim and Taylor 2002). Our deviating results might be explained by the fact that the respondents were asked about place attachment at the level of the region and not at the level of the dwelling or neighbourhood. Residents might move within or between neighbourhoods or switch between homeownership and being a renter, but remain to live within the region of northeast Groningen to which most are (very) strongly attached. This assumption is supported by our results with regard to the place of origin. The renters in our study more frequently had always lived in the region (64%) than the owner-occupiers (56%). In addition, 31% of the owner-occupiers

has not been born and raised in the region as compared to 23% of the renters. This might be explained because, before the earthquake problems became apparent, there was a trend for retirees from other, more urbanized, regions to buy a dwelling in this rural area after retirement.

4.3 Is place attachment related to cognitive and emotional characteristics, such as personal experience of earthquakes, emotional response, risk perception and psychological distress?

The third research question addressed whether place attachment was related to cognitive and emotional characteristics. Our results showed that residents with (very) strong place attachment more frequently reported that the recurring earthquakes increased their fear and more frequently reported to expect damage to the dwelling as a consequence of future earthquakes. This seems to confirm the higher threat—stronger place attachment bond as explained above. Note that the "actual" threat, as measured in the form of damage intensity of the neighbourhood, did not have any relationship to place attachment. Instead, the perceived threat might play a role in strengthening the bond with the place. Note further, however, that the study has a cross-sectional design and therefore cannot discern whether place attachment has been influenced by the perception of risk or that strong place attachment makes one more vulnerable for perceiving threats in the personal environment.

The review by Bonaiuto et al. (2016) showed that strong place attachment is generally related to high risk perception. Our results agree with this finding, but only for the risk awareness aspect of risk perception (i.e., the expected damage to the dwelling) and not for the risk worry aspect. Nevertheless, our study gives no reason to believe that strongly attached residents underestimate the potential risk because they feel safe in their homes and believe that a disaster 'will not happen to them' or is more likely to occur somewhere else, or with other people.

4.4 Is place attachment related to coping strategies, i.e. the intention to move and the acceptance of the situation?

The analysis showed that place attachment was negatively linked to the intention to move, thus stronger place attachment is related to a lower intention of moving. This finding agrees with previous research (e.g., Bonaiuto et al. 2016). There was some statistical evidence to assume that respondents with stronger place attachment more frequently do not accept the situation. This result seems somewhat surprising, as these respondents are also less willing to move. Apparently, they use other coping strategies to cope with the earthquake (related) problems, for example they might engage in a protest against further gas extraction (collective action intention) (Kutlaca et al. 2019) or they might seek social support. As mentioned above, the bonding between residents might have strengthened as a consequence of the earthquake issues (Hoekstra 2016).

4.5 Limitations

A limitation of the current study concerns the correlational character of this cross-sectional study. Similar to most other studies (Lewicka 2011b), this study can only report on relationships between variables and cannot discern which are causes and which are consequences, or whether some important variables were omitted from the study. Second, the composition of the respondent group was not entirely representative of the population of the nine risk municipalities. Single households were underrepresented and older respondents and couples without children were more frequently present in the respondent group. As explained above, older age is related to stronger place attachment. Thus, the strength of place attachment reported in our study could be somewhat higher than in the population. This effect is further strengthened by the fact that the area has experienced population decline. Residents with weaker place attachment (mostly young people) will be among the first residents to have left the area. Nevertheless, it is not expected that the sample bias has an effect on the conclusions of the study as age and household size were included in the statistical analyses and thus were corrected for. A final limitation concerns the use of single-item instruments for measuring underlying constructs, i.e., place attachment, psychological distress, risk awareness and the four items that reflect the emotional response. In the latter case, the four items could not be combined due to the non-unidimensional answering scale. A drawback of single-item measures is that they are less reliable than multi-item measures.

5 Conclusions

In conclusion, this study has found further evidence to support previous views that strongly attached individuals do perceive the risks and do feel emotionally distressed but are nevertheless unwilling to relocate when facing such risks. This is an important finding for the earthquake region in Groningen as this region is already prone to population decline. Further outmigration might be prevented by the removal of adverse effects, such as making buildings earthquake resistant, improving the damage compensation procedure and by offering ample compensation for the fall in property values (Boelhouwer and van der Heijden 2018).

Appendix 1: Variables included in the study

Place attachment

Do you feel an attachment to the region in which you live? (very strong; strong; moderate; weak/not)

Damage intensity of the neighbourhood (< 5%; 5–38.9%; 39–60%; > 60%)

Socio-demographic characteristics

Age (< 46; 46–55; 56–65; > 65)

Education (low; middle; high; unknown)

Household type (single; couple; couple with children; single parent)

Number of persons in the household (1; 2; 3; 4; 5 or more)

Municipality (Appingedam; Bedum; De Marne; Delfzijl; Eemsmond; Loppersum; Slochteren; Ten Boer; Winsum)

Gender (male; female)

Monthly net household income (≤ €2000; €2001–€3000; > €3000; unknown)

Tenure (owner-occupied; rental)

Length of residence (< 6 years; 6–10 years; > 10 years)

Place of origin (has always lived in the region; has mostly lived in the region; born and raised elsewhere)

Cognitive and emotional characteristics

Personal experience of earthquakes in Groningen (yes, once; yes, more than once; no)

Personal experience of damage to the dwelling (no; slight damage; heavy damage; unknown)

Emotional response (more and more; no change; less and less; don't know):

"It frightens me"

"I'm getting used to it"

"I'm getting anxious"

"It makes me nervous"

Risk awareness: expectation of (further) damage to the dwelling as a consequence of future earthquakes (yes; maybe; no; I don't know)

Risk worry (1 "totally disagree" to 5 "totally agree")

"I feel safe in my dwelling" (coding reversed)

"I am worried about the safety of my family"

"I feel unsafe as a consequence of the earthquakes"

"The threat of future earthquakes makes me insecure"

"I experience psychological problems as a consequence of the earthquakes" (disagree; neutral; agree; I don't know)

Coping strategies

Do you intend to move within 2 years? (yes; maybe; no)

"I feel that I have to accept this situation" (disagree; neutral; agree; I don't know)

Appendix 2: Potential predictors of the degree of place attachment

	(Very) strong		Moderate		No/weak		Total	Chi^2 test
	Count	%	Count	%	Count	%	Count	
Damage intensity neighbourhood								
< 5%	68	69	25	25	6	6	99	$\chi^2_{(6)} = 3.74$, $p = 0.71$
5–38.9%	656	68	245	25	66	7	967	
39–60%	1430	69	502	24	145	7	2077	
> 60%	694	66	280	26	83	8	1057	
Total	2848	68	1052	25	300	7	4200	
Age								
> 65	912	66	389	**28**	75	**5**	1376	$\chi^2_{(6)} = 31.78$, $\boldsymbol{p < 0.01}$
56–65	840	69	302	25	74	6	1216	
46–55	576	67	208	24	81	**9**	865	
< 46	502	70	147	**20**	67	**9**	716	
Total	2830	68	1046	25	297	7	4173	
Education								
Unknown	61	53	40	**35**	14	**12**	115	$\chi^2_{(6)} = 17.00$, $\boldsymbol{p < 0.01}$
Low	870	69	320	25	78	6	1268	
Middle	930	69	313	23	95	7	1338	
High	987	67	379	26	113	8	1479	
Total	2848	68	1052	25	300	7	4200	
Household type								
Single parent	78	62	32	25	16	**13**	126	$\chi^2_{(6)} = 16.61$, $\boldsymbol{p = 0.01}$
Single	513	69	190	25	45	6	748	
Couple	1478	67	576	26	142	6	2196	
Couple with children	768	69	253	23	97	9	1118	
Total	2837	68	1051	25	300	7	4188	
Number of persons in the household								
5 or more	149	72	35	**17**	24	**11**	208	$\chi^2_{(8)} = 21.92$, $\boldsymbol{p < 0.01}$
4	342	69	116	23	39	8	497	
3	294	64	117	26	45	**10**	456	
2	1554	68	596	26	145	6	2295	
1	507	68	187	25	47	6	741	
Total	2846	68	1051	25	300	7	4197	
Municipality								
Appingedam	157	72	53	24	9	4	219	$\chi^2_{(16)} = 30.74$, $\boldsymbol{p = 0.01}$
Bedum	277	68	100	24	31	8	408	
De Marne	240	67	100	28	16	4	356	
Delfzijl	533	65	206	25	76	**9**	815	
Eemsmond	377	70	120	22	38	7	535	
Loppersum	406	70	141	24	34	6	581	
Slochteren	347	65	140	26	50	9	537	

	(Very) strong		Moderate		No/weak		Total	Chi^2 test
	Count	%	Count	%	Count	%	Count	
Ten Boer	192	64	83	28	26	9	301	
Winsum	319	71	109	24	20	**4**	448	
Total	2848	68	1052	25	300	7	4200	
Gender								
Male	1448	68	523	25	145	7	2116	$\chi^2_{(2)} = 0.93$, $p = 0.63$
Female	1400	67	529	25	155	7	2084	
Total	2848	68	1052	25	300	7	4200	
Monthly net household income								
Unknown	758	66	298	26	99	9	1155	$\chi^2_{(6)} = 7.36$, $p = 0.29$
Low (≤ €2000)	689	68	259	26	64	6	1012	
Middle (€2001–€3000)	687	70	232	23	67	7	986	
High (> €3000)	714	68	263	25	70	7	1047	
Total	2848	68	1052	25	300	7	4200	
Tenure								
Owner-occupied	2500	68	913	25	263	7	3676	$\chi^2_{(2)} = 0.70$, $p = 0.70$
Rental	348	66	139	26	37	7	524	
Total	2848	68	1052	25	300	7	4200	
Length of residence								
> 10 years	2118	68	775	25	198	6	3091	$\chi^2_{(4)} = 10.51$, $\mathbf{p = 0.03}$
6–10 years	349	65	137	25	53	**10**	539	
< 6 years	365	66	138	25	47	8	550	
Total	2832	68	1050	25	298	7	4180	
Place of origin								
Has always lived in the region	1819	**76**	457	**19**	127	**5**	2403	$\chi^2_{(4)} = 178.47$, $\mathbf{p < 0.01}$
Has mostly lived in the region	350	64	159	29	38	7	547	
Born and raised elsewhere	679	**54**	436	**35**	135	**11**	1250	
Total	2848	68	1052	25	300	7	4200	
Personal experience of earthquakes in Groningen								
Yes, once	513	66	204	26	57	7	774	$\chi^2_{(4)} = 16.43$, $\mathbf{p < 0.01}$
Yes, more than once	2032	69	691	24	201	7	2924	
No	301	61	154	**31**	41	8	496	
Total	2846	68	1049	25	299	7	4194	
Personal experience of damage to the dwelling								
Unknown	279	65	117	27	36	8	432	$\chi^2_{(6)} = 16.05$, $\mathbf{p = 0.01}$
No damage	264	63	128	**30**	30	7	422	
Slight damage	1783	68	652	25	191	7	2626	
Heavy damage	522	72	155	21	43	6	720	
	2848	68	1052	25	300	7	4200	
"It frightens me"								
Don't know	466	**60**	232	**30**	73	**9**	771	$\chi^2_{(6)} = 31.72$, $\mathbf{p < 0.01}$
Less and less	432	68	161	25	38	6	631	
No change	925	67	345	25	106	8	1376	
More and more	946	72	288	**22**	81	6	1315	

	(Very) strong		Moderate		No/weak		Total	Chi^2 test
	Count	%	Count	%	Count	%	Count	
Total	2769	68	1026	25	298	7	4093	
"I'm getting used to it"								
Don't know	575	63	258	**28**	75	8	908	$\chi^2_{(6)} = 17.38, \boldsymbol{p < 0.01}$
Less and less	598	71	181	**21**	61	7	840	
No change	1016	67	396	26	106	7	1518	
More and more	573	70	186	23	54	7	813	
Total	2762	68	1021	25	296	7	4079	
"I'm getting anxious"								
Don't know	877	64	382	**28**	108	8	1367	$\chi^2_{(6)} = 13.44, \boldsymbol{p = 0.04}$
Less and less	202	71	62	22	21	7	285	
No change	1076	69	384	24	109	7	1569	
More and more	582	70	185	22	58	7	825	
Total	2737	68	1013	25	296	7	4046	
"It makes me nervous"								
Don't know	727	**63**	341	**29**	91	8	1159	$\chi^2_{(6)} = 25.24, \boldsymbol{p < 0.01}$
Less and less	172	72	53	22	15	6	240	
No change	762	67	295	26	83	7	1140	
More and more	1087	71	332	**22**	108	7	1527	
Total	2748	68	1021	25	297	7	4066	
Risk awareness (expect future damage)								
Don't know	261	62	121	29	38	9	420	$\chi^2_{(4)} = 24.90, \boldsymbol{p < 0.01}$
No/maybe	836	64	373	**29**	92	7	1301	
Yes	1746	71	558	**23**	170	7	2474	
Total	2843	68	1052	25	300	7	4195	
Psychological problems								
Don't know	282	61	134	29	44	10	460	$\chi^2_{(6)} = 14.06, \boldsymbol{p = 0.03}$
Disagree	1813	69	644	24	171	6	2628	
Neutral	496	67	185	25	55	7	736	
Agree	232	68	78	23	30	9	340	
Total	2823	68	1041	25	300	7	4164	
Intention to move within 2 years								
Yes	224	**53**	120	28	78	**18**	422	$\chi^2_{(4)} = 195.81, \boldsymbol{p < 0.01}$
Maybe	636	**59**	336	**31**	113	**10**	1085	
No	1987	**74**	596	**22**	109	**4**	2692	
Total	2847	68	1052	25	300	7	4199	
Acceptance of the situation								
Don't know	136	59	70	30	24	10	230	$\chi^2_{(6)} = 17.60, \boldsymbol{p < 0.01}$
Disagree	760	69	278	25	64	6	1102	
Neutral	445	66	187	28	44	6	676	
Agree	1484	69	509	24	168	8	2161	
Total	2825	68	1044	25	300	7	4169	

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