Measuring subjective response to aircraft noise: The effects of survey context

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In applied research, noise annoyance is often used as indicator of subjective reaction to aircraft noise in residential areas. The present study aims to show that the meaning which respondents attach to the concept of aircraft noise annoyance is partly a function of survey context. To this purpose a survey is conducted among residents living near Schiphol Airport, the largest airport in the Netherlands. In line with the formulated hypotheses it is shown that different sets of preceding questionnaire items influence the response distribution of aircraft noise annoyance as well as the correlational patterns between aircraft noise annoyance and other relevant scales.
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I. INTRODUCTION

The valid measurement of subjective reaction to environmental noise is both practically and theoretically relevant. In the policy practice, noise reaction measures are often used to construct so-called exposure-response relationships, which form the basis of noise regulations in many countries (see, e.g., Schultz, 1978; Fidell *et al*., 1991; Miedema and Oudshoorn, 2001). In addition, from a theoretical perspective, the valid measurement of noise reaction is required to correctly estimate the associations with relevant determinant variables, like noise sensitivity (Ellermeier *et al*., 2001), and/or criterion variables, like physical or mental health (Job, 1996).

To enhance the comparability of research results in this area an international team of noise researchers proposed two questions as standard indicators to measure noise reaction (Fields *et al*., 2001). In order to arrive at valid and reliable indicators careful attention was paid to the exact formulation of the questions and the answer-scale labels. While the authors mention the possible influences of context effects, to date, little attention has been paid to this issue.

Context effects are usually defined narrowly as the effects of preceding survey items on the target item, although they can be defined more broadly by including the effects of the survey frame (i.e., sponsor, topic, and stated purpose; Smith, 1992). The study of Bodin *et al*. (2012), for example, recently investigated the latter type of context effect. They compared the results of two surveys among the same population. One of these was introduced broadly and the other with the clearly stated aim of investigating noise and health. While the authors did find indications that noise-sensitive individuals were more likely to respond to the survey investigating noise and health, they could not find convincing evidence that contextual differences affected either answers or participation.

In this study we focus on the former type of context effects, namely, the effects of preceding survey items on the measurement of annoyance. Such context effects have also been termed question-sequencing effects (McColl *et al*., 2001). More specifically, this study investigates the influences of two different sets of preceding items on reported aircraft noise annoyance, the target item of this study. We assume that the preceding items will induce different *frames* of aircraft noise. Our aim is to show that the response distribution of aircraft noise annoyance as well as the meaning which respondents attach to the concept of noise annoyance is partly a function of these frames.

To achieve this aim a survey is conducted among residents living near Amsterdam Airport Schiphol. Respondents are (randomly) assigned to either one of two experimental conditions or a control condition. Based on a review of the literature, expectations are formulated related to the response distribution of the target item and about the strengths of the relations between the target item and other relevant scales. With respect to the response distribution, we expect that the typical context of aircraft noise annoyance used in present surveys about aircraft noise causes an increase in annoyance response as opposed to a neutral context.

II. BACKGROUND AND RESEARCH FOCUS

A. Theoretical mechanisms

Context effects have been explored extensively in the extant literature. Several reviews are available, some which focus on the theoretical (psychological) mechanisms that underlie contexts effects (Tourangeau and Rasinski, 1988; Smyth and Dillman, 2007), and others on the practical implications for survey research (McColl *et al*., 2001). This section selectively presents three interrelated theoretical notions that are assumed to underlie context effects and briefly discusses related empirical evidence. These notions will be used in Sec. II B to support the expectations of the present study.

One mechanism through which preceding survey items can influence the response on a target item is by establishing

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a *standard of comparison*. The experiment of Strack *et al.* (1985) is illustrative. In this experiment, subjects had to provide either positive or negative personal experiences from the past and then rate their current life satisfaction. As expected, the elicited memories served as standard of comparison to judge current life satisfaction; respondents who had recalled positive events rated themselves less happy than those who had recalled negative events.

Another relevant mechanism is the notion of *priming*. Through previous questionnaire items, priming can render specific beliefs (temporarily) more accessible. These activated beliefs can then "spread" to the target item. For example, Tourangeau and Rasinski (1988) showed that subjects who were primed with pro-abortion beliefs (questions about women's rights) were more likely to support abortion than subjects who were primed with anti-abortion beliefs (questions about traditional values).

A final notion, which is related to priming, is *framing* [for a review on this topic, see Chong and Druckman (2007)]. Like priming, framing renders some aspects of an issue more salient than others. But, unlike priming, framing effectively alters the meaning of the issue under consideration. The experiment of Nelson *et al.* (1997) is illustrative. In this study subjects were exposed to either one of two frames on welfare policy, one which defined welfare policy as a give-away program for poor people who do not deserve it (the so-called recipient frame), and the other as an excessively expensive program that threatened the health of the economy (the so-called economy frame). Even though there was no difference in the average levels of support for welfare policy across the two conditions, support for welfare policy in the recipient frame was more strongly related to external attribution beliefs (e.g., the belief that society has failed to provide good schools) than in the economy frame. Hence, in the recipient frame the meaning of "support for welfare policy" was aligned with the meaning induced by the frame, as a measure to help the poor. In the economy frame, on the other hand, external attribution beliefs were not associated with support for welfare since welfare policy was defined as a measure which threatened the economy.

The present study combines the notions described above. Specifically, previous questionnaire items are assumed to *prime* respondents into a certain *frame* of (aircraft) noise annoyance, resulting in different meanings of annoyance. In addition, we hypothesize that each frame of noise annoyance goes along with different *standards of comparison*, and therefore different response distributions on aircraft noise annoyance.

B. Research focus and hypotheses

To prime respondents with different frames of noise annoyance, frames first need to be identified and/or defined. This can be done deductively (from theory), inductively (from empirical evidence), or operationally. Guski *et al.* (1999), for example, theoretically deduced that noise annoyance can be seen as an emotion (e.g., feelings of fear or control), as the result of disturbance (e.g., interference with activities), as an attitude (an encompassing evaluative judgment with regard to the noise situation), as knowledge (e.g., about the health effects of noise), or as the result of a rational decision (i.e., a deliberate choice based on specific circumstances). To various extents each of these definitions (and related frames) of noise annoyance have received empirical support (Guski *et al.*, 1999). For example, in statistical (multivariate) models, constructs covering feelings of fear and control, perceived disturbance, attitudes toward the noise source, and knowledge about health effects, have been found to be strongly related to noise annoyance (Guski, 1999; Taylor, 1984; Kroesen *et al.*, 2008). Noise annoyance can therefore (partly) be seen as a reflection of feelings, disturbance, attitudes, and knowledge (Kroesen and Schreckenberg, 2011).

Frames of annoyance can also be *inductively* revealed by examining the ways in which people themselves define (aircraft) noise. For the case of Schiphol Airport, people's subjective viewpoints toward aircraft noise have been extensively explored by Bröer (2006), Kroesen and Bröer (2009), and Kroesen *et al.* (2011). These studies showed that people in their everyday natural conversations generally rely on policy-related arguments to evaluate aircraft noise, revolving mainly around the (national) economic benefits and environmental costs of aviation. In everyday settings the expression of annoyance therefore partly reflects a political attitude, representing the position one takes on the economy-environment dimension. This frame thus overlaps with the Guski *et al.* (1999) definition of annoyance as an *attitude*.

Finally, frames of noise annoyance can also be *operationally* defined by the way noise annoyance is measured. For example, a common practice in noise surveys is to measure aircraft noise alongside other noise sources, e.g., road traffic noise, neighbor noise (TNO and RIVM, 1998; Breugelmans *et al.*, 2004; Houthuijs and Van Wiechen, 2006). While people in their everyday lives generally do not take other noise sources into account when evaluating aircraft noise (Bröer, 2006), such an operationalization invites people to do so. Within this frame people are implicitly asked to indicate how disturbing each noise source is vis-à-vis the others. This frame therefore overlaps with the definition of Guski *et al.* (1999) of annoyance as the result of *disturbance*.

In this study, the effects of framing noise annoyance as an attitude and as perceived disturbance will be analyzed. For the remainder of this paper we will refer to these as the "natural-conversation" frame and the "multiple-sources" frame, respectively. We assume that these frames can be induced (primed) by different sets of preceding questionnaire items, namely, statements related to subjects' own communications about aircraft noise in the natural-conversation frame and items related to annoyance caused by various noise sources in the multiple-sources frame.

Next, we hypothesize that each frame goes along with different standards of comparison, which will affect the mean annoyance response. In the natural-conversation context we assume that people's position on the economy-environment dimension anchors people's reaction. Previous research by Kroesen and Bröer (2009) and Kroesen *et al.* (2011) has shown that the economic argument is dominant over the environmental one. These authors showed that three

clusters of people can be identified: one pro-economy, which denies the environmental argument, one emphasizing both the economic and environmental argument, and one pro-environment, which was *neutral* toward the economic argument. In other words, no cluster was identified which actually downplayed the economic argument. In effect, no cluster was found with a high average level of reported annoyance. Hence, given the overall dominance of the economic argument in natural conversations about aircraft noise we expect to find a moderate average annoyance response in the natural-conversation frame.

In the multiple-sources frame, on the other hand, we hypothesize that the most extreme noise sources in terms of the amount of disturbance caused will form the conceptual endpoints of the annoyance scale. In effect, we expect that, confronted with noise sources of which several are hardly audible in the residential environment (e.g., noise from the supply of shops, trains, and/or companies), aircraft noise (as the dominant noise source) will, in contrast, be judged more annoying. In other words, given the context of these other noise sources, people will feel legitimized to express a more extreme annoyance response, something which, due to the dominance of the economic argument, is unusual in people's ordinary frame of reference.

Next, we expect that the two frames will lead to a shift in the meaning attributed to aircraft noise annoyance. As mentioned before, we expect that, in the natural-conversation frame, aircraft noise annoyance is partly a reflection of a political attitude. Based on this expectation we assume that aircraft noise in this frame is more strongly related to two scales of political preference (negatively with individualism and positively with egalitarianism). In the multiple-sources frame, on the other hand, respondents have to rate multiple sources and are implicitly asked to indicate how disturbing each noise source is relative to the others. We therefore expect that aircraft noise annoyance measured in this frame is more strongly related to a hypothesized cause and consequence of the disturbance caused by aircraft noise, namely, noise sensitivity and residential satisfaction, respectively.

Summarizing the above, we hypothesize that aircraft noise annoyance measured in the context of people's own communications about aircraft noise would more strongly reflect a political attitude, while aircraft noise annoyance measured in the context of other noise sources would more strongly reflect the disturbance caused by aircraft noise.

Table I summarizes the expected signs and sizes of the correlations between aircraft noise annoyance and the included dimensions (noise sensitivity, residential satisfaction, individualism, and egalitarianism) in each of the two frames. We also included a control (no-frame) condition in which aircraft noise annoyance is measured in isolation. Through inclusion of this control condition it can be assessed whether the meaning of aircraft noise annoyance measured in isolation is indeed similar to its meaning in the natural-conversation context.

Finally, we are interested in the question whether people stick to the meaning of aircraft noise annoyance in their first-encountered context when aircraft noise annoyance is measured a second time in a different context later in the questionnaire. To investigate this, we will examine whether exposing subjects to other frames later in the questionnaire will result in changes in the correlational patterns between the target item and the included scales. Since these analyses are to be explorative in nature no explicit hypothesizes are formulated *a priori*.

TABLE I. Expected signs and sizes of the correlations between aircraft noise annoyance and the dimensions.

Dimension	No-frame (control)	Natural-conversation frame	Multiple-sources frame
Noise sensitivity	+	+	++
Residential satisfaction	−	−	−−
Individualism	−−	−−	−
Egalitarianism	++	++	+

III. METHOD

A. Data

For the experiment it was necessary that aircraft noise was the dominant noise source. Therefore, a neighborhood is selected (Amsterdam Buitenveldert) where the aircraft noise exposure level was moderately high. The annual noise exposure level in this neighborhood ranges from approximately 55 to 65 dB(A) L_{den}.

In the selected neighborhood, 3000 letters are distributed at random locations. The letters invited citizens to fill in an online questionnaire. Over the period of a month (July 2010), 293 people filled in the online survey (141 males and 152 females), resulting in a response rate of 9.8%.

The mean sample age (53.7) is significantly higher than the mean age of the Dutch population (40.1). Yet, all age groups are sufficiently represented in the sample: 19.9% is younger than 35 years of age, 35.0% is between 35 and 59 years of age, and 45.1% is 60 years of age or older. Respondents with a higher education are also overrepresented: 34.2% have completed high school or a secondary vocational education, 37.9% have a higher educational degree, and 27.9% have a university degree (in the Dutch population these percentages are 72.9%, 17.5%, and 9.6%, respectively).

B. The target item

In all conditions the target item, aircraft noise annoyance, is assessed with the standardized question of Fields *et al.* (2001): "Thinking about the last 12 months or so, when you are here at home, what number from 0 to 10 best shows how much you are bothered, disturbed, or annoyed by aircraft noise?" In line with the recommendations the endpoints of the 11-point scale are labeled "not annoyed at all" (0) and "extremely annoyed" (10).

C. Control and experimental conditions

In the control condition, the question about aircraft noise annoyance is presented in isolation. In the natural-conversation frame (the first experimental condition),

subjects have to answer 12 statements measured on 7-point Likert-type scales. The statements are derived from open interviews with residents (Bröer, 2006) and, as such, represent people's own communications about the topic of aircraft noise. The statements are

(i) Schiphol should be allowed to stay: long live aviation!
(ii) I trust the government to uphold the noise norms for Schiphol.
(iii) If people complain about aircraft noise they pursue their self-interest. They do not realize how important Schiphol is to The Netherlands.
(iv) I believe that Schiphol always gets its way.
(v) The government does not live up to its promise to reduce the noise.
(vi) I feel powerless in relation to the aircraft noise situation.
(vii) We should be proud of our national airport.
(viii) Aviation is important for the employment.
(ix) Noise annoyance due to aircraft noise is an important problem.
(x) Schiphol should be relocated to the sea.
(xi) Schiphol is an engine of the economy.
(xii) Aviation is a threat to the environment.

We made sure that the numbers of positive and negative statements were in balance. After these statements the question about aircraft noise annoyance followed immediately on the same webpage.

In the multiple-sources frame (the second experimental condition) aircraft noise annoyance is measured near the end of a matrix question,[1] which [using the standardized noise reaction question of Fields *et al.* (2001)] asked subjects to rate, from 0 to 10, how much they were bothered, disturbed, or annoyed by the following noise sources:

(1) Road traffic slower than 50 km/h.
(2) Road traffic faster than 50 km/h.
(3) The supply of shops.
(4) Neighbors.
(5) Helicopters.
(6) Trains.
(7) Trams/metro.
(8) Aircrafts
(9) Companies/industry.
(10) Construction and demolition activities (including renovation).

D. Questionnaire design

As discussed, to investigate whether respondents stick to the original meaning of aircraft noise annoyance in the first-encountered frame, the choice is made to expose all respondents to each frame in varying orders. The questionnaire lay-out is as follows.

On the first webpage all respondents have to answer several background questions (sex, age, education level, length of residence). Next, respondents are randomly assigned one of three routes. In the control condition, respondents answered the target item on three separate webpages, first in isolation (C1), then in relation to the other noise sources (C2), and finally in relation to the statements of other residents (C3). In the natural-conversation condition, respondents first answered the question about aircraft noise after answering the statements of other residents (NC1) and then in relation to the other noise sources (NC2). Finally, in the multiple-sources condition, respondents followed the reversed route, first answering the target item in relation to the multiple noise sources (MS1) and then in relation to residents' statements (MS2). After following the condition-specific routes, the routes converged again and all respondents answered the remaining part of the questionnaire. Figure 1 visualizes the lay-out of the online questionnaire.

In the experimental conditions respondents were not asked to answer the target item in isolation. Given that the no-frame condition provides no additional information to respondents, we did not expect that this would influence the response. In addition, the choice to direct respondents in the control condition first to the multiple-sources frame and then to the natural-conversation frame is arbitrary.

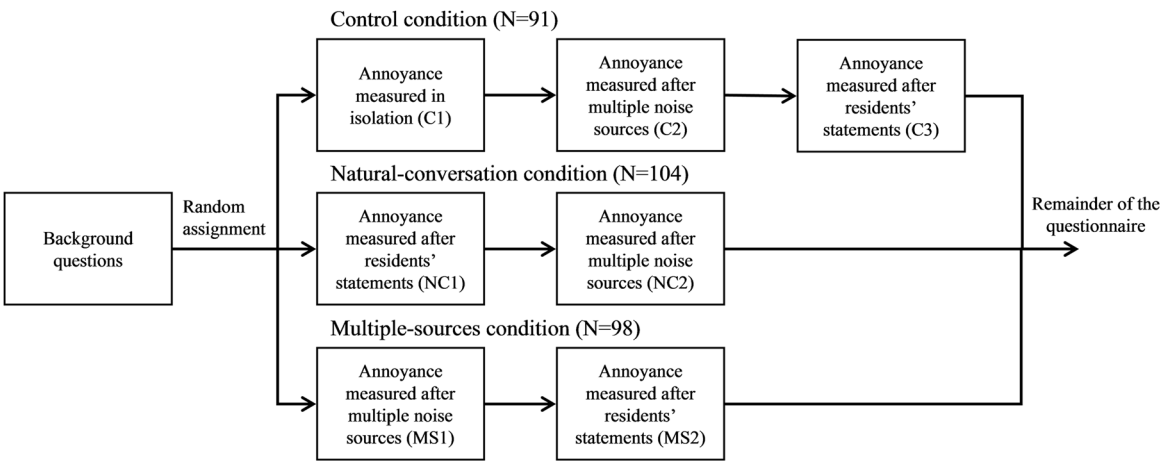

FIG. 1. Structure of the online questionnaire. Note: Each block represents a different webpage. Respondents were not allowed to scroll back.

TABLE II. Scales, items, and loadings.

Scale	Items	Loading
Noise sensitivity (alpha = 0.83)	I get used to noises without much difficulty.[a]	0.75
	I am good at concentrating no matter what is going on around me.[a]	0.72
	Sometimes noises get on my nerves and get me irritated.	0.75
	I find it hard to relax in a place that is noisy.	0.81
	I am sensitive to noise.	0.81
Residential satisfaction (alpha = 0.86)	I am satisfied with my living environment.	0.89
	Living in this neighborhood is not annoying.	0.80
	I feel at home in this neighborhood.	0.84
	I don't feel an urge to move out of this neighborhood.[a]	0.85
Individualism (alpha = 0.69)	Continued economic growth is the answer to improved quality of life.	0.79
	In a fair system people with more ability should earn more.	0.76
	A free society can only exist by giving companies the opportunity to prosper.	0.82
Egalitarianism (alpha = 0.55)	The government should make sure everyone has a good standard of living.	0.84
	I would support a tax change that made people with large incomes pay more.	0.84

[a]Item recoded.

E. Scales

To measure noise sensitivity, five items from Weinstein's noise sensitivity scale are used (Weinstein, 1978). A principal component analysis[2] revealed that the items converged on a single underlying factor (see Table II). To measure residential satisfaction, items are drawn from a previously developed scale (Adriaanse, 2007). Again, principal component analysis revealed that the items formed a uni-dimensional scale. To measure the social-political orientations (individualism and egalitarianism) items are selected from two scales which were previously developed by Wildavsky and Dake (1990) to test the hypotheses derived from cultural theory. The factor loadings of the items are sufficiently high, again indicating convergence. The reliability of the egalitarian scale, however, is poor. The correlational patterns of the two individual items with the variables of interest (aircraft noise annoyance) nevertheless showed similar patterns. We therefore choose to use both items to construct a composite scale. All scales are constructed by computing a sum score of the respective items.

IV. RESULTS

A. Univariate distributions

With respect to the univariate distributions we expected that the mean annoyance score in the multiple-sources frame would be greater than the mean scores in the no-frame and the natural-conversation frame. For the latter two frames we expected to find equal mean scores.

Table III presents the univariate statistics of aircraft noise annoyance in the varying frames. The sample distributions of aircraft noise annoyance for the first-encountered frames (C1, NC1, and MS1) are presented in Fig. 2. Analysis of variance reveals that the means of aircraft noise annoyance in the first-encountered frames (C1, NC1, and MS1) differ significantly across the three conditions ($F = 8.8$, $p < 0.000$).[3] A *post hoc* Bonferroni test shows, in line with expectations, that the means of the no-frame (C1: $M = 4.6$) and natural-conversation frame (NC1: $M = 4.7$) are not significantly different, but that both do significantly differ from the multiple-sources frame (MS1: $M = 6.1$).

Examination of the distributions in Fig. 2 shows that in the multiple-sources frame, the extreme categories on the right side of the scale (9 and 10) are used more often than in the other two frames. As a result, 43.3% of the sample in the multiple-sources frame can be identified as "highly annoyed" (defined as a person scoring 8 or higher), more than twice as much as in the no-frame and natural-conversation frame (in which these percentages are 16.5 and 16.3, respectively).

The results support the hypothesis that measuring aircraft noise annoyance in relation to other noise sources creates a context in which people on average express a more extreme annoyance response. Extreme responses are generally absent in the no-frame and natural-conversation frame conditions.

B. Bivariate correlations

We expected that the meaning people attach to the concept of aircraft noise annoyance is partly a function of the induced frame. To test this idea several hypotheses were formulated related to the correlations between aircraft noise

TABLE III. Univariate statistics of aircraft noise annoyance in the different contexts.

		N	Mean	Standard deviation	% Highly annoyed
Control condition	C1	91	4.6	2.7	16.5
	C2	91	4.8	2.9	23.3
	C3	91	4.6	2.9	22.7
Natural-conversation condition	NC1	104	4.7	2.9	16.3
	NC2	104	4.9	3.2	25.0
Multiple-sources condition	MS1	98	6.1	3.0	43.3
	MS2	98	5.5	3.0	29.0

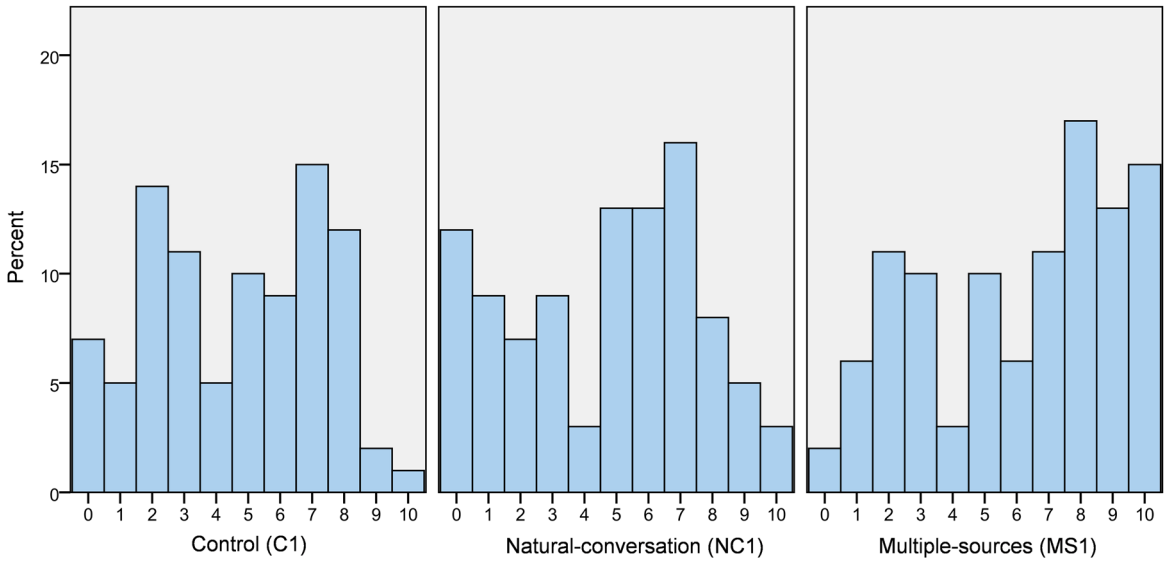

FIG. 2. (Color online) Distributions of aircraft noise annoyance in the three conditions.

annoyance and relevant scales. The (Pearson's) correlations are presented in Table IV.[4] In this section we will only discuss the correlations between the scales and the first measurement of aircraft noise annoyance within each route (C1, NC1, and MS1). Since there were clear expectations regarding the signs of the correlations (Table I), one-tailed significance tests were performed.

As hypothesized, aircraft noise annoyance is more strongly correlated with noise sensitivity in the multiple-sources frame than in the no-frame or natural-conversation frame. However, only between the correlations of the multiple-sources frame and the natural-conversation frame is the difference significant (at the 10% level).

Contrary to the expectations, the correlations between aircraft noise annoyance and residential satisfaction are of equal size in the no-frame and multiple-sources frame. In the natural-conversation frame this correlation tends to be lower, but not statistically significantly lower.

The political preference scales (individualism and egalitarianism) are, as expected, most strongly related to aircraft noise annoyance in the natural-conversation frame. In line with expectations these correlations tend to be smaller in the multiple-sources frame (but not significantly). Contrary to expectations, however, the scales are not significantly associated with aircraft noise annoyance when it is measured in isolation (i.e., in the control condition).

The correlations indicate that aircraft noise is interpreted differently across conditions. The differences between the natural-conversation frame and multiple-sources frame follow the *a priori* formulated expectations with respect to noise sensitivity and the two political preference scales. Hence, the interpretation of aircraft noise annoyance indeed depends on the frame in which the question is presented.

A remarkable finding is that the dimensions of individualism and egalitarianism do not significantly correlate with aircraft noise annoyance in the control condition. Contrary to the expectations, aircraft noise annoyance is not a reflection of political preference in the control condition, which is the case in the natural-conversation frame. An explanation might be that because people in the natural-conversation

TABLE IV. Correlation coefficients between the aircraft noise annoyance variables and the four scales. Correlations with the same uppercase superscript are significantly different at $p < 0.05$ (one-tailed). Correlations with the same lowercase superscript are significantly different at $p < 0.10$ (one-tailed).

		C1	C2	C3	NC1	NC2	MS1	MS2	NS	RS	IN	EG
Control condition	C1	1.00										
	C2	0.96*	1.00									
	C3	0.96*	0.95*	1.00								
Natural-conversation frame	NC1	—	—	—	1.00							
	NC2	—	—	—	0.92*	1.00						
Multiple-sources frame	MS1	—	—	—	—	—	1.00					
	MS2	—	—	—	—	—	0.91*	1.00				
Noise sensitivity	NS	0.36*$^{}$	0.33*^{a}	0.34*^{b}	0.34*^{c}	0.43*$^{}$	0.50*^{abc}	0.48*$^{}$	1.00			
Residential satisfaction	RS	−0.35*$^{}$	−0.30*$^{}$	−0.37*$^{}$	−0.28*$^{}$	−0.29*$^{}$	−0.36*$^{}$	−0.39*$^{}$	−0.42*$^{}$	1.00		
Individualism	IN	−0.09	−0.06^{d}	−0.06^{e}	−0.25*^{de}	−0.23*$^{}$	−0.15	−0.18**$^{}$	−0.11**$^{}$	0.08	1.00	
Egalitarianism	EG	−0.06^{AD}	−0.06^{BE}	−0.07^{CF}	0.27*^{ABC}	0.24*^{DEF}	0.11	0.09	0.04	0.00	−0.17*$^{}$	1.00

*Significant at $p < 0.05$.
**Significant at $p < 0.10$.

frame are confronted with the whole structure of the economy-environment debate, they have to rely on the more general political values to rationalize their annoyance response. In other words, to take an explicit stance in the economy-environment debate requires that people use their political value-orientations. People's annoyance response then reflects the chosen position. In the control condition, on the other hand, people do not have to take such an explicit stance in the economy-environment debate.

C. Directional changes and consistency within the conditions

The changes in the means of aircraft noise annoyance within each condition are small (see Table III). Moving from no-frame to the multiple-sources frame in the control condition, the mean annoyance score rises slightly from 4.6 to 4.8 ($t=-2.0$, $p=0.046$) and then drops again to 4.6 in the natural-conversation frame ($t=2.2$, $p=0.034$). This fits with the expectation that the multiple-sources frame elicits the highest average annoyance response.[5] In the natural-conversation condition, an equal, but insignificant rise of 0.2 is found in moving from the natural-conversation frame to the multiple-sources frame ($t=-1.8$, $p=0.069$).[6] The greatest difference (0.6) is found in the third condition in moving from the multiple-sources frame to the natural-conversation frame ($t=4.5$, $p=0.000$).[7] Again, this drop is in line with the expectation that in the natural-conversation frame expressing a high annoyance response is uncommon. Overall, the changes in the means within each condition are small and in line with the formulated expectations.

The extremely high correlations between the annoyance variables (see Table IV) within each condition suggest that once the target item is answered in one frame, it will not be reinterpreted when asked again in a different frame. The patterns of correlations between the annoyance questions and the four scales, which are nearly equal within each condition, also confirm this conclusion.

Overall, the small changes in the means and the high correlations between the measures of aircraft noise annoyance within each condition indicate that the meaning of aircraft noise annoyance does not substantially change within conditions. In other words, once respondents answer the target item in one particular frame, they will not reinterpret it when presented in a different frame later in the questionnaire.

V. IMPLICATIONS AND FUTURE RESEARCH DIRECTIONS

The present study shows that using the same instrument after different sets of preceding questions (or in isolation) can lead to different interpretations of the measured concept. Even in the natural-conversation frame, in which aircraft noise annoyance is placed in the context of statements derived from people's *own* communications about this topic, influenced the meaning attributed to it. This means that it is difficult, if not impossible, to define (in advance) the meaning of a concept like aircraft noise annoyance or any other measure of subjective reaction to noise. Instead, its meaning must be deduced after its measurement through examination of response and/or correlational patterns. This view on measurement is complementary to dominant conceptualizations of validity in the literature. These define validity either as a property of tests; a test should measure what a researcher *intends* to measure (Borsboom *et al.*, 2004), or as a property of test score interpretations; the quantity and quality of evidence in support of the interpretation *intended* by the researcher (Messick, 1989). Both assume that the researcher can always define beforehand the meaning of a concept or issue. This, however, is not always possible given that the researcher is often unaware of the actual meanings that are used by subjects in the field. In our opinion, researchers as well as research methods should be amenable to discover those meanings. To complement existing definitions, validity can be conceptualized as the degree of responsiveness of researchers and their methods to subjects' definitions of an issue.

The measurement of human reaction to noise for policy-related purposes is not value-free. Variations in question wording, answering scales and, as the present study shows, context can significantly affect the response distribution of a subjective measure. The selection of a particular method to measure human reaction to noise can therefore lead to drastically different policy implications. This supports the recommendation that exposure-response models should be used with caution in the policy practice. Moreover, in the ideal situation, the policy aim should be aligned with the way respondents interpret noise reaction questions. For example, does policy aim to reduce the annoyance response based on residents' subjective disturbance by different sources, or does it also want to take into account their stance in the economy-environment debate, which may be hypothesized to reflect both their disturbance and their acceptance of it given other considerations? The answer to this question should be leading in the way (and in what context) noise reaction is measured.

Additionally, the results of the present analysis may provide an explanation for the currently observed upward shift in exposure-response curves (Babisch *et al.*, 2009; Janssen *et al.*, 2011). The authors are aware of three (Dutch) large-scale studies that measured aircraft noise annoyance in relation to other noise sources (Breugelmans *et al.*, 2004; Houthuijs and Van Wiechen, 2006; TNO & RIVM, 1998). The exposure-response relationships derived from these data are indeed significantly higher than the European exposure-response curve. A systematic comparison of studies that measured aircraft noise annoyance in isolation versus studies that measured aircraft noise in the context of multiple noise sources can yield an estimate of the magnitude of the context effect.

Several directions for further research can be identified. An obvious one relates to the sample of the study, which is characterized by several limitations: (i) respondents are recruited from a single neighborhood near Schiphol, (ii) the response rate is low, and (iii) older/higher educated people are overrepresented. To generalize the results to the population of residents living in the Schiphol region, a probability sample would need to be drawn from this population. In

addition, any biases (e.g., a likely bias is that more annoyed people are overrepresented) could be decreased by increasing the response rate. These measures are also necessary if one is to establish the total effects of the investigated contexts on a general exposure-response relationship and/or to assess the size of the context effect at different noise levels. Nevertheless, the present experiment has shown that the effects of different contexts can be quite large.

Future research might also concentrate on other context effects. For example, aircraft noise annoyance could be placed in the context of more general aspects of the residential environment (e.g., having nice neighbors) or in the context of other daily hassles (e.g., having a cold). Alternatively, similar to the study of Bodin *et al.* (2012) the effects can be studied of the broader survey frame like the sponsor or the stated purpose of a study. For example, it seems plausible that people's decision to participate as well as their responses will be different in a survey of a university for scientific purposes than in a survey of a national institute for policy-related purposes. Since topic interest plays an important role in people's decision to participate in a survey (Groves *et al.*, 2004), large effects may be expected here. Finally, we would consider it worthwhile to study the (experimental) data with more advanced analysis techniques, like latent class analysis. With the use of such models the response patterns of different groups of respondents can be revealed, which provide more detailed information as to how respondents actually interacted with the questionnaire and which strategies they employed. To conclude, we believe that there are many research objectives in the applied field of noise annoyance research which are related to the possible effects of context. Such research is scientifically relevant, but also needed to properly inform noise policy.

VI. CONCLUSION

This study investigates the influence of survey context on reported aircraft noise annoyance, the target item of this study. This is achieved by measuring aircraft noise annoyance in isolation and after two different sets of preceding items. These preceding items are hypothesized to prime respondents into different frames of annoyance. The results show that the response distribution of aircraft noise annoyance as well as the meaning which respondents attach to the concept of noise annoyance is a function of the induced frames. When aircraft noise annoyance is measured in the context of other noise sources, the average response is significantly higher than when measured in isolation or in the context of people's own communications about aircraft noise. In addition, the preceding survey items (or frames) alter the meaning of "aircraft noise annoyance" to the extent that essentially different concepts are being measured. For example, when aircraft noise annoyance is measured in the context of other noise sources, it correlates more strongly with noise sensitivity than when measured in isolation. Third, once respondents adopt a particular interpretation of aircraft noise annoyance they do not reinterpret the concept when asked again later in the questionnaire. Finally, this study suggests that the currently observed upward shift in some exposure-response curves may be at least partly explained as an effect of the survey context.

[1]Aircraft noise was not placed at the very end of the block to ensure that it would not receive undue attention.
[2]A principal component analysis is a method which can be used to assess and reduce the dimensionality of the data. This is achieved by extracting common dimensions behind a set of interrelated variables (the principal components; Jolliffe, 2002).
[3]A non-parametric test (an independent samples Kruskal-Wallis test) also led to rejection of the null hypothesis ($p < 0.001$).
[4](Non-parametric) Spearman's rank correlations gave similar results.
[5]Non-parametric tests (related-samples Wilcoxon signed rank test) also led to rejection of the null hypotheses.
[6]Contrary to this result, a non-parametric test (related-samples Wilcoxon signed rank test) led to rejection of the null hypothesis.
[7]A non-parametric test (related-samples Wilcoxon signed rank test) also led to rejection of the null hypothesis.

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