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Residential satisfaction close to highways: The impact of accessibility, nuisances and highway adjustment projects

Marije Hamersma
Faculty of Spatial Sciences
University of Groningen
PO Box 800
9700 AV Groningen
The Netherlands
Phone: +31-50-363-3875
Fax: +31-50-363-3901
E-mail: m.hamersma@rug.nl

Joseph Sussman
Department of Civil and Environmental Engineering
Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, MA 02139
Phone: +1-617-253-4430
Fax: +1-617-258-5942
E-mail: sussman@mit.edu

Taede Tillema
Faculty of Spatial Sciences
University of Groningen
PO Box 800
9700 AV Groningen
The Netherlands
Phone: +31-50-363-3875
Fax: +31-50-363-3901
E-mail: t.tillema@rug.nl

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Marije Hamersma*
Faculty of Spatial Sciences
University of Groningen
PO Box 800
9700 AV Groningen
The Netherlands
Phone: +31-50-363-9052
E-mail: m.hamersma@rug.nl
* Corresponding author

Taede Tillema
E-mail: taedetillema@hotmail.com

Joseph Sussman
Department of Civil and Environmental Engineering
Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, MA 02139
Phone: +1-617-253-4430
Fax: +1-617-258-5942
E-mail: sussman@mit.edu

Jos Arts
Faculty of Spatial Sciences
University of Groningen
PO Box 800
9700 AV Groningen
The Netherlands
Phone: +31-50-363-3872
E-mail: e.j.m.m.arts @rug.nl

ABSTRACT

In this paper we focus on gaining insight into the residential satisfaction of households near highways, based on survey data collected among 1,225 respondents in the Netherlands living within 1,000 meters from a highway. Ordinal regression was used to study the impact of highway externalities on residential satisfaction. Moreover, we gained first insights into the reactions of people on highway adjustment projects, by studying people's expectations towards residential satisfaction as a consequence of the project with use of a multinomial logistic regression analysis.

On average, 85 percent of respondents reported being satisfied with living near a highway. Regarding explanatory characteristics, subjective evaluations of air and noise nuisance and of accessibility are of comparable importance and seem to outperform objective exposure calculations or distance from the highway or access lane in explaining residential satisfaction. Moreover highway interest is directly reflected in a higher satisfaction. However, other factors such as neighborhood design, traffic safety and social cohesion are important as well. People react differently to highway adjustment plans, negative expectations being highly driven by current negative feelings towards nuisance, and positive expectations by personal interest in accessibility and a positive attitude towards cars.

An important implication could be the notion that exposure is not the same as perceived nuisance, which may give reason to be cautious when making transportation planning decisions based solely on calculations. In addition, the finding that other (neighborhood) factors are also very important in explaining residential satisfaction is interesting when thinking about compensating for the negative effects of a highway in the neighborhood. Also, the results regarding reactions to an announced highway adjustment project might be used to better adjust the planning process to the characteristics of the residents in the area. Further research is necessary to deepen the results, for example through the addition of other road project locations, interviews and longitudinal data.

Keywords: highway infrastructure planning, accessibility, nuisance, residential satisfaction, planned highway adjustment projects.

Highlights

- We studied the impact of negative (nuisance) and positive (accessibility) highway externalities and a highway adjustment project on residential satisfaction near highways.
- Perceived nuisance and accessibility influence residential satisfaction, but other neighborhood factors are also important.
- Perceptions of accessibility and nuisance outweigh objective measures (exposure levels, distance from highway/accesslane).
- Highway users show a higher satisfaction level.
- Expectations towards highway adjustment projects are mixed; highway users and people who like driving in particular have more positive expectations, currently hindered people more negative expectations.

1. INTRODUCTION

A road has different faces. In positive terms, it is associated with development and progress of areas, as it brings accessibility and economic growth. However, with increasing car mobility, negative associations have increased as well. Growing mobility demands have resulted in traffic congestion problems and decreased service levels of roads (see for instance Bovy, 2001). To tackle this, investments are made to build new roads and improve current road infrastructure. Moreover, road infrastructure is associated with other negative externalities like noise, air pollution and accompanying health problems (see for instance Dora and Philips, 2000; Stansfeld et al. 2001), which has led to opposition against road infrastructure growth and an increase in environmental regulations (e.g. Arts, 1998).

The described tradeoff is particularly apparent at residential locations near roads. Residents living near roads theoretically benefit the most from positive externalities (accessibility gains) created by the presence of the road, provided an access lane is close by. Although in general the importance of accessibility in location choices seems to have decreased (Giuliano, 1989), specific groups of people still factor time and costs related to travel into their location choice (e.g. Tillema et al., 2010; van Ommeren et al., 1999). However, residents are also confronted with the negative externalities being particularly important at the local level, potentially contributing to a reduction in local environment quality (Bateman, Day, Lake and Lovett, 2001). In recent years, several studies have shown an increased incidence and severity of health problems possibly related to traffic emissions of air pollutants in people who live, work or attend school near the main roads (Barros et al., 2013).As such, both positive and negative externalities related to the road might influence people's location decisions. Once the location decision has been made, whether or not influenced by the (potential) externalities of the road, these externalities may impact people's overall residential perceptions and might foster potential (future) behavior.

Although there is quite some research being done on either explaining nuisance or accessibility interest and on the impact of road externalities on housing prices, there is hardly any information about how accessibility factors and negative environmental aspects related to roads are traded off in people's overall residential context. Moreover, the opinions currently being heard are mainly the ones of the people attending consultation meetings, often with the intention to oppose plans (Tillema et al., 2012). It is unclear to which extent their view can be considered representative for the view of the 'silent majority'.

In order to gain a more inclusive insight, many research disciplines like sociology, psychology, planning and geography emphasize the relevance of using the concept of 'residential satisfaction', this being a good proxy for people´s overall wellbeing and an important driver for future moving intentions (Kroesen et al., 2010; Lu, 1999; Sabagh et al., 1969; Speare, 1974). The use of residential satisfaction in analyzing the trade-off created by the road can be beneficial for several reasons. First of all, residential satisfaction is an interesting concept to study the relative importance of accessibility and nuisances alongside other residential characteristics. This creates a broader and more balanced insight into residential experiences, based on the opinions of a wider community. Second, residential satisfaction can be an important and valuable mediating concept between positive and negative externalities on the one hand and household coping strategies on the other hand, as a lower satisfaction might set certain behavior in motion (e.g. Speare, 1974). And third, as residential satisfaction is more volatile than, for example, moving behavior or housing prices, it can be a first, direct and thereby better indicator for changes in people's wellbeing (Rossi, 1955), for example as a consequence of planned road adjustment projects.

Despite the potential usefulness of the concept of residential satisfaction for studying the residential context close to roads, we are not aware of any studies in which both fields are jointly analyzed. Hence,

the objective of this paper is to gain greater insight into residential satisfaction close to roads, in which we focus on residential locations near *highways*[1]. We particularly aim to study the effects of both highway accessibility and negative externalities, alongside other contextual factors. Moreover, since residential satisfaction is an interesting concept for measuring the impact of distortions, we also aim to gain first insight into the extent to which plans for highway infrastructure adjustments influence residential satisfaction. Such findings can be useful for future highway infrastructure planning and may be used to relieve locational stress, prevent protest and possible relocations, and may give input for more inclusive planning, which helps ensure a proper fit of the infrastructure in its physical and social environment.

To gain the needed insights, we collected survey data among 1,225 residents living in seven different neighborhoods located near highways in the Netherlands, a densely populated country with a well-developed transport network, a high level of (European) environmental regulations (e.g. regarding exposure levels) and quite some money spent on road mitigation measures (e.g. van der Gift et al., 2012; Arts, 1998). Highway infrastructure projects in the Netherlands often face societal discussion between groups in favor and groups opposing more investments in roads (e.g. Arts, 2007), which makes it an interesting case in which to study our research objectives. Because we were also interested in the effect of an announced change in highway infrastructure on people´s residential satisfaction, two neighborhoods were selected where highway adjustment projects are about to take place. For our first objective to analyze the impact of highway externalities on residential satisfaction, we used ordinal regression. In addition, to gain insights into our second objective, to analyze people's expected change in residential satisfaction (increase, decrease or no change) as a consequence of highway adjustments, we performed a multinomial logistic regression.

The outline of this article is as follows: Section 2 reviews the literature on residential satisfaction and its explanatory characteristics, focusing on the influence of negative externalities and accessibility and highway adjustment projects. Section 3 describes the empirical data and the applied method of analysis. The results are presented in section 4 and the conclusions in section 5.

2. THEORETICAL FRAMEWORK

2.1 Residential satisfaction research

Residential satisfaction can be regarded as consisting of satisfaction with the neighborhood and with the dwelling. Whereas some studies focus on the neighborhood (e.g., Hur and Morrow-Jones, 2008; Lovejoy et al, 2010), others distinguish between housing and the neighborhood (e.g. Lu, 1999), or use a combined measure for residential satisfaction (e.g. Kroesen et al., 2010). The two items, however, appear to be highly correlated (Galster and Hesser, 1981; Lu, 1999; Morris et al., 1978).

Generally speaking, three groups can be distinguished with regard to factors influencing satisfaction: personal characteristics, characteristics of the dwelling and neighborhood factors (see, for example Buys and Miller, 2012; Galster and Hesser, 1981; Lu, 1999; Morris et al., 1978). Authors emphasize the importance of both objective and more subjective factors, i.e. the perceptions and attitudes that people attach to attributes, in explaining differences between people (e.g. Kroesen et al., 2010; Parkes et al., 2002; Speare, 1974).

Although quite some variations are found in different research settings - for example with respect to gender, family size and tenure duration -, generally speaking, residential satisfaction seems to increase

[1] In the Netherlands, highways are the main roads in the road transport network.

with income, education level and age (e.g. Campbell et al., 1976; Lu, 1999). The first two probably have to do with affordability which increases freedom in making the residential choice, while the latter might relate to place attachment. With respect to dwelling characteristics, aspects such as owning a house, house size, living in a detached house and attractiveness of design are all positively linked to satisfaction (e.g. Buys and Miller, 2012; Galster and Hesser, 1981; Lu, 1999). When it comes to (social) neighborhood factors, residential satisfaction seems to be higher in rural and in more prosperous areas, and in areas with fewer ethnic minorities. Moreover, studies find that people seem to especially value social contacts, traffic safety and social safety, an attractive neighborhood with facilities in reach and a good environmental quality in their residential satisfaction (see for instance Buys and Miller, 2012; Galster and Hesser, 1981; Lovejoy et al., 2010; Lu, 1999).

2.2 Accessibility, nuisance and residential satisfaction

Highway externalities (i.e. accessibility gains and nuisances) can also be categorized as neighborhood characteristics. In analyzing their effect, we have to take account of the fact that both aspects could be created by more than just the highway. Van Wee (2013) states that the level of accessibility of an area depends on the location of activities, quality and quantity of infrastructure and needs of people and companies. The highway, our focal point of study, is one of the aspects contributing to accessibility, being mainly related to reaching activities by car in a more regional context. Also with respect to nuisances, although traffic is mentioned as the main source of nuisances (e.g. Theebe, 2004), nuisances can be created by many other sources, such as industry or neighbors. Following Tillema et al. (2012) we have distinguished three types of highway externalities: noise, air pollution and barrier-effects.

Although we are not aware of residential satisfaction studies that looked at the relation between both aspects in a highway context, there are studies that did include measures of nuisances and (regional) accessibility in other research settings, giving some indications regarding their impact. In general, studies including perceptions of nuisances and regional accessibility find both aspects to be of comparable importance, being among the most important factors alongside aspects such as general appearance, satisfaction with the density of housing, cleanliness, crime rates and neighborhood friendliness (as already touched upon in the previous section) (Buys and Miller, 2012; Cook, 1988; Howley et al., 2009; Hur and Morrow-Jones, 2008; Lovejoy et al., 2010; Savasdisara, 1988). However, a good assessment of their relative importance compared to other factors is complicated by different combinations of included factors on the one hand and differences in how constructs are defined on the other hand, leading to variations in importance in different studies. Some studies include accessibility factors such as job accessibility (e.g. Cook, 1988; Howley at al., 2009; Hur and Morrow-Jones, 2008) and accessibility to family and friends (Hur and Morrow-Jones, 2008) and others combine both perceived local (e.g. access to facilities) and regional accessibility in one overall accessibility-index. (e.g. Buys and Miller, 2012; Lovejoy et al., 2010; Savasdisara, 1988). With regard to nuisances, some studies mainly looked into noise nuisance (e.g. Cook, 1988; Lovejoy et al., 2010), while others use a combined measure such as ‘traffic’ (Hur and Morrow-Jones, 2008) or ‘environmental quality’ (Howley at al., 2009; Savasdisara, 1988).

There are also studies that specify different types of nuisances. Buys and Miller (2012) included both perceived noise and air quality (although not specifically related to highways), with the former slightly more important, in explaining residential satisfaction in an urban area in Brisbane, Australia. In their study on life satisfaction in Germany, however, Rehdanz and Maddison (2006) found that people, although in general more annoyed by noise, are more affected by a change in perceived air quality. In addition, most stated preference studies seem to find that air pollution reductions are valued slightly

higher than noise reductions (see, for instance, Hunt, 2001; Sælinsminde, 1999; Wardman and Bristow, 2004).

Kroesen et al. (2010) include both calculated aircraft exposure measures, as well as perceived aircraft, road traffic and railway noise nuisance, alongside personal variables and dwelling characteristics to measure residential satisfaction in a Dutch neighborhood near Schiphol Amsterdam Airport in 1996/1997. They found that calculated aircraft noise exposure has a higher explanatory power than perceived aircraft noise nuisance and explain this by stating that noise nuisance does not seem to cover all potential perceived nuisances, which advocates for paying attention to more types of nuisance.

In general studies only find weak relations with respect to more objective measures of accessibility and nuisance. Van Praag and Baarsma (2005) did not find a direct relation between objective noise levels and life satisfaction in a residential area surrounding Schiphol Amsterdam Airport. However, they did find a direct relation between life satisfaction and perceived noise nuisance. Morris (2012) studied how the distance to certain activities like rail transit affects wellbeing, but only found marginal effects, mentioning self-selection as a possible cause: people living further away from the activity may attach less importance to it, weakening the relationship. Positive and negative externalities may also balance each other out. Additionally the different spatial scales on which accessibility and negative externalities may operate should also be taken into account (Tillema et al., 2012) when analyzing the effect of distance. The effects of noise and air pollution, for instance, are generally limited to an area close to the polluting source (see e.g. Nelson, 1982). Within this range, accessibility can be considered constant. Brereton et al. (2008) for example found that people living in proximity to a major road are less happy. However, although more constant on shorter distance, accessibility effects may extend far beyond the immediate vicinity of the road. Highway accessibility may still be an important factor in the location choice for specific groups of people (e.g. Tillema et al., 2010). That is to say, accessibility may guide the choice for a neighborhood, while other local environmental qualities may determine the final location choice within the neighborhood (Tillema et al., 2012), which may lead to a location choice somewhat further away from the highway. Therefore, not only absolute distance but also highway usage may be a relevant measure to study accessibility gains. With respect to use, Kroesen et al. (2010) indeed found air plane users to be more satisfied living in an aircraft exposure area. Results of studies including travel time are however mixed: some found a negative relation (Choi et al., 2013), while others did not find any significant effects (Brereton et al., 2008). This brings us back to the relevance of perceptions. People may have a different value of time (e.g. Geurs and Van Wee, 2004). Moreover they differ in the way they perceive nuisance; studies looking into the relation between noise exposure and noise annoyance often fail to find a one-to-one relationship (Job, 1988; Schreckenberg et al., 2010; Zimmer and Ellermeier, 1999; Miedema and Vos, 1999). Because of this notion, studies often conclude that subjective evaluations have more explanatory power (e.g. Parkes et al., 2002).

2.3 Residential satisfaction and road projects

To keep up with current and future accessibility demands, new roads are constructed and current roads are adjusted and extended. As a consequence residential areas will change, with potential consequences for nuisances, accessibility and residential satisfaction.

The risk and insecurity associated with the change, e.g. about neighborhood amenities, personal security and house prices (Dear, 1990) during and after the adjustment and the feeling of being excluded from the discussion may push people to protest against plans (Healey, 1997). An example is NIMBY (not in my backyard) opposition, characterizing social response to unwanted facilities (such as road and rail line

construction) (Wolsink, 2000). Common to all facilities that generate NIMBY reactions is that benefits spread regionally (like highway accessibility improvement), while 'costs' are mainly concentrated locally (e.g. Aeschbacher, 2006). Also, resistance against car use in general may provoke opposition (e.g. North, 1998). As a result, people may decide to protest if they consider the project undesirable for some reason or in extreme cases may even decide to move. However, as people attach different values to the facility, differences in reactions are to be expected (e.g. Aeschbacher, 2006).

2.4 Expectations

Based on the theoretical framework discussed, in this section we put forward some expectations towards our research objectives. We defined three expectations with regard to our first objective; gaining greater insight into the impact of highway externalities on residential satisfaction of households near highways.
The first definition relates to the trade-off between positive and negative externalities. As described in section 2.2, studies including perceptions of both regional accessibility and nuisance in other research settings seem to conclude that both aspects are of comparable importance in residential satisfaction (Buys and Miller, 2012; Cook, 1988; Howley at al., 2009; Hur and Morrow-Jones, 2008; Lovejoy, 2010; Savasdisara, 1988). Perceptions seem to be better estimators than objective measures (e.g. Kroesen et al., 2010; Hur and Morrow-Jones, 2008; Lee and Guest, 1983; Lovejoy et al., 2010; van Praag and Baarsma, 2005). Additionally, accessibility and nuisance may have influence on different spatial scales; whereas noise effects largely seem to fade away at a distance of 300-600m meters from a highway (Eliasson, 2005; Nelson, 1982); accessibility is quite constant on shorter distance but may extend far beyond the immediate vicinity of the road (see Tillema et al., 2012). This may mean that the relative impact of noise may be stronger at shorter distance from the road. As highway accessibility may be a reason for people to choose a residential location in proximity of a highway (e.g. Tillema et al., 2010), highway usage may also be reflected in higher residential satisfaction.
Our first expectation is:

E1: Accessibility and nuisances are of comparable explanatory importance in relation to residential satisfaction. Subjective evaluations outweigh objective measures. Highway interest may be an important estimator. Close to the highway infrastructure nuisance effects are expected to dominate.

The second expectation focuses on highway nuisances. As described in section 2.2, different kinds of nuisance effects related to the highway can be distinguished; e.g.: noise, air pollution and. barrier-effects (Tillema et al., 2012). Mixed results are found with respect to the relative importance of noise and air nuisance; some studies finding noise more important (Buys and Miller, 2012), while others find air pollution to be more important (e.g. Rehdanz and Maddison, 2006; Wardman and Bristow, 2004). As several studies indicate the strong influence of neighborhood appearance on people's residential satisfaction (e.g. Hur and Morrow-Jones, Parkes et al., 2002), we might also expect barrier-effects of the highway to have an impact. To conclude, it is difficult to judge the relative importance of the three types of nuisances based on current literature.
Therefore, the expectation is as follows:

E2: People living near a highway are expected to be comparably (i.e. approximately same explanatory strength and same sign) influenced in their residential satisfaction by air pollution and noise nuisance. Barrier effects may also have a negative impact.

The third expectation is related to the broader residential context. As discussed in section 2.2, several studies indicate that although (regional) accessibility and nuisance are among the most important factors, other neighborhood factors such as general appearance, satisfaction with density of the built environment, cleanliness, safety from crime and good neighbors seem to be at least of equal importance (e.g. Howley at al., 2009; Hur and Morrow-Jones, 2008; Lovejoy et al., 2010). However, because of our focus on residential locations near highways, we might expect accessibility and nuisance to play a more prominent role. This leads to our third expectation.

E3: Nuisance and accessibility are among the most important factors in explaining residential satisfaction at locations near highways.

Our fourth expectation relates to our second research objective, which is to gain greater insight into the extent to which plans for highway adjustment projects influence residential satisfaction. As discussed in section 2.3, concerns about possible changes regarding, for example, house prices, personal security and neighborhood amenities (Dear, 1990) or resistance against car usage in general (e.g. North, 1998) together with the feeling of being excluded from the discussion on infrastructure change, may push people to protest (Healey, 1997) and may provoke opposition. However, as also described in section 2.3, differences in interest in the facility under construction may lead to diversity in reactions (e.g. Aeschbacher, 2006). From this we may expect people with a higher interest in highway accessibility and people with a positive attitude towards driving to have more positive expectations.
This leads to our fourth expectation:

E4: Plans for highway infrastructure adjustments influence residential satisfaction in a negative way (4a). People with a positive attitude towards cars or with an interest in highway-accessibility have more positive expectations towards residential satisfaction as a consequence of the highway adjustment project (4b).

3. RESEARCH DESIGN AND METHOD

3.1 Data collection

To gain knowledge on the issues raised above, we conducted a survey in 2011 among residents living near highways in the Netherlands. Seven highway locations geographically distributed throughout the Netherlands were selected.
In two of the selected locations, a highway adjustment project is planned (i.e. Groningen and Utrecht, see Figure 1). Because of the dense road infrastructure network already in place, current and future road infrastructure projects in the Netherlands, like in most western countries, will mainly consist of extensions and improvements of the existing network (e.g. Tillema et al., 2012). Both projects entail considerable extensions of existing infrastructure in the near future. The timing of the projects is comparable; at the moment of the questionnaire taking place, both projects were in a phase in which preliminary design decisions were about to be taken. Both projects have planned realization dates between 2015 and 2020.
The questionnaire was distributed in different neighborhoods within a one kilometer radius from the highway. This radius was partly based on studies indicating that noise effects seem to fade away at a

distance of 300-600 meters from a highway (Eliasson, 2005; Nelson, 1982). To get sufficient variation in highway exposure levels, we extended the distance to 1,000 meters.

The selected locations comprise a variety of residential groups (differences in income, age, etc) and house types (diversity in price, owned and rented). In the Netherlands about 60% of Dutch residents own their homes and residents are in general satisfied with their residential location (e.g. van Poll et al., 2011). There is a sophisticated system of environmental controls and (mitigation) policies (Arts, 1998); for example, restrictions exist regarding the maximum levels of nuisance (new) buildings may be exposed to. However, not all properties meet these levels (Theebe, 2004). Like in many other countries, house prices in the Netherlands are slightly negatively affected by noise exposure (e.g. Theebe, 2004). In our sample, the percentage of owned houses is on average somewhat higher (75%) than the Dutch average.

Depending on the size of the neighborhood and the number of zip codes in each area, 2 to 10 addresses were selected per zip code. A total of 5,500 questionnaires were distributed manually. 1,396 people participated, which corresponds to a response rate of about 25 percent. In total 1,225 valid questionnaires were used for the analysis in this paper. The response was found to be representative for the selected neighborhoods.[2]

The survey consisted of questions about the current household situation; residential location decisions, neighborhood perceptions, residential satisfaction and other relevant background characteristics of the household were collected. For the two locations with planned highway adjustments, a short description of the plans was included in the questionnaire; questions relating to the adjustment process, people's attitudes and expectations were asked as well.

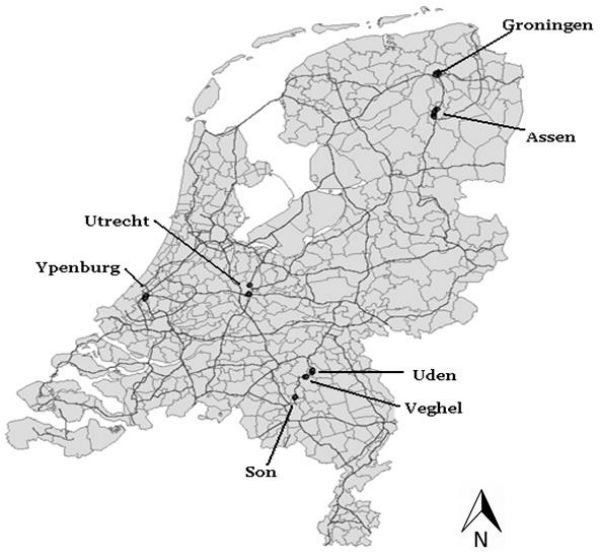

FIGURE 1 Geographical spread of selected locations.

[2] We checked the response for potential bias. For example, possibly there would be a higher response closer to the highway or in the areas with higher exposure. However this was not found to be the case (the response was 22.7% within 300m; 27.6% within 300-600m and 23.1% within 600-1000m from the highway, respectively). Moreover, the response population is representative for the neighborhood based on gender, family composition and age, older respondents are slightly overrepresented.

3.2 Model specification and data preparation

Our analysis consists of two parts. First, we looked into the impact of the highway on residential satisfaction in a 'stable' situation without planned highway infrastructure changes. The dependent variable is residential satisfaction (see Table 1). Individuals were asked to respond to propositions regarding satisfaction with the neighborhood and the dwelling. To define satisfaction in our study we combined people´s house satisfaction and neighborhood satisfaction (both graded on a 7-point Likert scale) into one overall construct called 'residential satisfaction' (Correlation of 0.560).

We rounded average values to the nearest integer to get back to the original ordinal scale. We estimated three models. Model A only contains objective explanatory characteristics, whereas model B covers both objective and subjective characteristics (1,225 respondents). Model C includes some variables related to reaching the work location by car which are only available for working respondents (i.e. 759 out of 1,225 have a job). We applied ordinal regression and used complementary log-log link as most of our respondents report a high satisfaction level.

In the second part of the analysis we aim to gain first insight into the extent to which plans for highway infrastructure adjustments influence residential satisfaction. On the two locations where a highway adjustment was planned (i.e. Groningen and Utrecht; a total of 541 respondents), people were asked whether they expect their satisfaction level to change as a consequence of the adjustment. We used the expected change in satisfaction as a dependent variable in a multinomial logistic regression model to estimate the chance of someone expecting a negative impact, a positive impact or no change in satisfaction (i.e. the reference category).

Several explanatory variables are included in both analyses (see Table 1). As highway accessibility and -nuisances play an important role in our study, both aspects were taken along in quite some detail, some variables directly and some only indirectly relating to the highway. With respect to perceptions of accessibility, a more general as well as a more highway-specific measure was included, the former relating to the satisfaction with overall accessibility of the residential location, the latter to satisfaction with home to work accessibility by car. More objective measures of highway accessibility were also included. To measure possible accessibility gains of living close to a highway, we included the distance between the zip codes within our sampled neighborhoods and the nearest highway access lane, which we computed by use of GIS and road network data. Additionally, people were asked to indicate their work commute duration. Moreover, we added information relating to highway accessibility interest, such as highway use frequency and the preference for living near the highway. The attitude towards car driving was included in the model as well.

Regarding negative externalities, the survey included questions and items on three types of perceived nuisance: noise, air pollution and barrier-effects. The noise and air constructs were calculated by means of five items, that included perceived actual observance of nuisance (either inside or outside the house), and items focusing on perceived concerns and health problems. We checked whether the specific questions "I am annoyed by.." and "I am worried about.." were measuring different things. As a very strong relation was found between both we decided to combine them into one variable. The variable measuring perceived barrier-effects was defined by combining perceptions on visual and physical obstruction, integration in the landscape and perceived unattractiveness. Correlations and factor tests showed that combining these variables was justified. The constructs were made by taking the mean of the different items included. We also obtained objective information. People were asked whether they have an actual view of the highway or a screen (i.e. a proxy for visual nuisance). GIS was used to compute the distance between the zip codes within our sampled neighborhoods and the highway. Moreover, we

obtained data from the Dutch Ministry of Infrastructure and Environment on mathematical exposure calculations for noise (DB) and air (NO2 and PM10) by road traffic for each 6-digit zip code around Dutch highways.

In addition to accessibility and nuisance aspects, various other variables were selected because of their potential relevance in explaining residential satisfaction. With regard to neighborhood factors, subjective evaluations of certain aspects of their residential location were included, such as attractiveness, traffic safety, social cohesion, greenery, and more local accessibility measures like the number of facilities and parking places. Population density and the average house price level of the neighborhood ,obtained from Statistics Netherlands, were also included. Several studies show house prices to be lower in close vicinity of a road (see for instance Theebe, 2004; Bateman et al, 2001); Lower house prices may compensate for the negative effects associated with the highway. A dummy variable for each residential location was added, to cover potential (geographical) location-specific effects. Finally, dwelling characteristics (type of house, insulation) were included, as well as personal factors like socio-economic background characteristics.[3]

TABLE 1 Descriptive characteristics of variables in analysis

	All respondents	**Working respondents**	**Respondents announced highway adjustment project locations**
	Percentage/ mean	**Percentage/ mean**	**Percentage/ mean**
1.Factors directly related to the highway			
A.Accessibility			
Objective Information			
0-300m from access lane	18.5%	21.3%	30.3%
Perceptions			
Satisfaction with residential location accessibility (1-7)	6.3	6.3	6.3
Satisfaction with home to work accessibility by car(1-7)		5.7	
Interest/use			
Use. often in traffic jam	6.1%	8.9%	6.3%
Use. not often in traffic jam	78.0%	81.4%	72.4%
(Almost) no use	10.2%	5.5%	18.1%
Use of highway unknown	5.8%	4.2%	3.2%
Preference to live near highway (1-7)	2.6	2.7	2.4
Commute duration (minutes)		25.7	
Attitude about car driving (1-7)	4.9	5.0	4.7

[3] Missing cases in the nominal variables (for example missing income; education) are included in the model with the label "unknown" (for example "income unknown") to 1) include as many respondents as possible and 2) see whether respondents who did not fill in the question have a distinct residential satisfaction level. This was not found to be the case as none of the "unkown" variables is significant. As there are only a limited number of missing cases and they often belong to the same respondents, some of the "unknown" variables show high coefficients because of high correlation within the restricted models (Analysis 1 Model C and Analysis 2). However, excluding the variables does not significantly change estimates of the other variables.

B.Nuisance			
Objective Information			
0-300m from highway	36.3%	39.6%	37.0%
Decibel exposure (level 1-7)	3.2	3.3	3.6
NO2 exposure (ug/m3)	2.9	3.1	3.0
Seeing highway	5.0%	4.6%	4.9%
Seeing screen	7.8%	8.5%	9.7%
No view on highway	86.0%	86.1%	83.8%
View unknown	2.0%	1.7%	1.6%
Perceptions			
Perceived noise nuisance (1-7)	2.1	2.0	2.3
Perceived air nuisance (1-7)	2.5	2.4	2.8
Perceived barrier-effects(1-7)	3.3	3.4	3.6
2.Factors not directly related to the highway			
A. Neighborhood characteristics			
Objective Information			
Population density (km^2)	4,700	4,800	5,200
Average housing value neighborhood (euro's)	255.5	255.2	207.5
Location Assen	17.2%	17.7%	
Location Utrecht	20.8%	22.0%	47.8%
Location Groningen	23.1%	22.3%	52.2%
Location Son	13.2%	10.5%	
Location Uden	8.7%	7.0%	
Location Veghel	8.4%	9.7%	
Location Ypenburg	8.7%	10.8%	
Perceptions			
Satisfaction with amount of green (1-7)	5.6	5.5	5.3
Satisfaction with traffic safety (1-7)	5.2	5.2	5.0
Satisfaction with contact level (1-7)	5.4	5.4	5.4
Satisfaction with attractivity buildings (1-7)	5.4	5.3	5.1
Satisfaction with facility level (1-7)	5.5	5.6	5.7
B.Dwelling characteristics			
Objective Information			
House built < 1980	45.3%	40.3%	46.4%
House built >1979	50.2%	54.7%	46.2%
House built unkown	4.5%	5.0%	7.4%
Detached house	35.3%	33.7%	6.7%
Non detached house	64.0%	65.6%	92.4%
Type of house unknown	0.7%	0.7%	0.9%
Rented house	24.1%	20.6%	37.4%
Owned house	75.2%	78.9%	61.7%
Owned/rented unknown	0.7%	0.5%	0.9%
Well insulated house	90.6%	91.3%	83.8%
Poorly insulated house	8.6%	7.9%	15.5%
Insulation unknown	0.8%	0.8%	0.7%
C.Personal characteristics			
Objective Information			

Female	46.9%	51.7%	55.4%
Having children	36.3%	50.1%	26.9%
No children	63.5%	49.8%	71.1%
Children unknown	0.2%	0.1%	2.0%
Age: 20-25	3.2%	3.8%	5.6%
Age: 26-40	23.6%	32.5%	30.5%
Age: 41-60	45.2%	58.1%	43.0%
Age: 61 and above[a]	28%	5.5%	20.9%
High education	60.9%	68.9%	67.1%
Low education	39.1%	31.1%	32.9%
Monthly income below 4000 euro's	69.3%	63.8%	74.5%
Monthly income >4000euros	23.9%	29.0%	18.6%
Monthly income unknown	6.8%	7.2%	6.9%
Tenure duration<10	47.3%	56%	51.6%
Tenure duration >30	9.2%	1.7%	6.0%
Tenure duration unknown	3.4%	2.1%	4.2%
3.Dependent			
A.Analysis 1: Dependent variable: residential satisfaction			
Residential satisfaction =1 (very low)	1.5%	0.9%	0.0%
Residential satisfaction =2	2.3%	2.2%	0.7%
Residential satisfaction =3	3.5%	3.4%	2.2%
Residential satisfaction =4	7.1%	10.0%	9.1%
Residential satisfaction =5	19.3%	20.9%	17.9%
Residential satisfaction =6	40.7%	42.7%	44.9%
Residential satisfaction =7 (very high)	25.6%	22.8%	25.2%
B.Analysis 2: Dependent variable: expected change in residential satisfaction because of announced highway adjustment			
Expects decrease in satisfaction			37.4%
Expects no change in satisfaction			26.9%
Expects increase in satisfaction			35.7%
N	1,225	759	541

[a] We preferred age-squared groups as we believe they are more interpretable. The groups were roughly determined based on life phase; students (20-25), starting workers (26-40), experienced workers (41-60) and almost retiring (61 and above).

4. RESULTS

In this section we describe the results of the multivariate analysis. In section 4.1 we discuss the factors explaining residential satisfaction in a 'stable situation'. In section 4.2 we look into peoples' expected changes in satisfaction as a consequence of announced highway adjustments. In both sections we distinguish between objective explanatory factors and more subjective ones and refer to our expectations as stated in section 2.4.

4.1 Residential satisfaction in a 'stable' situation

4.1.1 Residential satisfaction, accessibility and nuisance in general

Table 1 (3A) shows that, generally speaking, respondents appear satisfied with their residence, i.e. house and neighborhood; about 85 percent of respondents reports being satisfied (i.e. summation of categories 5-7 in table 1). Kroesen et al. (2010) found comparable satisfaction levels in an aircraft exposure area in the Netherlands. Moreover, this is in line with various international studies at other (non-highway) locations, which also found high satisfaction ratings (e.g., Eliasson et al., 2002; Lu, 1999; Hur and Morrow-Jones, 2008; Buys and Miller, 2012).

With respect to the perception of nuisance, results are similar (Table 1; 1B). On a Likert-scale from 1 (very low perceived nuisance) to 7 (high level of perceived nuisance), the average nuisance amounts to 2.1 for noise. Nuisance levels for air (i.e. 2.5) and barrier-effects (i.e. 3.3) appear to be modest as well.

With respect to current accessibility (Table 1A), generally speaking, respondents seem quite happy. Satisfaction with overall accessibility of the residential location scores a mean value of 6.3 (i.e. on a scale from 1, very unsatisfied, to 7, very satisfied). Employed respondents gave an average score of 5.7 with respect to satisfaction with home to work accessibility by car. This relatively positive picture might indicate some self-selection; the most noise- sensitive people may have moved away or may not have chosen a highway location in the first place.

TABLE 2 Results explanatory analysis

	Analysis 1: Explaining residential satisfaction			**Analysis 2: Explaining chance for a decrease. increase vs no effect on residential satisfaction because of highway adjustment project**	
	Ordered logistic regression			**Multinomial logistic regression**	
	Model A: Objective factors	Model B: Objective and subjective factors	Model C: Objective and subjective factors	Expect *decrease* vs no change	Expect *increase* vs no change
	All respondents	All respondents	Working respondents	Respondents planned highway adjustment project	Respondents planned highway adjustment project
1. Factors directly related to the highway					
A.Accessibility					
Objective Information					
0-300m from access lane (ref=300-1000m from access lane)	-.083	-.172	-.122	.718	-.037
Perceptions					

Satisfaction with residential location accessibility (1-7)			.186	***	.132	*	.061		.069			
Satisfaction with home to work accessibility by car (1-7)					.009							
Highway interest/use												
Use. often in traffic jam (ref=use but not often traffic jam)	.067		-.001		-.179		.800		-.384			
(Almost) no use	-.148		-.349	**	-.256		.717	*	-1.012	***		
Use of highway unknown	.129		.262		-.251		-.688		-.444			
Preference to live near highway (1-7)			.058	**	.078	**	-.053		.203	***		
Commute duration (minutes)					.001							
Attitude about car driving (1-7)			-.041		-005		-.100		.223	**		
B.Nuisance												
Objective Information												
Population density (km^2)	-.009		-.025		.000		.081		-.023			
0-300m from highway (ref=300-1000m from highway)	.000		.522		.165		-.722		-.534			
Decibel exposure (level 1-7)	-.013		-.014		-.074		.382		-.051			
NO2 exposure ($ug/m^{3)}$	-.023		.012		.052		.034		-.027			
View of highway (no view of highway/screen)	.177		.503	**	.987	***	.262		-.524			
View of screen	-.417	***	-.143		.020		.065		.374			
View unknown	-.114		-.390		.034		-.163		-1.713			
Perceptions												
Perceived noise nuisance (1-7)			-.087	*	-.075		.298	**	.028			
Perceived air nuisance (1-7)			-.125	**	-.133	*	.442	***	.040			
Perceived barrier-effects (1-7)			-.062	.	-.099		.132		.013			
2.Factors not directly related to the highway												
A.Neighborhood characteristics												
Objective Information												
Average housing value neighborhood (euro's)	.001		-.002	*	.000		.001		-.001			
Location Assen (ref=Location Ypenburg)	.254		-.232		.201							
Location $Utrecht_b$	.073		-.353		.091		1.326		-.579			
Location Groningen	.305		.035		.426							
Location Son	-.075		-.393		-.092							
Location Uden	.450	*	-.056		-.171							
Location Veghel	.404		.070		.256							
Perceptions												
Satisfaction with amount green (1-7)			.030		.045		.041		.118			
Satisfaction with traffic safety (1-7)			.167	***	.187	***	.017		-.006			
Satisfaction with contact level (1-7)			.317	***	.242	***	.053		.050			
Satisfaction with attractivity buildings (1-7)			.452	***	.520	***	-.293	**	-.024			

Satisfaction with amount of parking places (1-7)	.053 **	.020	.148	.047
Satisfaction with facilities (1-7)	.021	.042	-.126	-.017
Current residential satisfaction (1-7)			.048	.182
B.Dwelling characteristics				
Objective Information				
House built < 1980 (ref=house built>1979)	-.001	-.103	-.305 **	.237	-.113
House built unkown	-.203	-.443 **	-.309	-.385	-.336
Detached house (ref=not detached house)	.253 **	.140	.155	.478	.261
Type of house unknown	.250	.504	12.407	60.210	46.433
Rented house (ref=owned house)	-.200 **	-.018	-.313 **	-.257	.091
Owned/rented unknown	.494	.083	-12.397	-16.993	-16.454
Well insulated house (ref=not-well insulated)	.054	-.048	-.014	.388	.479
Insulation unknown	-.579	-.030	.042	1.830	14.127
C.Personal characteristics				
Objective Information				
Female (ref=male)	.021	-.002	.047	.103	-.216
Having children (ref=no children)	-.075	-.061	-.144	.109	-.108
Children unknown	1.222	.768	-.734	-43.120	-14.429
Age: 20-25 (ref=26-40)	.299	.871 ***	.688 **	-.348	.929 *
Age: 41-60	.114	.136	.151	.278	.142
Age: 61 and above	.498 ***	.384 **	-.237	.489	.544
High education (ref=low education)	-.108	-.063	-.087	.690 *	.006
Monthly income >4000euros (ref=income below 4000euros)	-.005	.003	-.167	-.341	.210
Monthly income unknown	-.023	.159	-.057	.004	.428
Tenure duration <10 (ref=tenure between 10 and 30 years)	.249 ***	.054	.001	.388	.558 *
Tenure duration >30	.249	.034	.449	-.599	.942 *
Tenure duration unknown	.319	.488 *	-.464	-.306	-.009
3. Interactions				
Satisfaction residential location accessibility *0-300m from access lane		-.010	.038		
Perceived noise nuisance* 0-300m from highway		-.250 ***	-.327 ***		
Perceived air nuisance * 0-300m from highway		.038	-.002		
Perceived barrier-effect nuisance * 0-300m from highway		.012	.072		
4. Intercepts				
A.Analysis 1 Dependent variable: residential satisfaction				
Residential Satisfaction=1	-6.681 ***	-2.774 **			

Residential Satisfaction=2	-4.598	***	-.585		-.312			
Residential Satisfaction=3	-3.265	***	.874		.915			
Residential Satisfaction=4	-1.943	***	2.382	***	2.516	***		
Residential Satisfaction=5	-.827	*	3.727	***	4.015	***		
Residential Satisfaction=6	.668		5.735	***	6.181	***		
B.Analysis 2 Dependent variable: expected change in residential satisfaction because of announced highway adjustment project								
Intercept							-6.582	**	-3.937	**
Nagelkerke Rsq	.106		.635		.713		.514	
LL	3.032.501		2.088.296		1.142.012		865.648	
N	1225		1225		759		541	

***=significant at <1%; **=significant at<5%; *=significant at<10%

b In analysis 2, reference category is Groningen.

4.1.2 Explaining residential satisfaction

Factors related to the highway

Our first expectation (E1) regarding the tradeoff between accessibility and nuisances was confirmed to a large extent. The effect of perceived noise and air nuisance (see 1B in table 2) seems to be comparably strong to the effect of perceived overall accessibility of the residential location (see 1A in table 2). Also as expected (E1) and in line with Kroesen et al. (2010), highway usage in itself is directly reflected in higher residential satisfaction (Model B), thereby compensating for negative externalities. Partly related to this, residents who had a preference for living near a highway appear to be more satisfied (models B and C). However, attitude towards driving and the highway-related satisfaction with the home to work accessibility by car (Model C on working respondents) do not directly impact residential satisfaction on highway locations. Especially the latter is surprising as some other studies did find a relationship between job accessibility and residential satisfaction (e.g. Hur and Morrow-Jones, 2008; Howley et al., 2008) and people may have specifically chosen to live close to a highway because of regional accessibility gains. Nevertheless this latter aspect may also make people more critical, weakening the relationship. With respect to nuisance, perceived barrier effects were not found to be significant.

In line with other studies (e.g. van Praag and Baarsma, 2005) we found that perceptions of nuisances outweigh objective measures (E1b), as we found no direct effect of highway exposure levels (see B1 in table 2). Moreover, the actual commute duration (Model C) as well as the objective distance to the highway and the access lane are not significant. Surprisingly, however, after correcting for all other factors, actually being able to see the noise mitigation screen from home appears to result in lower residential satisfaction, compared to not having sight on highway or screen, at least in Model A. Instead, people who can actually see the highway traffic from their house appear to be more satisfied in model B and C.

We also expected (E1) that both externalities would exert an influence on different spatial scales, with noise effects dominating on shorter distance while small distance differences (i.e. respondents all live within a 1 km radius from a highway) hardly affecting car accessibility. We cannot confirm this expectation based on objective measures as both exposure and distances were not found to be significant. However, we did find that the impact of perceived noise nuisance on satisfaction is much stronger closer to the highway, while the impact of perceived other nuisances and accessibility is not significantly

different at 0-300m distance compared to 300-1,000m (i.e. the interaction effect is not significant, see 3 in table 2).
Regarding the relative importance of different nuisances (E2), we found as expected a comparable, statistically significant impact for both perceived noise and air nuisance, which is in line with studies concluding that noise nuisance does not cover all annoyance perceived when being confronted with exposure (e.g. Kroesen et al., 2010; Job, 1999). In contrast to our expectation, however, perceived barrier effect nuisance was found to have no direct significant impact on residential satisfaction.

Other contextual factors
Although highway externalities seem to impact residential satisfaction, the question is how important these externalities are compared to other personal, dwelling and neighborhood factors. Our third expectation (E3) is that, based on other studies (see, for instance Hur and Morrow-Jones; Buys and Miller, 2012; Lovejoy et al., 2010), perceived nuisance and accessibility are among the most important factors in explaining residential satisfaction near highways. Our findings support our expectation. However, people's evaluations on the attractiveness of neighborhood design and on social cohesion are more important than accessibility and highway nuisances.
Although of (slightly) lower importance, some other variables also significantly influence residential satisfaction in our models. With regard to neighborhood characteristics (see table 2; 2A.), satisfaction with current traffic safety (model A and B) and the number of parking places (model B) show a positive relationship with residential satisfaction. Additionally, we find some indication that satisfaction levels seem to be lower in neighborhoods with higher mean house prices (Model B). It may be that lower house prices partly compensate negative effects of nuisance, although this is speculative and outside the scope of our current study. Surprisingly, and in contrast to other studies (Hur et al., 2010; Hur and Morrow-Jones, 2008; Kearney, 2006; Lee et al., 2008), we did not find significant effects with respect to satisfaction considering the amount of greenery and satisfaction with the number of facilities in the neighborhood. Possibly this is related to correlations with other neighborhood aspects like attractive neighborhood design (see also Lovejoy et al., 2010). Also, location dummies are not significant.
With respect to dwelling characteristics we find that house owners and respondents living in detached houses have higher residential satisfaction, which is in line with literature (e.g. Buys and Miller, 2012; Lu, 1999). However, when adding subjective characteristics, i.e. models B and C, these factors turn out to be statistically non-significant. Also, we do not find a significant difference with respect to insulation type of the house.
Finally, with regard to personal characteristics, age is found to be an important factor in explaining residential satisfaction; with the middle group of respondents (26-60 years of age) the least satisfied. Although indirectly related, we may point out here that studies explaining noise annoyance also often find middle-aged people to be most annoyed (e.g. Miedema and Vos, 1999). Moreover, in contrast to our expectation that people with a longer house tenure duration might be more satisfied as they have had more opportunities to move, there seems to be an indication that households that have been living in their house shorter (<10 years) are more satisfied. Cognitive dissonance might play a role; people who have recently bought a house in the area may first relax their attitudes about the negative aspects of the new neighborhood, as they want to convince themselves of having made the right choice in buying the house. This effect is not robust, however, given its statistical insignificance when adding subjective characteristics (models B and C). Finally, no significant effects are found with respect to other personal characteristics such as gender, family composition, education and income.

4.2 Planned highway adjustments and residential satisfaction

4.2.1 Expectations towards satisfaction in general

Our second objective was to gain greater insight in people's reactions to change, for which we focus on the two locations in our data set with announced highway adjustments (i.e. Groningen and Utrecht). Table 1 (3A) shows that current residential satisfaction at these locations is comparable with that at the other locations (88% compared to 85% is satisfied). We also did not observe a significantly lower satisfaction for these two specific highway locations in either Model A, B or C.

In contrast to our expectation (E4) that the majority of people would have a negative attitude towards the highway adjustments, expectations towards the effects of the adjustments on residential satisfaction are mixed (Table 1; 3B). The groups of respondents with either positive or negative expectations are roughly of the same size. Moreover, a substantial group (26.9%) indicated not to be influenced by the adjustment plans at all. The fact that we found mixed viewpoints may be due in part to the fact that the questionnaire was set out in a relatively early phase of the projects, in which opposition is generally still confined to a relatively small group of people (e.g. Dear, 1992). However also when respondents were not yet informed about the project, they were given the chance to form their opinion based on the concise project information provided in the questionnaire. Which people are more likely to be influenced by the announced adjustment?

4.2.2 Explaining expectations towards residential satisfaction

Factors related to the highway

Our fourth expectation (E4), being that highway users and people with a positive attitude towards cars (Table 2; 1A) would be more positive about the project, was to a large extent confirmed: Indeed we found that people using the highway and people who are more positive about cars in general more often expect their residential satisfaction to increase. The current opinion about accessibility did however not have statistically significant impact; we did not find that people who are currently less satisfied with their residential location accessibility or home to work accessibility by car[4] more often expect the road project to improve their satisfaction. Possibly, concerns about accessibility deterioration during or after the highway adjustment project may play a part. We did find that people who currently report high noise and air nuisance levels more often expect a negative effect of the adjustment on their residential satisfaction (Table 2; 1B). So although nuisances may also reduce after the highway adjustment has taken place, negative concerns seem to dominate. These concerns may relate to possible increase of nuisance, but may also related to changes in neighborhood amenities (changes in the design, the amount of nuisances), the development of house prices and personal security (for example traffic safety) may be behind this (e.g. Dear, 1990). Again, after correction for the subjective measures, more objective measures of noise and air exposure, distance to the highway or access lane did not show extra influence[5] (table 2; 1A). Also, view of the highway showed no impact.

[4] We also looked into the relation between current satisfaction of home to work accessibility by car and expectations towards satisfaction for working respondents. However also in this case significant effect was found.

[5] We also estimated the model without inclusion of subjective variables. In this version, people in high noise exposure areas are more negative. Also the people in Utrecht are more negative. Both effects fall away after inclusion of perceived variables.

Other contextual factors

Respondents with higher levels of education, who are generally more environmentally aware (e.g. Kollmuss and Agyeman, 2002), were shown to have marginally more negative feelings with regard to their satisfaction level as a consequence of highway adjustment projects (table 2; 2C). Young people (aged 20-26) however, were shown to have slightly more positive expectations; possibly because they are more flexible in dealing with change (see e.g. Halek and Eisenhauer, 2001) or just do not care that much as they are less place-attached and may be better able to move house in case they are dissatisfied (see e.g. Dunn, 2003). Again, we found that households with short (<10 years) and long (>30 years) tenure are more positive, which means that the middle group of households (tenure between 10 and 30 years)is most critical towards the adjustment. Possibly a mixture of a higher highway tolerance for the longest tenure and cognitive dissonance for the shortest tenure group play a part here. Interestingly, as we already found people who are more satisfied with attractiveness of building in the neighborhood to be more satisfied in general, we also found that these people less often expect the highway adjustment to have a negative effect on satisfaction. Other personal characteristics (i.e. gender, income, household composition), dwelling (i.e. house ownership, house type) and neighborhood characteristics (i.e. house prices in neighborhood, evaluations of greenery, neighborhood safety, facilities and the contact level), were not found to be statistically significant (table 2; 2A-B-C).

TABLE 3: Expectations and findings

E1	Partly confirmed	Comparable but opposite impact of perceived air/noise nuisance and accessibility of residential location on residential satisfaction. Barrier-effects and satisfaction with home to work accessibility by car however not significant. Noise nuisances more important closer to the highway. Subjective measures weigh out objective measures. Highway usage has a positive impact on residential satisfaction.
E2	Partly confirmed	Perceived air and noise nuisance have a comparably strong impact, but perceived barrier-effect nuisance is of lower importance.
E3	Partly confirmed	Highway externalities are among the main drivers of residential satisfaction. However, attractive design the neighborhood and social cohesion appear to be more important.
E4	Partly confirmed	Mixed reactions to a proposed highway adjustment. Highway users and people who have a positive attitude towards car driving more often have positive expectations; people who currently perceive a lot of hindrance more negative expectations. People being currently more critical towards accessibility do not have more positive or negative expectations.

5. CONCLUSIONS

In this paper we focused on gaining insight into household's residential satisfaction near highways based on survey data collected in the Netherlands in 2011. We aimed to study the effect of both accessibility and negative externalities, alongside other contextual factors, on the residential satisfaction of households living close to highways. Moreover, the objective was to gain insight into the extent to which highway project plans influence residential satisfaction. We formulated four expectations that pay attention to respectively 1) the trade-off between highway related accessibility and nuisance in explaining residential satisfaction, 2) the impact of different types of highway nuisances, 3) the relative importance of highway externalities compared to other personal, dwelling and neighborhood characteristics, and, finally 4) reactions concerning announced highway adjustment projects.

Regarding our first research aim, results indicated that, on average, respondents are satisfied with living near a highway and in that sense are not different from other studies (e.g. Eliasson et al., 2002; Hur and Morrow-Jones, 2008; Kroesen et al., 2010; Lu, 1999). Perceived nuisance appears to be moderate, and most respondents are satisfied with current accessibility of house and work. With respect to our first expectation (E1), we found that perceived accessibility of the residential location and noise and air nuisance are of comparable importance in explaining residential satisfaction. The impact of noise nuisance is stronger nearer to the highway, which supports the expectation that highway externalities may have influence on different spatial scales. As expected, and in line with other research (e.g. Kroesen et al., 2010), we found highway use (which may be a reason for living at a highway location) directly reflected in higher residential satisfaction. However, in contrast to other studies including measures of perceived regional accessibility (e.g. Hur and Morrow-Jones, 2008; Howley et al., 2009), satisfaction about work accessibility by car was not significant in our analysis. Objective measures like highway exposure and distance from highway or access lane were shown to have no effect, which supports the findings of other studies (e.g. Van Praag and Baarsma, 2005). Regarding our second expectation (E2), we found that noise and air pollution have a comparably strong impact. This confirms the conclusion of other studies (e.g. Job, 1988; Kroesen et al., 2010),that only measuring noise nuisance is not enough to measure all nuisances related to a polluting source. Perceived barrier-effects did not significantly contribute to the model. However, a view on the highway seems to be evaluated more positively compared to a screen, at least when it comes to residential satisfaction. In line with our third expectation (E3) and other studies on residential satisfaction (e.g. Hur and Morrow-Jones, 2008; Lovejoy et al., 2010) we found that perceived highway externalities are among the most important factors in residential satisfaction; only perceived neighborhood design, social cohesion and perceived traffic safety display a higher explanatory effect. In that sense, our respondents do not seem to differ much from residents living in other residential settings.

Our second analysis, in which we aimed to explore reactions towards future highway adjustments (E4) showed that opinions are mixed; the size of the group expecting an increase is comparable to that of the group expecting a decrease in satisfaction. As expected, highway users and people with a positive attitude towards cars showed more positive expectations, while non-users and respondents with more negative current nuisance perceptions were shown to display more negative feelings, possible fed by a mixture of concerns about changes in neighborhood amenities, house prices and personal security (Dear, 1990) but also environmental awareness and aversion against increased car use in general (North, 1988). Current perceptions about accessibility were not shown to impact expectations directly: people currently perceiving accessibility to be low do not seem to believe that the road project will significantly improve this situation. Expectations may also be attenuated by concerns about accessibility problems during or after the adjustments.

This study may have several practical implications. First of all, the overall positive evaluations of residential satisfaction near highways may imply that, generally speaking, problems regarding living near highways (at least in the Netherlands) may be somewhat overstated, although some self-selection effects and cognitive dissonance may be in effect here. Secondly, the notion that highway users show higher satisfaction levels as a result of living close to highways may be taken into account when thinking about the design of future highway locations. Moreover, the notion that the explanatory power of subjective nuisance outperforms calculated exposure levels, which are often used in transportation planning practice, may give reason for caution when making decisions based on calculated measures only. In addition, the fact that perceived noise and air nuisance both have a strong impact suggests that both aspects should be taken seriously. In relation to that, the finding that other neighborhood factors are at least as important as

highway-related factors indicates the importance of taking a broader perspective on (future) highway planning. Finally, our findings towards the effect of highway adjustment projects on residential satisfaction indicate that there are mixed opinions towards adjustments; opinions of people being present at consultation meetings and who often oppose plans may not always be representative for the larger population; the planning process might be improved by better understanding factors that drive attitudes by taking account of residential population characteristics.

Our research also poses new questions for further, more in-depth, research. We point to some of these possibilities. First, further research may focus more specifically on the interrelationship between highway externalities, residential satisfaction, relocation and house prices near highways, in order to gain a deeper understanding of people's coping strategies and potential self-selection. Second, it may be worthwhile to include a control group of people not living near highways in order to define whether people who live near highways differ in their residential satisfaction and to assess the extent to which explanatory factors change. Third, other research methods could be used to study and deepen our results: more longitudinal-based research could be useful to gain greater insight into changes of people's perception and reactions over time, e.g. by analyzing residential satisfaction both before and after a road project, and to study how information supply or mitigation measures could alleviate perceived nuisance. Moreover, more qualitative research, i.e. in depth-interviews and focus groups, may be useful to better understand the factors that drive people's perceptions and acceptance of plans.

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