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# Explaining Car Drivers' Intention to Prevent Road-Traffic Noise: An Application of the Norm Activation Model

**Elisabeth Lauper[1], Stephanie Moser[1], Maja Fischer[2], and Ellen Matthies[3]**

**Abstract**

Strengthening car drivers' intention to prevent road-traffic noise is a first step toward noise abatement through voluntary change of behavior. We analyzed predictors of this intention based on the norm activation model (i.e., personal norm, problem awareness, awareness of consequences, social norm, and value orientations). Moreover, we studied the effects of noise exposure, noise sensitivity, and noise annoyance on problem awareness. Data came from 1,002 car drivers who participated in a two-wave longitudinal survey over 4 months. Personal norm had a large prospective effect on intention, even when the previous level of intention was controlled for, and mediated the effect of all other variables on intention. Almost 60% of variance in personal norm was explained by problem awareness, social norm, and biospheric value orientation. The effects of noise sensitivity and noise exposure on problem awareness were small and mediated by noise annoyance. We propose four communication strategies for strengthening the intention to prevent road-traffic noise in car drivers.

[1]University of Bern, Switzerland
[2]University of Leuven, Belgium
[3]University of Magdeburg, Germany

**Corresponding Author:**
Elisabeth Lauper, Department of Psychology, University of Bern, Fabrikstrasse 8, 3012 Bern, Switzerland.
Email: elisabeth.lauper@psy.unibe.ch

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At present, road traffic is one of the most environmentally harmful human activities. Beyond its well-known negative effects, such as greenhouse-gas emissions and air pollution, noise emissions are a serious, but often neglected, problem. The magnitude of road-traffic noise emissions is strongly influenced by a car driver's behavior, beside the technical characteristics of the vehicle, its tires, and the pavement. Thus, noise abatement starts—apart from technical improvements and legislation—in the head of each car driver. Unfortunately, there is still too little knowledge on the psychological fundamentals underpinning car drivers' motivation to prevent road-traffic noise. Therefore, in the present study we investigate the psychological predictors of car drivers' intention to prevent road-traffic noise.

## Effects and Origins of Road-Traffic Noise

The negative effects of road-traffic noise include depreciation of property and loss of rent, disturbance of wildlife, and most importantly, adverse effects on humans' well-being and health. To prevent severe health impairments, the World Health Organization (WHO) recommends maximum noise levels of 55 dB(A) during daytime (WHO, 1999) and 40 dB(A) at night (WHO, 2009). At present, these critical values are often exceeded. According to the WHO, road-traffic noise leads to annoyance for one in three individuals during daytime and causes disturbed sleep at night for one in five individuals in the Western part of Europe (WHO, 2011). Moreover, exposure to road-traffic noise may cause serious physical health problems, particularly sleep disturbance (de Kluizenaar, Janssen, van Lenthe, Miedema, & Mackenbach, 2009; Phan, Yano, Nishimura, Sato, & Hashimoto, 2010), high blood pressure (van Kempen & Babisch, 2012), and cardiovascular diseases (Babisch, 2014; Davies & Van Kamp, 2012). In addition, Öhrström (1991) found a reduction in psychological well-being due to road-traffic noise, and Dratva et al. (2010) reported negative effects of road-traffic noise on health-related quality of life.

From a technical perspective, road-traffic noise consists of three major components: propulsion noise, rolling noise, and aerodynamic noise (van Blokland & de Graaff, 2012). For private, light vehicles (such as cars) on flat ground, propulsion noise dominates at low speed (up to 30 km/hr), whereas rolling noise dominates at higher speed. Aerodynamic noise is only relevant at very high speed (200 km/hr and more) or at extremely low rolling noise

(van Blokland & de Graaff, 2012). There are other noise sources that accompany road-traffic, for example, loud music, honking, rattling cargo, banging doors, and defective equipment, such as noisy mufflers. These noise sources might also disturb and annoy people, but they are only relevant for single vehicles and on single occasions and therefore do not strongly contribute to the total road-traffic noise level. Hence, noise abatement is most promising when the focus is on the reduction of propulsion and rolling noise.

## Abatement of Road-Traffic Noise

Because of the severe effects of road-traffic noise, there are governmental regulations designed to protect individuals from these impairments. Policy measures to protect individuals from the adverse effects of road-traffic noise have a relatively long history. Early and still important approaches focused on regulatory measures, particularly on guidelines setting the maximal noise burden for residential areas and office buildings but also guidelines on vehicle propulsion noise and the noise emissions of tires and pavements (den Boer & Schroten, 2007; Schick, 1990; Swiss Agency for the Environment Forests and Landscape, 2002).

Such guidelines combined with economic incentives have encouraged technical innovations (e.g., low-noise pavements, vehicles, and tires) that reduce road-traffic noise at the source. Other measures frequently used for the reduction of noise at source are land use regulations, implementation of speed reductions and traffic management (e.g., nighttime restrictions). Although the prevention of road-traffic noise at source is highly efficient, the most frequently used measures only combat the dispersion of noise (e.g., through the construction of noise barriers) or reduce the effect of noise at the receiver end (e.g., by insulating dwellings at "hotspots"; den Boer & Schroten, 2007).

A further path complementary to requirements, bans, and rules is to motivate the noise producers, that is, the motorists, to change their noise-producing behavior voluntarily. The most effective behavior changes for reducing propulsion and rolling noise are avoiding journeys by car and changing one's travel mode from private to public transport. However, the implementation of these behaviors is very demanding. Other behaviors such as buying low-noise tires and a smaller car or using a low-noise driving style require fewer changes in a car driver's lifestyle and are therefore easier to implement.

In the past, some of the interventions targeting motorists were narrowed to educational approaches that involved delivering information about the extent of noise pollution and health risks from excessive noise stress (e.g., Noisetube.net, 2013; Swiss Federal Office for the Environment, 2009a, 2013); however,

other interventions focused on motivating people to practice noise-reducing behaviors. For example, in the 1970s the U.S. Environmental Protection Agency (1980a, 1980b) started efforts to support communities in engaging their citizens in noise abatement such as the Extended Care Health Option (ECHO) program. In Europe, researchers united in the program SILENCE drafted a handbook for decision makers and action planers that contains advice on motivating behavior change in motorists (Kloth, Vancluysen, & Clement, 2007). Moreover, in Switzerland, a number of programs run by governmental and non-governmental organizations have started promoting low-noise behaviors such as changing travel mode, using a low-noise driving style, and buying low-noise tires or low-noise cars (Cercle Bruit, 2014; Fachstelle Lärmschutz Kanton Zürich, 2014; Lärmliga Schweiz, 2014; Swiss Federal Office for the Environment, 2014b). However, the potential for noise reduction due to voluntary behavior change among motorists is not yet exhausted (Vlek, 2005). One reason for this might be that scientific fundamentals are missing: There is a complete lack of research on motorists' underlying motivation to prevent road-traffic noise and their knowledge about noise-reducing behaviors.

## Psychological Research on Road-Traffic Noise

So far, psychological research on traffic noise has not focused on noise-producing behaviors, but mainly on the psychological and physiological impacts of exposure to noise on human beings. Two psychological constructs that are frequently observed in this context are the individual's noise annoyance and noise sensitivity. Noise annoyance has been defined by Guski, Felscher-Suhr, and Schuemer (1999) as ". . . a multifaceted concept, covering mainly (1) immediate behavioural noise effects aspects, like Disturbance and Interfering with intended activities, and (2) evaluative aspects like Nuisance, Unpleasantness, and Getting on one's nerves" (p. 525). Noise annoyance is the most frequently reported negative effect of road-traffic noise (Guski, 2008; Ouis, 2001). Moreover, noise annoyance has been linked to negative health-related outcomes (e.g., Dratva et al., 2010), and some authors proposed that noise annoyance is a mediator of the effect of noise exposure on health-related outcomes (Fyhri & Klæboe, 2009; Urban & Máca, 2013). Noise sensitivity can be defined as a personality trait that is positively associated with negative health-related outcomes (Heinonen-Guzejev et al., 2004, 2007; Welch, Shepherd, Dirks, McBride, & Marsh, 2013) and influences individuals' annoyance reports (Fields, 1993; Guski, 1999). Moreover, some authors propose that the effect of noise sensitivity on health-related outcomes might be at least partly mediated by noise annoyance (Shepherd, Welch,

Dirks, & Mathews, 2010; Urban & Máca, 2013). Thus, while the effects of traffic noise on individuals ("the victims") are well documented, there is a lack of psychological research on a voluntary change in behavior on the part of noise-producing "offenders," that is, motorists.

## Potential Psychological Predictors of Car Drivers' Intention to Prevent Road-Traffic Noise

In designing effective measures that address voluntary change of behavior to prevent road-traffic noise, it is important to understand the causes of people's motivational preparedness (or "intention") to act. The intention to behave in an environmentally friendly manner has frequently been shown to have a substantial effect on the performance of specific behaviors (e.g., Bamberg & Möser, 2007; Bamberg & Schmidt, 2003; Klöckner, 2013a; Klöckner & Blöbaum, 2010). Consequently, the intention to prevent road-traffic noise might be an important factor in fostering noise-preventing behaviors. It is to be expected, moreover, that strong intentions not only support noise-preventing behaviors but also increase the acceptance and support of political actions that aim to prevent road-traffic noise. So far, research has neglected to investigate predictors of the intention to prevent road-traffic noise.

The goal of this study is therefore to test for effects of psychological predictors on the intention to prevent road-traffic noise. The results of the study provide starting points for the design of effective interventions to enhance the intention to prevent road-traffic noise in car drivers. Given that the intention to prevent road-traffic noise is the motivational basis for behavior change, the knowledge gained will thus contribute to the abatement of road-traffic noise in a way complementary to requirements, bans, and rules.

The motivation to prevent road-traffic noise is predominantly an altruistic motivation, that is, it is characterized by the actor's intention to benefit another individual without regard for personal gain. When driving, most drivers are not annoyed by the noise of their car, among other things because modern cars are usually well insulated against noise. In contrast, the noise produced annoys people outside of the car who are sleeping, working, or relaxing, for example. Therefore, car drivers rarely benefit personally from their own noise reduction efforts, but these efforts benefit other people. However, it should be noted that noise-preventing behaviors might have benefits for the users themselves; for example, applying a low-noise driving style saves fuel for the driver. Nevertheless, we assume that individuals first form the intention to prevent road-traffic noise and only subsequently choose a specific behavior that matches the goal of noise prevention. Consequently, we assume that the intention to prevent road-traffic noise is driven by an altruistic motivation.

One theory that has been suggested for the explanation of altruistic behaviors is the norm activation model (NAM; Schwartz, 1977; Schwartz & Howard, 1981). The NAM seems to be especially useful for the explanation of behavior intentions (Abrahamse, Steg, Gifford, & Vlek, 2009; Eriksson, Garvill, & Nordlund, 2006; Gärling, Fujii, Gärling, & Jakobsson, 2003; Nordlund & Garvill, 2003; Steg & Vlek, 2009), which makes it a suitable theory for the purpose of the present study.

The NAM describes "a decision-making process through which personal and social norms mediate the influences of general values on altruistic and/or helping behavior" (Schwartz & Howard, 1981, p. 193). This process consists of five stages: attention, motivation, evaluation, defense, and behavior. For each stage, the theory describes different personal and situational variables that influence progression. Applications of the theory, however, frequently only focus on the personal and situational variables of the first two stages of the NAM, that is, the attention and the motivation stages. Moreover, there are a number of different versions of the NAM which have been used in past decades in the field of environmental psychology, probably because the original description of the NAM by Schwartz (1977) and Schwartz and Howard (1981) was on a conceptual level and could not be unequivocally operationalized in empirical research studies (for a discussion, see Klöckner, 2013b). Despite this variation in the use of the NAM, there are key constructs that are repeatedly observed, namely, personal norm, problem awareness, awareness of consequences, perceived social norms, and value orientations.

Personal norm is the central construct of the NAM. A personal norm captures the feeling of moral obligation to act pro-socially. Personal norms are specific to a certain type of behavior and need to be activated before becoming relevant. Most authors who investigate pro-environmental behavioral intentions support the assumption that personal norm is a direct predictor of intention (e.g., Abrahamse et al., 2009; Eriksson et al., 2006; Gärling et al., 2003; Nordlund & Garvill, 2003).

Frequently studied antecedents of the personal norm are awareness of need or problem awareness and awareness of consequences (e.g., Hunecke, Blöbaum, Matthies, & Höger, 2001; Klöckner & Blöbaum, 2010; Matthies, Selge, & Klöckner, 2012). Problem awareness is the awareness that a valued object is threatened and in need of support, or more specifically, the awareness that an environmental problem exists and a solution is needed. The awareness of consequences is the belief of a person that his or her actions contribute to a worsening of the problem.

Schwartz and Howard (1981) propose that perceived social norms influence the formation of personal norms. Consequently, many authors observing environmentally relevant behaviors have implemented social norms as

antecedents of personal norms (e.g., Hopper & Nielsen, 1991; Klöckner, 2013a; Klöckner & Blöbaum, 2010; Klöckner & Matthies, 2009). Social norms capture the perceived social expectations of relevant others for particular actions or topics.

Frequently, general values are conceptualized as the background against which a person creates a personal norm (Klöckner, 2013b; Nordlund & Garvill, 2002, 2003; Schwartz, 1977; Steg, Dreijerink, & Abrahamse, 2005; Stern, Dietz, Abel, Guagnano, & Kalof, 1999). Values are defined as "desirable transsituational goals, varying in importance, that serve as guiding principles in the life of a person or other social entity" (Schwartz, 1994, p. 21). In the explanation of pro-environmental behavior, three types of value orientations are frequently distinguished: egoistic, altruistic, and biospheric (De Groot & Steg, 2007; Stern, 2000). People with strong biospheric value orientations emphasize the environment and the biosphere, people with strong altruistic value orientations prioritize the welfare of other people, whereas people with strong egoistic value orientations focus on maximizing their individual outcome.

Although the NAM is based on the assumption that the value of one variable (e.g., personal norm) influences the value of another variable (e.g., behavior intention), many of the non-experimental studies using the NAM suffer from an important methodological weakness: They use cross-sectional data. Whereas cross-sectional data allow only for conclusions about covariation among the variables, longitudinal data allow for stronger causal conclusions by accounting for the time dimension, specifically by testing whether the predictor precedes the outcome in time (Burkley & Blanton, 2008; Finkel, 1995). However, even if longitudinal data are used, few studies control for the prior level of the outcome. If the prior level of the outcome is not statistically controlled for, the prospective effect of the predictor can be strongly misleading (Burkley & Blanton, 2008; Cole & Maxwell, 2003). Thus, in the present study, we use longitudinal data and take the prior level of the outcome into account.

We tested the questions of the present research using longitudinal data from a naturalistic field study. Although it is not an intervention study, the measured variables are not supposed to be completely stable over time in everyday life (which would be reflected by a test–retest correlation lower than 1.00 for the outcome). We assume that people evaluate their attitudes and intentions from time to time and, consequently, some participants will alter their attitudes and intentions between the two measurement occasions. However, these changes are expected to differ between individuals. Therefore, in the present study, the crucial question is whether the predictors measured at Time 1 explain (at least partially) the observed changes in the outcome variable over time.

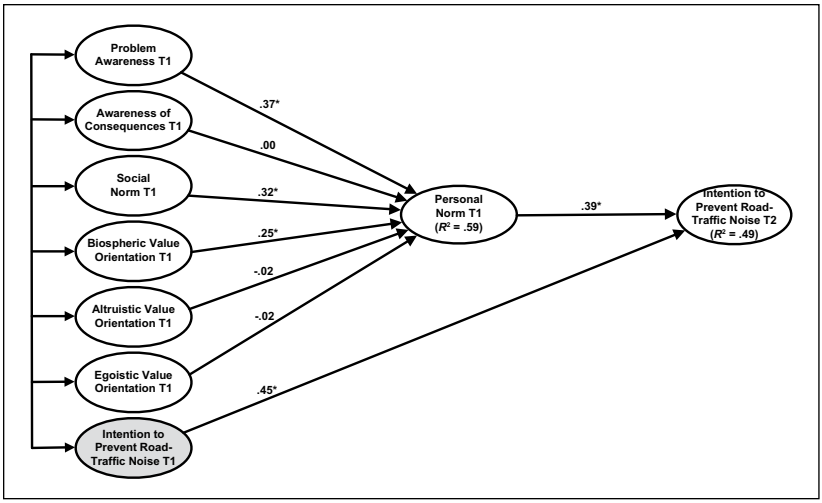


**Figure 1.** Predicting intention to prevent road-traffic noise.
*Note.* The figure shows standardized regression coefficients and explained variances ($R^2$) of endogenous variables. To keep the figure simple, only latent variables are shown, and indicators and residual variances are omitted. T = Time.
*$p < .05$.

## The Present Study

First, we examine the prospective effects of psychological predictors on car drivers' intention to prevent road-traffic noise. Second, we test for the effects of car drivers' experiences with road-traffic noise on their judgments of the severity of road-traffic noise (i.e., problem awareness). To do this, we test two statistical models. The first model captures the prospective effects of the predictors of the NAM on the intention to prevent road-traffic noise (see Figure 1). In this model, we account for the assumption of the NAM that personal norm is positively related to intention and mediates the effects of all other predictors. Furthermore, in line with previous research (e.g., Klöckner & Blöbaum, 2010; Matthies et al., 2012), we hypothesize that problem awareness and awareness of consequences are positively related to personal norm. In addition, we suppose that individuals' personal norm is stronger when they perceive that relevant others support the prevention of road-traffic noise (i.e., social norm) as proposed by several authors (e.g., Hopper & Nielsen, 1991; Klöckner, 2013a; Klöckner & Blöbaum, 2010; Klöckner & Matthies, 2009; Schwartz & Howard, 1981). Finally, in accordance with De Groot and Steg (2007), we hypothesize that altruistic and biospheric value orientations are

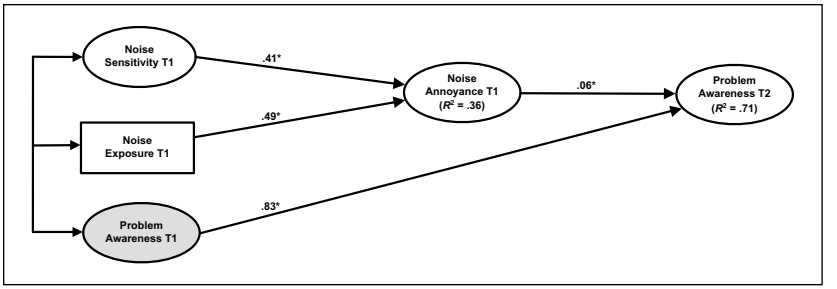


**Figure 2.** Predicting problem awareness.
*Note.* The figure shows standardized regression coefficients and explained variances ($R^2$) of endogenous variables. To keep the figure simple, only latent variables are shown, and indicators and residual variances are omitted. T = Time.
*$p < .05$.

positively related to personal norm, though we expect the effect of biospheric value orientation to be stronger than the effect of altruistic value orientation. In contrast, an egoistic value orientation should be negatively related to personal norm.

With our second model, we test for the predictors of problem awareness (see Figure 2). We hypothesize that problem awareness arises mainly in persons who have experience with road-traffic noise, specifically those who are exposed to road-traffic noise in their home. Therefore, we expect that noise exposure, noise annoyance, and noise sensitivity are positively related to problem awareness. In addition, in line with previous research (Fyhri & Klæboe, 2009; Shepherd et al., 2010; Urban & Máca, 2013), we suppose that noise annoyance at least partly mediates the effects from noise exposure and noise sensitivity on problem awareness.

Finally, we investigated car drivers' knowledge about noise-preventing behaviors. We assume that the intention to prevent road-traffic noise is the basis for behavior change in car drivers, and that, as a next step, car drivers have to choose a behavior that helps them reach this noise-prevention goal. Such a selection is only possible when car drivers have knowledge of noise-preventing behaviors.

## Method

The study participants were required to be car drivers and therefore had to have a driver's license (in Switzerland, the driver's license cannot be obtained before the age of 18). For the purposes of the present study, that is, the investigation of relationships between variables and not the interpretation of mean

levels, representativeness was not required. We decided therefore to conduct a web-based longitudinal survey in the German-speaking part of Switzerland, consisting of a baseline survey (Time 1 in autumn 2011) and a follow-up assessment 4 months later (Time 2 in spring 2012). The participants were recruited by (a) using a Swiss database of individuals with a general interest in participating in psychological surveys; (b) using the campus register of Bachelor, Master, and PhD students at the University of Bern; (c) advertising the study on various Internet websites; and (d) distributing flyers among clients of companies such as tire and car retailers. Visitors to the survey website received preliminary information on the purpose and procedure of the study. They were further informed that all participants could take part in a lottery to win one of 10 vouchers for online stores (with a value of 100 Swiss Francs, equivalent to US$110). After giving a valid e-mail address, participants received their personal link to access the survey. They were informed that their responses would be treated as strictly confidential. Participants who registered their e-mail address and who did not complete the survey were sent an e-mail reminder after 1 week. Four months after registering on the study website, participants received an invitation to the follow-up assessment. Participants who did not complete the follow-up were sent an e-mail reminder after 1 week.

## *Participants*

The sample included 1,002 car drivers (52.3% female).[1] The mean age of participants at the baseline assessment was 31.96 years ($SD$ = 12.7, range = 19-80). One percent had completed the obligatory 9 school years or less, 53% had completed secondary education (approximately 12 years), 42% had a master's degree, and 4% had a doctoral degree. The follow-up assessment was completed by 792 individuals (79% response rate). To investigate the potential impact of dropouts, differences in demographic variables were examined for participants who completed both assessments versus participants who did not complete the follow-up assessment. No significant differences emerged for age, sex, or education. Although the sample was not nationally representative, the sample is sufficiently diverse with regard to many characteristics such as age, education, and residence (i.e., urban vs. rural areas).

## *Measures*

Where no measures were available for the specific focus of this study (i.e., road-traffic noise), measures were adapted from the underlying theories. All

variables were measured with three or more items. The complete set of items can be found in the online appendix (at http://eab.sagepub.com/supplemental).[2] For theoretical reasons, in the first model, the present research uses measures of intention from the baseline (prior level of outcome) and the follow-up assessment (outcome), and measures of all other variables from the baseline assessment. Correspondingly, for the second model we used the measures of problem awareness from the baseline and from the follow-up assessment, and all other variables from the baseline assessment. Thus, there is a clear temporal ordering of predictors (which were assessed at Time 1) and outcome (which was assessed at Time 2).

*Problem awareness.* The measure includes items that were constructed according to the NAM (awareness of need; Schwartz, 1977; Schwartz & Howard, 1981). The scale included four items (Cronbach's α T1 = .91, Cronbach's α T2 = .91), for example, "In Switzerland, the noise produced by road traffic leads to a decrease in quality of life." Responses were measured on a 6-point scale (1 = *strongly disagree*; 6 = *strongly agree*).

*Awareness of consequences.* Items were constructed according to the NAM (Schwartz, 1977; Schwartz & Howard, 1981). The scale included four items (Cronbach's α = .88), for example, "When driving a car, I produce noise that has a negative impact on other people's quality of life." Responses were measured on a 6-point scale (1 = *strongly disagree*; 6 = *strongly agree*).

*Social norm.* Items were constructed according to Klöckner and Matthies (2009). The scale included three items (Cronbach's α = .85), for example, "People who are important to me think that road-traffic noise is a major problem." Responses were measured on a 6-point scale (1 = *strongly disagree*; 6 = *strongly agree*).

*Value orientations.* Egoistic, altruistic, and biospheric value orientations were assessed with a scale developed by De Groot and Steg (2007, 2008). All three scales included four items (Cronbach's α: egoistic value orientation = .77, altruistic value orientation = .73, biospheric value orientation = .89). Item examples are "Influential: having an impact on people and events" (egoistic value orientation), "Social justice: correcting injustice, caring for the weak" (altruistic value orientation), and "Preventing pollution: protecting natural resources" (biospheric value orientation). Participants rated the importance of these 12 values "as a guiding principle in their lives" on a 6-point scale ranging from −1 *opposed to my values* to 4 *extremely important* (with 0 labeled as *not important*), as proposed by Raymond, Ward, and De Groot

(2011). Participants were told that usually only two values should be rated as extremely important.

*Personal norm.* Items were constructed according to the NAM (Schwartz, 1977; Schwartz & Howard, 1981). The scale included three items (Cronbach's α = .85), for example, "In line with my principles, I try to prevent road-traffic noise." Responses were measured on a 6-point scale (1 = *strongly disagree*; 6 = *strongly agree*).

*Intention to prevent road-traffic noise.* Items were constructed with close reference to intention as proposed by Gärling et al. (2003). The scale included three items (Cronbach's α T1 = .92, Cronbach's α T2 = .93), for example, "I intend to keep the road-traffic noise I produce low." Responses were measured on a 6-point scale (1 = *strongly disagree*; 6 = *strongly agree*).

*Noise annoyance.* To assess noise annoyance, a three-item scale was used (Cronbach's α = .91). One item was adapted from the International Commission on the Biological Effects of Noise (ICBEN) scale (Fields et al., 2001), and two items were adapted from a Swiss governmental survey on environmental issues (Diekmann, Meyer, Mühlemann, & Diem, 2009). An item example is "Thinking about the last 12 months, how much did you feel disturbed or annoyed by road-traffic noise when you were at home?" Responses were measured on a 5-point scale (1 = *not at all*; 2 = *slightly*; 3 = *moderately*; 4 = *very*; 5 = *extremely*).

*Noise sensitivity.* To assess noise sensitivity, again, a three-item scale was used (Cronbach's α = .76). Two items were adapted from the NoiSeQ scale (Schütte, Marks, Wenning, & Griefahn, 2007). One item was adapted from Weinstein (1978). An item example is "I am sensitive to noise." Responses were measured on a 5-point scale (1 = *strongly disagree*; 2 = *slightly disagree*; 3 = *moderately agree*; 4 = *slightly agree*; 5 = *strongly agree*).

*Noise exposure.* To assess noise exposure, the coordinates of the participant's home were linked with the noise exposure values of the "sonBASE" database of the Swiss Federal Office for the Environment (2010). The noise exposure value is displayed as dB(A), that is, an adjusted decibel measure, which makes it possible to use the decibel as a uniform measure for all frequency ranges. Because the dB(A) measure only expresses the sound pressure level at a specific point in time, a mean value (Leq) is calculated which is equivalent in energy terms to the current pollution level (for more information, see Swiss Federal Office for the Environment, 2009a, 2009b). We used noise exposure during daytime.

**Table 1.** Means and Standard Deviations of Study Variables.

| Variable | *M* | *SD* |
|---|---|---|
| Problem awareness T1 | 4.17 | 1.19 |
| Problem awareness T2 | 4.24 | 1.15 |
| Awareness of consequences T1 | 3.87 | 1.33 |
| Social norm T1 | 3.05 | 1.31 |
| Egoistic value orientation T1 | 0.69 | 0.91 |
| Altruistic value orientation T1 | 2.67 | 0.83 |
| Biospheric value orientation T1 | 2.74 | 0.93 |
| Personal norm T1 | 3.51 | 1.35 |
| Intention to prevent road-traffic noise T1 | 4.24 | 1.34 |
| Intention to prevent road-traffic noise T2 | 4.44 | 1.24 |
| Noise annoyance T1 | 1.92 | 1.03 |
| Noise sensitivity T1 | 2.85 | 1.00 |
| Noise exposure T1 | 53.81 | 9.95 |

*Note.* Noise exposure is given in dB(A). Regarding the other measures, the response scales ranged from 1 to 5 for noise annoyance and noise sensitivity; from −1 to 4 for egoistic, altruistic, and biospheric values; and from 1 to 6 for all other measures. T = Time.

*Knowledge about noise-reducing behaviors.* Participants were asked to respond to the question "What can car drivers do to produce as little noise as possible?" Responses were collected using an open format (i.e., a text field); 83% of the participants provided responses.

### *Statistical Analyses*

The model analyses were conducted by using structural equation modeling (Kline, 2011) with the Amos 22 structural equation modeling program (Arbuckle, 2006). Missing values were replaced with the full information maximum likelihood procedure following suggestions by Schafer and Graham (2002). Model fit was evaluated by the Tucker–Lewis index (TLI), the comparative fit index (CFI), and the root-mean-square error of approximation (RMSEA). We used cutoff values as proposed by Hu and Bentler (1998, 1999), stating that values of at least 0.95 for TLI and CFI and less than or equal to 0.06 for RMSEA indicate a good fit between the hypothesized model and the observed data.

## Results

Table 1 shows means and standard deviations of the study variables. The participants had a positive intention to prevent road-traffic noise on both

measurement occasions. In addition, problem awareness was found to be distinctly positive on both measurement occasions. Awareness of consequences and personal norm was not as strong, but still positive. In contrast, the participants tended to disagree slightly on the social norm items. They had fairly strong altruistic and biospheric value orientations, but a weak egoistic value orientation. Moreover, participants on average reported medium-sized noise sensitivity but rather weak noise annoyance. Exposure to road-traffic noise during daytime ranged between 25 dB(A) and 83 dB(A). As the WHO (1999) recommends a maximum noise level of 55 dB(A) during daytime, this meant that 44.27% of the participants were exposed to road-traffic noise exceeding the health limit. This is slightly lower than the percentage of people in Switzerland (50%) who are exposed to road-traffic noise over 55 dB(A) during daytime, as reported by the Swiss Federal Office for the Environment (2014a).

## *Predicting the Intention to Prevent Road-Traffic Noise*

We first tested the measurement model, including latent variables of all constructs; the fit of the measurement model was good.[3] The intercorrelations among the latent variables are shown in Table 2. All correlations were significant and in the expected direction.

Second, we tested the model as shown in Figure 1. The structural model fits the data well with $\chi^2(432) = 1{,}405.7$, $p < .05$, TLI = 0.94, CFI = 0.95, and RMSEA = 0.047 (90% confidence interval of RMSEA = [0.045, 0.050]). As expected, personal norm measured at Time 1 was a significant predictor of the intention to prevent road-traffic noise measured at Time 2 even when the Time 1 intention was controlled for. This means that a stronger personal norm leads to a stronger intention to prevent road-traffic noise. Moreover, personal norm and intention at Time 1 together explained a large amount of variance (49%) in the intention to prevent road-traffic noise.

Furthermore, as hypothesized, personal norm mediated the effects of all other predictors on the intention to prevent road-traffic noise. We evaluated an additional model, testing all direct paths simultaneously to investigate direct effects of problem awareness, awareness of consequences, social norm, and altruistic, biospheric, and egoistic value orientations on the intention to prevent road-traffic noise. Because of the exploratory character of these tests, we adjusted the significance level to $p < .01$. None of the direct paths were significant.

In sum, variance in personal norm could be explained by problem awareness, social norm, and biospheric value orientation. The hypothesized positive effect of problem awareness on personal norm was of medium size. In

**Table 2.** Intercorrelations Among Latent Variables in the Model "Predicting the Intention to Prevent Road-Traffic Noise."

| Latent variables | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1. Social norm T1 | — | | | | | | | |
| 2. Problem awareness T1 | .74* | — | | | | | | |
| 3. Awareness of consequences T1 | .45* | .62* | — | | | | | |
| 4. Egoistic value orientation T1 | −.14* | −.18* | −.22* | — | | | | |
| 5. Altruistic value orientation T1 | .25* | .24* | .22* | −.18* | — | | | |
| 6. Biospheric value orientation T1 | .32* | .37* | .30* | −.16* | .58* | — | | |
| 7. Personal norm T1 | .66* | .68* | .43* | −.16* | .29* | .46* | — | |
| 8. Intention to prevent road-traffic noise T1 | .40* | .45* | .34* | −.15* | .19* | .36* | .72* | — |
| 9. Intention to prevent road-traffic noise T2 | .39* | .48* | .34* | −.17* | .27* | .38* | .68* | .67* |

*Note.* T = Time.
*$p < .05$.

contrast, counter to our expectations, awareness of consequences was not a significant predictor of personal norm. In several studies, problem awareness and awareness of consequences could not be differentiated (Klöckner & Blöbaum, 2010; Klöckner & Matthies, 2009; Matthies et al., 2012). However, in the present study, a confirmatory factor analysis revealed that the two constructs can be distinguished.[4] Nevertheless, the two constructs were strongly correlated with $r = .62$; given this overlap, it is likely that the effect of awareness of consequences on personal norm is fully captured by the even stronger effect of problem awareness on personal norm.

As expected, we found a positive significant effect of perceived social norm on personal norm with a medium effect size. Surprisingly, only biospheric, but not egoistic or altruistic, value orientation contributed to the explanation of personal norm. The relation between biospheric value orientation and personal norm was in the expected direction, meaning that the stronger participants' biospheric value orientation was, the more strongly they felt obliged to prevent road-traffic noise; the effect was of medium size.

## *Predicting Problem Awareness*

Again, we first tested the measurement model by conducting a confirmatory factor analysis. The measurement model fitted the data well.[5] The intercorrelations of the latent variables are shown in Table 3. Beside the correlation

**Table 3.** Intercorrelations Among Latent Variables in the Model "Predicting Problem Awareness."

| Latent variables | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Noise exposure T1 | — | | | | |
| 2. Noise sensitivity T1 | −.10* | — | | | |
| 3. Noise annoyance T1 | .43* | .31* | — | | |
| 4. Problem awareness T1 | −.06 | .58* | .36* | — | |
| 5. Problem awareness T2 | −.07 | .53* | .35* | .84* | — |

*Note.* T = Time.
*$p < .05$.

between noise exposure and problem awareness (Time 1 and Time 2), all correlations were significant and in the expected directions.

Second, we tested the model shown in Figure 2. The structural model fits the data well with $\chi^2(80) = 259.5$, $p < .05$, TLI = 0.97, CFI = 0.98, and RMSEA = 0.047 (90% confidence interval of RMSEA = [0.041, 0.054]). As expected, noise exposure, noise annoyance, and noise sensitivity were positively related to problem awareness. We evaluated an additional model, testing all direct paths simultaneously to investigate direct effects of noise sensitivity and noise exposure on problem awareness. The two direct paths were not significant; therefore, noise annoyance fully mediates the effects of noise sensitivity and noise exposure on problem awareness. However, the effect of noise annoyance on problem awareness is small when the prior level of problem awareness is controlled for. Therefore, variance in problem awareness is mostly explained by the prior level of problem awareness.

## *Knowledge About Noise-Reducing Behaviors*

More than 80% of the participants named at least one behavior that serves to reduce noise (Table 4). Most terms fall into the category of "changing driving style": More than 60% of the participants reported changes in driving style or aspects of driving style as means of preventing road-traffic noise. Almost 25% reported changing travel mode from private to public transport or cycling/walking or reducing the number of car trips. Other reported behaviors were the choice of quiet vehicles (13%), buying low-noise tires (11%), and abstaining from noise-reinforcing vehicle equipment. Twenty percent of the answers were grouped into the category "others"; these were single entries like not honking, no loud music, choice of route so as to avoid populated areas. Half of the participants who mentioned a specific behavior cited

**Table 4.** Knowledge on Noise-Reducing Behaviors, Multiple Answers Possible.

| Behavior | Frequency | %[a] |
|---|---|---|
| Changing driving style | 630 | 63 |
| Changing travel mode choice | 241 | 24 |
| Choice of vehicle type | 132 | 13 |
| Buying low-noise tires | 122 | 12 |
| Abstaining from noise-reinforcing vehicle equipment | 108 | 11 |
| Other[b] | 201 | 20 |

[a]Proportion of the total sample ($N$ = 1,002).
[b]For example, not honking, no loud music, choice of route, avoiding populated areas.

behaviors from only one category. Nonetheless, 30% reported behaviors from two and 15% from three categories. Only 3% of the participants referred to four different noise-reducing behavior categories and only two persons reported behaviors from more than four different categories. However, even when most participants reported behaviors from only one or two categories they frequently gave several responses. This was particularly true for the category driving style, where participants often reported several aspects of a low-noise driving style such as driving at low engine speed or anticipating traffic flow.

## Discussion

The goal of the present study was to test for prospective effects of the psychological predictors of the NAM on car drivers' intention to prevent road-traffic noise. Moreover, we studied the effects of noise-specific predictors (i.e., noise exposure, noise sensitivity, and noise annoyance) on car drivers' problem awareness. The analyses were based on data from a large longitudinal sample of car drivers.

The present research shows that a feeling of moral obligation to prevent road-traffic noise (personal norm) is an essential predictor of the intention to prevent road-traffic noise. This confirms previous research, stating that personal norm strongly predicts pro-environmental intentions (Abrahamse et al., 2009; Gärling et al., 2003; Nordlund & Garvill, 2003). Also in line with previous research is the finding that personal norm mediates the effects of all other predictors on intention (e.g., Harland, Staats, & Wilke, 2007; Nordlund & Garvill, 2002, 2003). However, other studies found direct effects, particularly of social norms on intention or behavior, whereas ours did not (e.g., Hunecke et al., 2001; Klöckner & Blöbaum, 2010; Matthies et al., 2012).

Although in the present study social norm had no direct effect on the intention to prevent road-traffic noise, social norm was one of the three significant predictors of personal norm. This is in line with previous research: When social norm was considered in applications of the NAM, it had a substantial effect on personal norm (e.g., Hopper & Nielsen, 1991; Klöckner, 2013a; Klöckner & Blöbaum, 2010; Matthies et al., 2012).

The second significant predictor of personal norm is problem awareness. In contrast, awareness of consequences is not a significant predictor of personal norm. As stated above, it is possible that the effect of awareness of consequences on personal norm is fully captured by the even stronger effect of problem awareness on personal norm. Another explanation is that people recognizing the problem of road-traffic noise feel morally obliged to prevent noise, independently of their awareness of their own contribution to the problem. One reason for this might be that people evaluate their contribution to the total noise emission as negligible, or in other words, that they believe that the behavior change of a single person could not have any effect on total road-traffic noise.

Although problem awareness was very stable over time, we found a small, but significant effect of noise annoyance on change in problem awareness (and, moreover, noise sensitivity and noise exposure had significant indirect effects on problem awareness). The only small effects found lead to the assumption that individuals' experiences with road-traffic noise and their noise sensitivity do not strongly influence their judgment of the severity of road-traffic noise. Therefore, addressing people's own suffering from noise is not a promising strategy for noise abatement.

Instead of addressing people's own discomfort due to road-traffic noise, focusing on protection of the environment and thereby activating individuals' biospheric value orientation seems a promising strategy. We draw this conclusion because in the present study biospheric value orientation was found to be the third significant predictor of personal norm. In general, value orientations affect the rating of importance and evaluation of consequences of behavior. Consequently, a stronger biospheric value orientation is associated with the evaluation of environmental consequences (e.g., loss of environmental quality due to noise emissions), an altruistic value orientation is associated with the evaluation of altruistic aspects (e.g., the noise exposure of others), and an egoistic value orientation is associated with losses or gains for oneself. Because in the present study egoistic and altruistic value orientations are not related to personal norm, we suppose that the study participants judge road-traffic noise to be a greater risk for the non-human environment than for humans. More generally, the participants categorize road-traffic noise as an environmental and not as a social problem. Therefore, appealing to a desire

for the conservation of quiet environments might enhance personal norm through biospheric value orientation.

In sum, the present results have theoretical implications for the use of the NAM. The NAM was here applied for the first time to the prevention of road-traffic noise and it seems to be applicable to this environmental topic. First, because the NAM predictors explained a substantial effect of intention even when the previous level of intention was controlled for. Second, because the role of personal norm as a mediator, a central assumption of the NAM, is confirmed. Another important theoretical implication is the strong effect of social norm on personal norm. This implies that social norms are an important predictor of personal norm, especially in the context of road-traffic noise, but potentially also in other applications of the NAM.

In addition, the present research, for the first time, connects one's own noise sensitivity and noise exposure with the awareness that road-traffic noise is a serious problem for the health and well-being of humans and animals. The analyses showed that noise sensitivity and noise exposure do indeed affect this problem awareness but only via noise annoyance. That is, neither noise exposure nor noise sensitivity leads to higher problem awareness but they influence the subjective noise annoyance. Therefore, individuals exposed to road-traffic noise are only aware of the noise problem when feeling annoyed. Importantly, we have to note that the prospective effect of noise annoyance on problem awareness was small.

Finally, given that we assume that after forming the intention to prevent road-traffic noise car drivers have to choose behaviors that accord with this goal, we found that the participants' knowledge of noise-preventing behaviors could still be improved. In particular, most car drivers do not know about low-noise tires and are not aware that cars differ in their noise emissions. Moreover, even though more than 60% knew that driving style influences the noise a car produces, almost 40% are still ignorant of the fact.

### *Limitations*

Several limitations of our study should be noted. First, given that the present research investigated the intention to prevent road-traffic noise and not effective noise-reducing behaviors, we have to consider that although intention and behavior are substantially related, intentions do not automatically lead to the intended behavior. Second, although we used longitudinal data and controlled for the prior level of the outcome, the causal relations between the constructs must be interpreted with caution. Third, although the models examined fit the data well and the explained variances were found to be high, it cannot be ruled out that the inclusion of further predictors could provide

additional important insights. Fourth, although our measurement instruments proved valid in the confirmatory factor analysis, we note that some of the items were designed for the particular purpose of this study. Their validity should be confirmed in future studies, and this is particularly true for the operationalization of awareness of consequences. Future research should test if people have a higher awareness of consequences when they focus on a more narrowly defined reference area (e.g., their own neighborhood).

## *Starting Points for Interventions*

The present results have practical implications for the abatement of road-traffic noise via voluntarily behavior change of car drivers. Based on the findings of our study, we suggest four key strategies for strengthening personal norms or their predictors in car drivers.

*Focusing on quietness.* The results of the present study indicate that car drivers view noise abatement as a means of environmental protection and not as a means of human protection. Therefore, communication focusing on protection of nature and preservation of recreational areas might strengthen personal norms via biospheric value orientation and problem awareness. This could be done for example by using a scenario of the quiet and restorative landscapes that can be achieved by car drivers' contribution to noise prevention.

*Communicating social noise-prevention norms.* Social norms could be enhanced by social models displaying their noise-prevention norms. Social models can come from the individual's social network, ideally from persons who are close to the individual (Smith & Louis, 2008) or persons who serve as block leaders (Abrahamse & Steg, 2013). In addition, persons from a group with higher social status (e.g., celebrities) are effective social models. Importantly, social norms are more powerful when they are focal at a behavioral decision point (Kallgren, Reno, & Cialdini, 2000). For example, a slogan or a song presented by a celebrity on the radio during the rush hour could motivate car drivers to drive quietly.

*Enhance empathy.* One way to enhance an individual's problem awareness and activate personal norms is to enhance empathy for people who are exposed to noise, for example, by fostering perspective-taking (for example, see Berenguer, 2007, 2010; Pahl & Bauer, 2013) or by presenting information about who is exposed to road-traffic noise. One proposal for such an intervention is to portray people suffering from road-traffic noise. Another

possibility is to make the sufferers visible to car drivers, for example, by showing street-side pictures of sleepless people or children wearing ear protections while playing. Importantly, as the participants in our study seem to deny that their own driving behavior contributes to the problem of road-traffic noise, such campaigns should avoid making car drivers feel that the majority of other motorists usually produce noise (in the sense of a descriptive norm), because this could diminish the effect of existing noise-prevention norms (Cialdini, 2003).

*Commitment.* Simply asking people to commit themselves to traffic-noise reduction enhances the probability that existing personal norms or even the intention to prevent road-traffic noise is activated directly (for the discussion of the effects of commitment interventions, see Abrahamse & Steg, 2013). Commitment is a promising technique: Although it has been shown to have smaller short-term effects than other techniques, its long-term effects last longer than those of other intervention techniques (Hopper & Nielsen, 1991).

Importantly, given that car drivers' knowledge about noise-preventing behaviors is still modest, the four proposed strategies should be combined with specific behavior recommendations for car drivers, such as adopting a low-noise driving style, and buying low-noise tires and quiet cars.

## Conclusion

Road-traffic noise is a serious environmental problem that affects the health and well-being of numerous people. The present study provides fundamentals for noise abatement interventions that target prevention of road-traffic noise by motivating voluntary behavior change on the part of the noise-producing offenders—that is, the motorists. Strengthening the intention to prevent road-traffic noise in car drivers is a first step toward voluntary change of behavior. The present study provides information on the predictors of the intention to prevent road-traffic noise, and thus indicates starting points for interventions. The results suggest that the intention to prevent road-traffic noise can be fostered mainly by focusing on moral aspects of road-traffic noise. Importantly, this should be followed by specific behavior recommendations for car drivers, such as adopting a low-noise driving style or buying low-noise tires.

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## Notes

1. On the study website, additional samples were surveyed, namely motorcyclists and individuals who stated that they never drove cars or motorcycles. These additional samples are not examined in the present article. Moreover, we did not include 38 participants who lived outside of Switzerland, because the items in the measure of problem awareness referred to Switzerland.
2. The survey was conducted in German. Information on the German-language items is available from the corresponding author.
3. Measurement models do not include any direct paths between the latent constructs (in contrast to structural models) but exclusively correlational paths. Systematically relating all constructs included in the model allows for testing how well the latent constructs are measured by the underlying measures by calculating a confirmatory factor analysis. The errors of the indicators of the intention to prevent road-traffic noise were correlated over time to account for systematic indicator-specific variance not captured by the latent construct. The fit of the measurement model was as follows: $\chi^2(425) = 1{,}136.4$, $p < .05$, Tucker–Lewis index (TLI) = 0.96, comparative fit index (CFI) = 0.96, and root-mean-square error of approximation (RMSEA) = .041 (90% confidence interval of RMSEA = [0.038, 0.044]).
4. A one-factor solution fits the data poorly: $\chi^2(20) = 1{,}196.1$, $p < .05$, TLI = .58, CFI = .77, RMSEA = .242 (90% confidence interval of RMSEA = [0.231, 0.254]). In contrast, the two-factor solution fits the data well: $\chi^2(19) = 105.6$, $p < .05$, TLI = 0.97, CFI = 0.98, and RMSEA = 0.067 (90% confidence interval of RMSEA = [0.055, 0.080]). Importantly, the fit of the two-factor model was significantly better than the fit of the one-factor model, $\Delta\chi^2(1) = 1{,}090.5$, $p < .05$.
5. The errors of the problem awareness indicators were correlated over time to account for systematic indicator-specific variance not captured by the latent construct. The fit of the measurement model was as follows: $\chi^2(77) = 213.3$, $p < .05$, TLI = 0.98, CFI = 0.99, and RMSEA = 0.042 (90% confidence interval of RMSEA = [0.035, 0.049]).

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## Author Biographies

**Elisabeth Lauper** is a research scientist in the Department of Psychology and the Centre for Development and Environment at the University of Bern, Switzerland. Her research interests are in the field of environmental psychology, in particular understanding and influencing environmentally relevant behavior.

**Stephanie Moser** is a senior research scientist in the Centre for Development and Environment at the University of Bern, Switzerland. Her research focuses on individual and societal processes regarding the diffusion of sustainable behaviors.

**Maja Fischer** is a PhD student at the Catholic University of Leuven, Belgium, and a former research scientist at the Centre for Development and Environment at the University of Bern, Switzerland. Her research interests include the explanation of altruistic behaviors and the design and evaluation of interventions for behavior change.

**Ellen Matthies** is an environmental psychology professor at the Otto-von-Guericke University of Magdeburg, Germany. Her main research field is man–environment interactions, with a focus on environmentally relevant behaviors (electricity use and car use) and the theory-driven development and evaluation of interventions to promote sustainable consumption.