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Review

Instruction's effect on semantic scale ratings of interior car sounds

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ABSTRACT

The aim of the study presented here is to examine the effects of instructions on the perception of a sequence of interior car sounds in three different conditions. In each condition, participants listened to the same sound sequence, but the type of information given during the instruction phase, prior to the listening test, were different. In the first condition, a group of participants listens to the sound sequence without any external information except that the sound sequence was recorded inside a car. In the second condition, another group of participants was informed by a text of the successive events that are presented in the sound sequence. In the third condition, participants were informed first by the same text as in condition 2, and then by several pictures showing the different steps that could be heard from the beginning to the end of the sound sequence. Each of the three groups of subjects participated in three tasks: an identification task, a recognition task, and a semantic judgment task using twelve verbal attributes. We assessed how listeners' judgments of the sound sequence were affected by external information. Results show that the effect is dependant on the type of verbal attribute and on the combination of external information. The verbal information, provided without visual information in condition 2, improves the identification and recognition scores, and thus influences positively the comprehension of the sound sequence and the feeling of immersion. The added visual information, in condition 3, does not change the identification scores, but affects judgements on the pleasantness scale. It appears that the perception of the sound sequence was influenced by visual cues. This study reveals that the format of instructions influences perceptive judgments of the sound sequence tested, but globally factors accounting for the participants' perception across the three conditions are not modified.

Contents

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1. Introduction

Usual studies on sound quality are mainly focused on psychoacoustic description and have not yielded much information to the participants about the sound event itself and the global context in which the event appears. It means that participants of a listening test have to focus on the acoustic properties rather than on the meaning of the sound source and its characteristics. It is appropriate when the aim of an experiment is to describe the timbre of a set of sounds, or to determine the preference of listeners as a function of the acoustic properties of the sounds. Yet, in daily life situation, sound appraisal is also based on the identification of the source in its context. As a consequence, connotation aspects, positive or negative, of the identified source may affect judgements on the sounds. A similar situation in a laboratory context would assume that listeners are capable to identify the source that has produced the sound just by listening to its acoustic properties. Actually, an imposing series of experiments reported by Ballas [1] showed that, in a listening condition, acoustic properties accounted for only about half of the variance in identification time and accuracy of everyday sound sources, which means its perception depends on other factors (ease with which a mental picture of the sound is formed, context independence, familiarity with the sound, clarity of the sound, etc...). On the other hand, in daily life situation, characteristics of the sound source and its context are perceived via other sensory modalities (visual for example) that influence appraisal made on the sound. Several studies have shown the effect of one sensory modality on the judgements made in the other modality. Anderson et al. [2] studied the influence of auditory information on the preference of outdoor visual settings. Results depend on the type of the visual environment presented. For instance, specific visual settings, such as woods, create expectations on what participants would like to hear in such an environment. In this case, sensitivity to sound stimuli is enhanced when the sound environment is not congruent with participants' expectations. In another study by Viollon et al. [3] on the influence of visual settings on sound ratings, results show roughly that the more urban the visual setting, the more negative the sound ratings. This result is dependent on the type of sounds. In [4], Patsouras et al. investigated the influence of different colors of trains on the judgment of the loudness of sounds corresponding to passing trains. The results showed that red trains are judged as being louder than green trains. Similar results on noise evaluation in passenger cars were found by Namba et al. [5] when the effect of visual monitoring while driving was examined. The uncomfortable impression of heavy traffic makes the impression of sounds more negative whereas the comfortable highway driving makes the sounds perceived as being softer. These studies reveal that the perception of an event in one modality is influenced by information presented in another modality.

In an experiment by Abe et al. [6], additional information about sound events was presented in a verbal descriptive form. Results showed that the verbal information did not affect the judgment of the sound quality, although the detailed impression of specific sounds was slightly influenced. In a more recent study [7] by the same authors, effects of verbal versus visual information about environmental sounds were investigated. Results show that judgments on aesthetic scales are positively increased by addition of verbal and visual information to sounds generated by water in natural environment ("roaring of waves"). In contrast, judgments are decreased for other type of sounds such as "noise of scratching". For specific sounds, visual information had larger effect than did verbal information, but the influence of visual and verbal information on sound evaluation appeared to be significant and similar overall. To summarize, all the studies mentioned show that additional information, pictures or moving images, presented simultaneously, influences auditory perception. However, in Abe et al.'s study [7], visual and verbal information are compared whereas the former one is presented simultaneously to the sound, and the latter one is presented prior to its production. Thus observed effects were a consequence of the type of information as well as a consequence of an interaction between sounds and pictures as both were presented simultaneously, whereas the verbal information was presented before to the sound sequence.

It appears that we unconsciously or consciously utilize information other than the acoustic properties to evaluate the quality of a sound. That information are part of the total perception of the sound source, and correspond to the knowledge related to the source in terms of identification and functionality, on the one hand, and in terms of its aspect via other sensory modalities. They are the external information about the sound (by opposition, acoustic properties are the intrinsic information of the sound) used as cues to evaluate a sound source. In a simple experimental setup, external information on the source and its context of use can be provided to the participants before the presentation of the sound, as it was proposed by Abe et al. when the verbal information was presented prior to the listening test. The aim of the present article is to examine if external information (verbal and visual), given during the instruction phase, describing the sound events occurring in a sound sequence recorded in an interior car, will improve identification or recognition of these events, and consequently, will influence overall appraisal on several semantic scales related to the whole sound sequence, and if the visual information of the car will have an effect on the same scales. In other words, this study examines if prior knowledge on the sound sequence composed of successive sound events, from the entrance of the passenger in the car to the departure (related to a daily life situation), will modify the overall understanding, and thus judgments of the participants by comparing appraisals on semantic scales obtained in three different conditions that will be described below.

In the present study, external information (verbal and visual) are provided to participants during the instruction phase – prior to the listening test – in order to improve their comprehension of the different events of the sequence, but not to interfere with it during the listening test. More precisely, the aim of this study is not to compare the effect of visual information versus verbal information, but the effect of the type of information by comparing three experiments in which the sound sequence is presented, respectively alone, with verbal information, or with verbal and visual information. The sound sequence tested corresponds to a real-life interior car situation composed of successive events, and the information which were given to the participants concern each event and their ordering in the sound sequence (such as a scenario). Effect of external information is evaluated by comparing identification and recognition scores for each event of the sound sequence. Then, judgments of the whole sound sequence are examined on twelve semantic scales to check if the sound sequence is indeed better understood, and consequently, judged differently on the scales related to the sound properties. Ballas et al. [8] and Howard et al. [9] studied extensively the influence of different factors on identification of everyday sounds. Part of their work focused on similarities between environmental sounds and speech. They showed that when sequences were made of everyday sounds, sequences organized following a grammatical structure were more easily learned when the rules were interpretable, than when the rules were arbitrary. The hypothesis of our study is that external information given to the participants prior to the listening test will provide them an overview of the temporal organization of the sounds, and thus a better mental picture the sound sequence when judged on semantic scales.

In the first part of the article, the experimental setup and the procedure are presented. The three tested conditions vary according to the type of information given to the participants during the instruction phase before the listening test (Section 2.1). In the first condition, no information was provided to the participants. In the second condition, explicit information was provided by a written text about the specific equipments of the vehicle heard in the sound sequence and about each successive event organized in the sequence according to the specified scenario presented below. It was expected that the verbal information provided by the text would improve identification of the several events, and thus, would provide a better understanding of the whole sequence. In the third condition, visual information was added to the text in order, on the one hand, to help participants to improve again their understanding of the scenario thanks to a mental image strengthened by a visual presentation of each event, and on the other, to examine if the visual information of the car could influence the judgments. The sound sequence used is a representation of the scenario: "to start the engine" ("phase d'accueil dans un véhicule" in French) and was created from recordings as described in Section 2.3. In each condition, subjects performed three tasks: an identification test, a recognition test and a semantic rating test (Section 2.5). The three tasks were carried out in the same order in each condition. The indentification task, consisting in labelling the events of the sequence, was performed to check if the information provided during the instruction phase has improved participants's knowledge on the events. The recognition test was performed after the indentification test, in case the participants had not succeeded labelling some events, yet they had recognized them (see footnote 2 for a distinction between identification and recognition). For the third test, it was intended that participants had been involved primarily in a process of identification/recognition of the events in order to force them to have a mental image of the events when judging the whole sequence on the semantic scales. Finally, results obtained for each task in the three different conditions are presented in Section 3. Then, in Section 4, we discuss how listeners' perception of the sound sequence was affected by the external information.

2. Experiment

2.1. Experimental conditions

Three different groups of participants participated in the experiment, one for each experimental condition. Each group performed the three tasks described in the procedure (Section 2.5). Participants all received instructions before the listening test. The first part of the instructions explaining the task was the same for the three groups of participants, the second part of the instructions describing the sound sequence was different across the three experimental conditions. The three experimental conditions are, respectively labeled C1, C2, and C3. The amount of information increases from C1 to C3. The following section presents the type of information given about the sound sequence in each condition.

- *Condition 1* (C1). Participants were just informed that the sound sequence had been recorded inside a car.
- *Condition 2* (C2). Participants were informed, like in condition 1, that the sound sequence had been recorded inside a car and in addition, a text was presented describing specific equipment of the vehicle (e.g. "parking assistance signal"), the statement of the script "the engine is started", and the successive events that were present in the sound sequence. The text is presented in Appendix A.
- *Condition 3* (C3). Participants were informed first by the same text as in condition 2 and then by several visual slides showing the different events that could be heard from the beginning to the end of the sound sequence (four pictures are presented in Appendix A). The text, in conditions 2 and 3, and the visual slides, in condition 3, were provided to the participants during the instruction phase – prior to the listening test. The car used was a Vel Satis, an executive[1] car manufactured by Renault.

2.2. Participants

Three groups of 30 "naïve" participants took part in the experiment (45 females, 45 males). By "naïve" we mean a participant who does not work for the car manufacturer Renault. Their ages varied from 21 to 56. Each group performed the three tasks in one condition. No participant reported having any hearing problems.

2.3. Sound sequence

The sequence called "the engine is started" ("phase d'accueil dans un véhicule", in French) has been defined as a succession of ten events, respectively named: door slammed (porte claquée, in French), seat-belt unrolled (ceinture déroulée), seat-belt attached (ceinture attachée), magnetic card inserted (carte magnétique insérée), start button pressed (bouton de démarrage appuyé), started engine (moteur démarré), self-locking activated (fermeture de porte déclenchée), reverse gear engaged (marche arrière enclenchée), parking assistance actuated (radar de recul déclenché), and blinker actuated (clignotant actionné). These ten events were defined as part of the sequence on the basis of an informal action analysis of the corresponding scenario and on usage knowledge provided by the car manufacturer.

[1] Executive car is a British term used generally to describe an automobile larger than a large family car, but which is not a high-end or an ultra luxury car, a multi-purpose vehicle, or a sport utility vehicle.

The production of the sequence was made by an operator who successively brought into operation the ten events mentioned previously in the most realistic manner carried out the scenario.

The first step of the work consists in making continuous recordings of the whole sound environment sequence. This is done in seven different vehicles from different brands. The sound recordings are made in a semi-anechoic chamber with two distinct technical devices:

– a binaural system (HEAD Measurement Systems, HMS) including a light headphone equipped with ear microphones in order to get the global sound scene,
– nearfield microphones (Grass) positioned close to the sound sources in order to capture each isolated event more precisely, and as much as possible, without the "compartment effect".

This set of signals is collected by a multi-channel acquisition system (Head Acoustics) linked to a PC laptop (direct-to-disk architecture). Moreover, an impulse response measurement is taken in each car compartment in order to get information on their acoustic signature.

The nature of data recorded allows to sound edit four different types of sequences:

– a *raw* sequence: "cleaned" binaural channels (initial section, length, etc.)
– an *augmented* sequence: binaural channels mixed with isolated channels taken from nearfield recordings (thanks to synchronization between channels)
– an *encrusted* sequence: binaural channels without the events (background) mixed mainly with isolated channels taken from nearfield recordings, and, in few particular cases, with an alternate take of binaural recordings (because in that cases, the nearfield recordings did not provide audio quality high enough).
– an *isolated*sequence: succession of the isolated events mainly taken from nearfield recordings and, in few particular cases, with an alternate take of binaural recordings.

After an informal listening session of these four representation modes and internal discussions – both done by the five authors – the "*encrusted* sequence" was retained, with regards to three main criteria: high-quality in audio (especially, with regards to sound recording quality and signal-to-noise ratio), sequence integrity (integration quality of the different sequences) and sound rendering realism (mainly relied on spatial audio rendering). One vehicle among the seven initially proposed was selected for the continuation of the work. As a result, this editing phase produced finally one stereo sequence corresponding to the sound rendering of the scenario "the engine is started". The sequence lasts 43 s.

2.4. Apparatus

In each experimental condition, the sound sequence used was generated at a sampling rate of 44.1 kHz with 16-bit resolution by PC Linux workstation equipped with a RME Hammerfall 9652 digital-signal-processing card. The sounds were converted by a RME Analog/Digital Interface ADI-8PRO digital-to-analog converter. The stimuli were amplified by a Yamaha P2075 stereo amplifier and presented dichotically over a Sennheiser HD250 linear II headset (with no specific pre-processed equalization). Participants were seated in a double-walled IAC sound-isolation booth. Levels were calibrated using a Brüel & Kjær 2238 Mediator sound level meter (the sonometer was mounted on a device – basically, a plate with a 1/2" hole in its centre – so as to allow the headphones to be positioned in a reproducible and similar way for both channels during the calibration process). The equivalent average sound level measured using the A-weighting (LAeq) of the whole sound sequence is 58.1 dBA; more information (duration, sound level) on each sound event is reported in Table 1. The experiment was run using the PsiExp v2.5 experimentation environment including stimulus control, data recording, and graphical user interface [10].

Table 1
Information (duration, level) on each sound event of the sequence

Event No.	Event label	Duration (msec.)	Sound Level (dBA)
1	Slamming door	650	60.6
2	Seat-belt	3000	41.9
3	Hauling seat-belt	2000	53.6
4	Magnetic card	700	55.0
5 + 6*	Start button/engine	1500	63.8
7	Self-locking	300	59.6
8 + 9*	Reverse gear/parking assistance signal	11500	58.1
10	Blinker	7500	58.8

* Concatenated events, because of their temporal proximity.

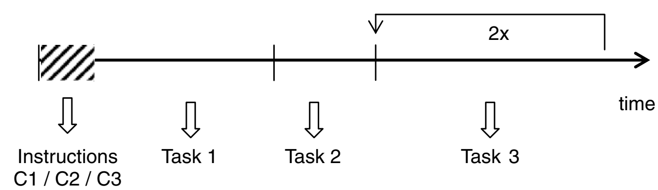

Fig. 1. Experimental procedure.

2.5. Procedure

Three tasks were successively performed by all participants (Fig. 1). Participants received written instructions explaining the tasks.

– Task 1. Identification test
In Task1 participants were asked to listen to the sound sequence once and to try to identify each sound event. This was specified to produce written verbalizations focused on the events description, and not on the sound characteristics description or preference. Participants were instructed to provide a noun labeling the event and a complement describing the action made by, or on, the event (e.g. "door closing"). This procedure is similar to the one used by Ballas [1] concerning the identification of everyday sounds. Thus, as they listened, participants wrote down a short description of each event identified.
– Task 2. Recognition[2] test
In Task 2 the sound sequence was presented again. At the end of the sound sequence, a list of the ten events heard was presented in French to the participants. The list is presented in Table 2 in French and in English. They were asked to indicate how well they recognized each event through a marking

[2] Remark: in psychophysics, the term identification consists in asking the participant to give the name of a stimuli. This task corresponds to task 1. The term recognition is restricted to the type of paradigms with two stages and in which the task of the participant is to say if each stimulus, presented during the second stage, was or was not, previously presented during the first stage. Here the task corresponds to task 2.

Table 2
List of events presented in French to the participants

Mark	Sound events	Abbreviations used
	Clignotant actionné/Blinker actuated	Blinker
	Moteur démarré/Started engine	Engine
	Ceinture déroulée/Seat-belt unrolled	Seat-belt
	Porte claquée/Door slammed	Slamming door
	Marche arrière enclenchée/Reverse gear engaged	Reverse gear
	Ceinture attachée/Seat-belt attached	Hauling seat-belt
	Radar de recul déclenché/Parking assistance actuated	Parking assistance signal
	Fermeture de porte déclenchée/Self-locking activated	Self-locking
	Bouton de démarrage appuyé/Start button pressed	Start button
	Carte magnétique insérée/Magnetic card inserted	Magnetic card

system of 0, 1, and 2. Marks 0, 1, and 2 indicate respectively that the event is "not recognized at all", "recognized, but not so easily", and "very well recognized".

– Task 3. Semantic rating test
In Task 3, the sound sequence was judged on twelve semantic differential scales. Semantic differential scales [11] have been used widely to describe the "meaning" of perceptive or cognitive events. Several important studies on the verbal attributes of timbre have utilized this technique (see Kendall & and Carterette [12] for a review, or more recently in French, Faure [13]). In the present article, instead of using bi-polar adjective pairs (e.g. dull-sharp) as in the traditional semantic differential paradigm, we choose an attribute and its negation (e.g. sharp–not sharp) as was proposed by Kendall and Carterette [12]. Authors termed this method *verbal attribute magnitude estimation* (VAME) since the task for the participant is to rate the degree to which an attribute is possessed by a stimulus. The authors proposed the VAME method because the main problem in the use of bi-polar opposites is that the "opposite" is not always an antipode – Is *dull* the opposite of *sharp* when used to describe sounds? In addition, most semantic differential studies consist of a single stimulus presentation followed by a list of all differentials, not always randomized in their order. To minimize any order effect, two replications of the set of twelve semantic scales were randomly presented to participants, for a total of 24 ratings by participant. Continuous rating scales were displayed one after the other and the sound sequence was repeated every four ratings. Participants judged the verbal attribute by using a mouse to move a slider on the scale. When participants pressed the "Valid" button, the judgment was recorded as a number on a 100-point scale and a new scale was presented on the screen.

In Parizet et al.'s study [14], the verbal attributes used for a differential semantic test were presented in a sentence to eliminate any risk of semantic ambiguity, and were presented without any precaution. The results were more reliable when the labels' meaning was highlighted by the sentences. Thus, in the present study, to practice the verbal attributes, each one was presented in a sentence in order to propose a meaning for the labels shared by all participants in the specific context of the experiment [15].[3] For instance, the meaning of the verbal attribute *pleasant* was introduced by the sentence "I like to hear him talking, his voice is *pleasant*". The sentence introducing the word *loud* ("The TV is loud, we can't have a discussion") clearly means that the sound level is very high as it is impossible to discuss. In other words, we insist here that "loud" is used to judge the sound level of the car sound, and not the unpleasantness. The twelve attributes and the corresponding sentences were sent to the participants by e-mail one week before the listening test (see Appendix B).

[3] The main idea is that it is through communication that the participants exchange and develop their subjective representations. Using sentences to present the labels allows each participant to better structure their own representations with reference to the information obtained from the experimenter. In this case, it is possible to expect an intersection of the subjective representations of the different participants. This interaction between representations created a stabilization of the individual representations associated with each label.

2.5.1. Verbal attributes (VA) selection

In a study by Chouard et al. [16], a list of verbal attributes was obtained specifically to characterize car sounds. Results show that verbal descriptions can be classified in two categories at two levels; a local one and a global one. The first category is mainly focused on the sound in terms of *sound quality* (I) and *timbre* (II). The second one is focused on the sound source in terms of perceived *comfort* of the vehicle (III) and *car properties* (IV) such as material, strength, etc. These four types of descriptions (I–IV) were retained, and two more were added to evaluate the subjects' involvement corresponding respectively to the degree of *comprehension* (V) of the sound sequence and to the degree of *immersion* (VI) in the sound sequence. The former category, *comprehension* (V), was added in order to check how the subjects judged their own comprehension of the sound sequence according to the additional information. The latter one, *immersion (VI)*, was added because it was shown that it is a significant dimension in soundscapes perception [17]. Verbal attributes (VA) for the six types of descriptions are presented in Appendix B.

3. Results

Three groups of 30 participants participated in each task, one group by condition.

3.1. Task 1

Task 1 consisted of collecting free verbalizations produced to name events present in the sound sequence. Then, the verbalizations were analysed for each event in two main semantic categories: "action description" and "object description". The category "action description" corresponds to the verbalizations indicating an action involving an object, contrary to the category "object description" referring to the description of the object. The choice of these two categories was made according to the results obtained by Guyot [18] on domestic sounds and by Faure [13] on musical sounds. Both studies showed that participants used two different strategies to classify or describe sounds. The first strategy is based on the description of the sound using timbre and temporal characteristics, and the other one is based on the description of the sound production. The latter strategy is based on two aspects consisting of identifying the sound object and the action performed on the object. In Task 1, participants were asked to identify the sound events taking into account as much as possible these two aspects using the simple description composed of a noun and a complement. Most of the time, participants produced verbalizations composed of both terms, but despite the instructions, some verbalizations were composed of only one term because labels to describe an action are less accessible for some sounds (e.g. "Blinker"), and inversely for others (e.g. "Slaming Door").

In addition, a third category was added for verbalizations with an explicit use of onomatopeia which are sometimes adopted in everyday situations to label specific events such as the cadence of a blinker for example (e.g. "tic–tac").

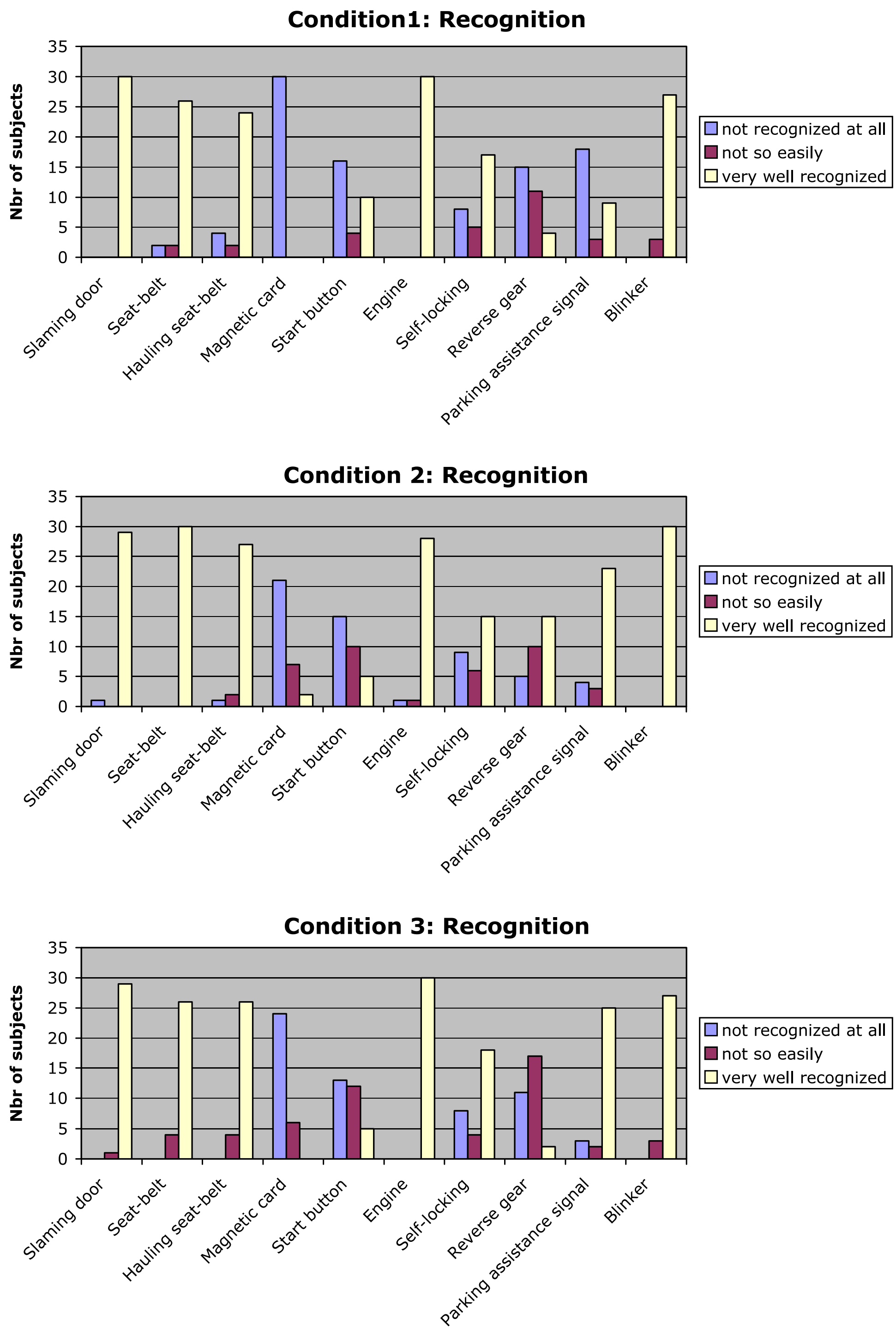

Fig. 2. Scores of recognition obtained for each event in conditions 1, 2, and 3.

Cumulative frequency is used to determine the number of expressions associated to semantic categories for each specific event. A summary of these expressions is presented in Appendix C. For instance, in condition 1 (Appendix C Table A), if we consider the semantic category "object description" the *blinker* event was identified and named *blinker* by 20 participants, *blinker signal*by 2, *blinker noise* by 2, and *blinker click* by 1. *Blinker on* was used by 3, concerning the semantic category "action description". The event identification score is calculated across the three semantic categories for each event. The onomatopoeia *tic-tac* was used once. As a result, the *blinker* event was correctly identified 29 times in condition 1, 26 times in condition 2, and 28 times in condition 3. In this specific case, additional information (verbal in condition 2, or verbal and visual in condition 3) did not modify the identification score. On the other hand, the identification score obtained for the *self-locking* event increased across conditions; 7, 14 and 18 respectively for condition 1, 2, and 3. The same kind of increase was obtained for the *parking assistance signal* event (respectively 14, 22, 20) but without differences between condition 2 and 3. Thus, for such events, additional information produced a positive effect on the identification score. Finally, identification scores are very low for a few events such as

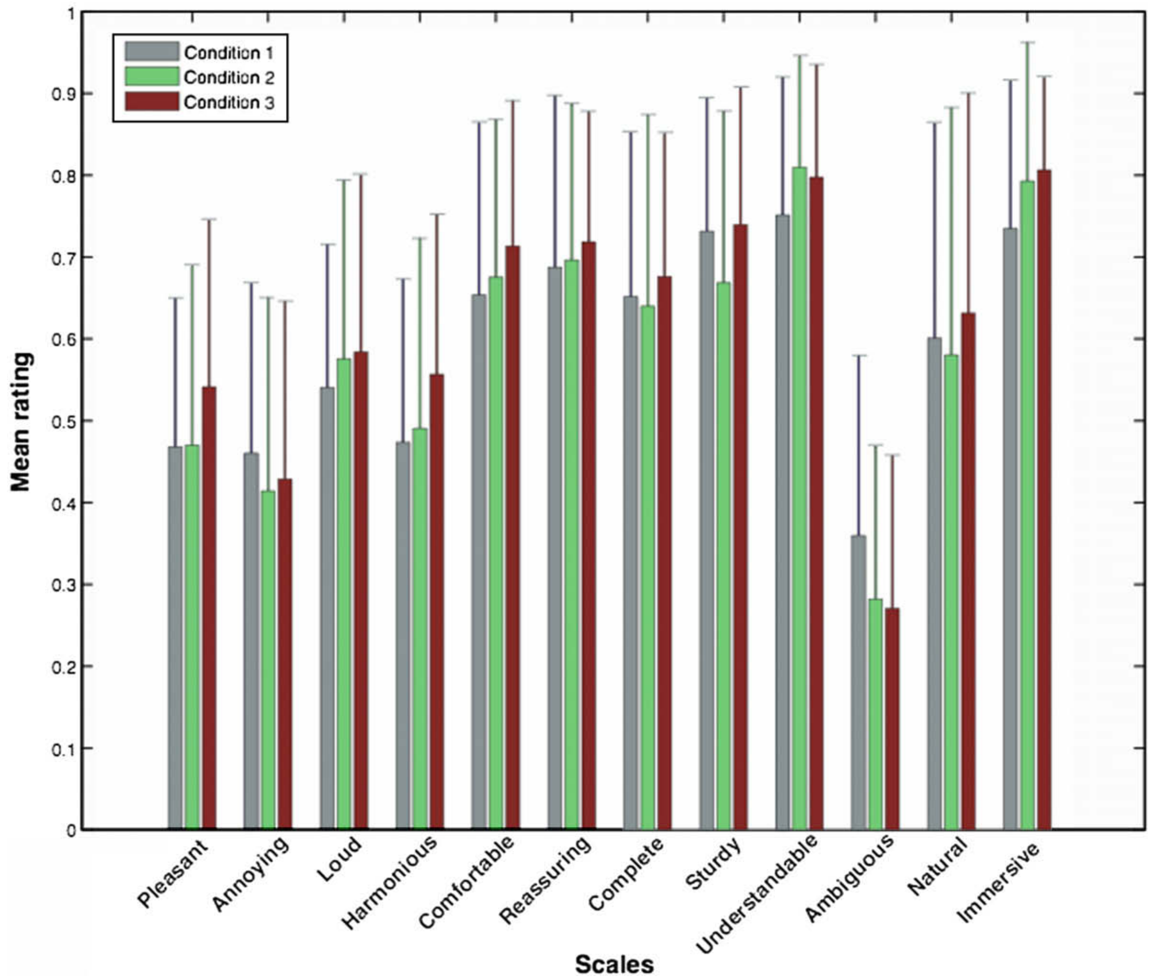

Fig. 3. Mean ratings obtained for the twelve VA scales in conditions 1, 2, and 3. 1 SD is indicated for each scale and for each condition.

magnetic card (respectively 1, 4, 2) or *starting button* (respectively 4, 4, 3) whatever the condition. To summarize, results revealed two tendencies for unusual events, corresponding to relatively new car equipment. Additional information had an effect for some events such as *parking assistance signal*, but not for others such as *magnetic card* or *starting button*. It seems that for the *parking assistance signal*, the iconic relation between the sound (acceleration of the rhythm) and the action (obstacle approaching) is well understood when additional information is provided, but this is not the case for the other events. On the other hand, additional information did not have any effect for events which had already a high identification score in condition 1 (75% of correct identification) such as *blinker, engine* and *belt.* Thus only 2 events in task 1 were better identified between the conditions (“parking assistance signal”, “self-locking”). Part of the verbalizations in conditions 2 and 3 are similar to the descriptions provided by the text during instructions, which means that participants tacitly adopt those expressions to name events of the sound sequence.

3.2. Task 2

Fig. 2 presents scores of recognition obtained for each group of 30 participants respectively for condition 1, 2, and 3. Recognition performances were compared between experimental conditions in order to determine whether additional information had an effect on recognition performance. A χ^2 test revealed a significant difference between condition 1 and condition 2 (χ^2 (9) = 56.25, $p < 0.001$), between condition 1 and condition 3 (χ^2 (9) = 32.20, $p < 0.001$), and no difference between condition 2 and 3, for the answer “very well recognized”. The same result was obtained for the two other types of answer. The major improvement in conditions 2 and 3 was obtained for the event “parking assistance signal”. One could observe a slight improvement for the event “magnetic card”. Patterns of recognitions for condition 2 and 3 are quite similar. Results obtained in task 2 confirm results observed in task 1. The event “parking assistance signal” is the only one for which identification performances were improved in conditions 2 and 3.

3.3. Task 3

Task 3 consisted of ratings on twelve semantic differential scales that were then factor analyzed.

3.3.1. Reliability

For the three groups of participants, the repetition (test and retest) factor is examined considering individual ratings averaged over the VA scales. Test–retest reliability obtained is $r = 0.97$, $r = 0.96$, and $r = 0.98$ ($p < 0.005$), respectively for conditions 1, 2 and 3. Since the repetition did not involve any difference both datasets were aggregated for further analysis.

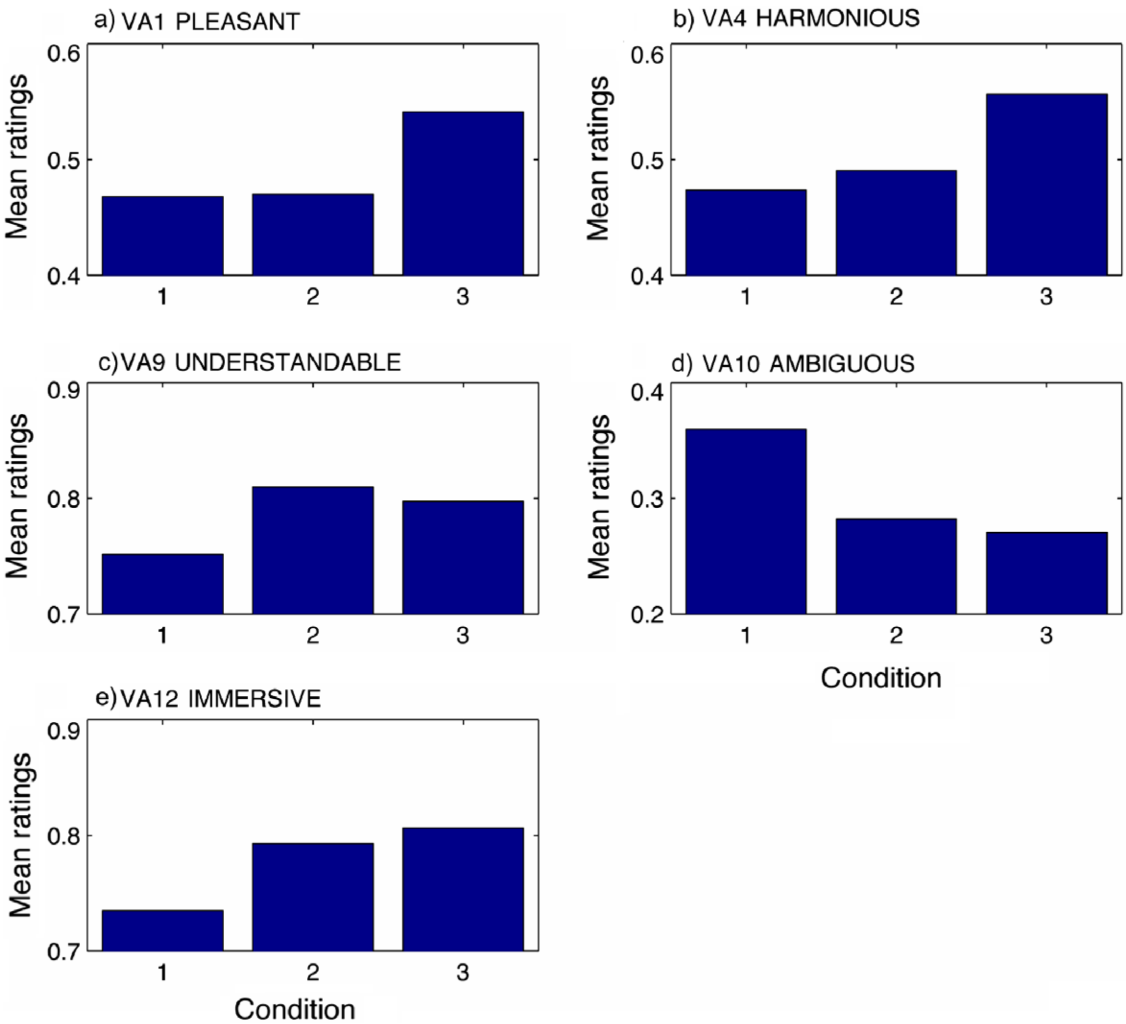

Fig. 4. Mean ratings obtained for the scales VA1, VA4, VA9, VA10, and VA12 in conditions 1, 2 and 3.

Table 3
Significant effects of conditions 1, 2, and 3 on each VA scale

Scale	Verbal attribute	Significant effect ($p < 0.1$)	Global interpretation
Type I			
VA 1	Pleasant	C3 > C2 = C1	More pleasant in 3
VA 2	Annoying		
Type II			
VA 3	Loud		
VA 4	Harmonious	C3 > C1	More harmonious in 3 than in 1
Type III			
VA 5	Comfortable		
Type IV			
VA 6	Reassuring		
VA 7	Complete		
VA 8	Sturdy		
Type V			
VA 9	Understandable	C3 = C2 > C1	More understandable in 2 and 3
VA 10	Ambiguous	C1 > C2 = C3	More ambiguous in 1
Type VI			
VA 11	Natural		
VA 12	Immersive	C3 = C2 > C1	More immersed in 3 and 2

3.3.2. Results presentation

Fig. 3 presents mean ratings obtained for the twelve VA scales in conditions 1, 2, and 3. Values stand between 0 and 1 corresponding respectively to the attribute (e.g. *pleasant*) and its negation (e.g. *non pleasant*). On the average, it is clear that the degree of differentiation of ratings between the three experimental conditions is not very important except for few VA scales (*pleasant*, *harmonious*, *understandable*, *ambiguous*, *immersive*). On the other hand, mean ratings are coherent across VA scales. For instance, the mean value is high on VA9 (*understandable*) and low on VA10 (*ambiguous*), which means that the more the sound sequence is judged understandable, the less it is judged ambiguous. More specifically, the sound sequence is judged less understandable and more ambiguous in condition 1 than in conditions 2 and 3, which is coherent with the amount of information, provided to the participants. Furthermore, participants judged that they were more immersed in conditions 3 and 2 than in condition 1. Concerning judgments focused on sound, it appears that the sound sequence is judged more pleasant and harmonious in condition 3 than in conditions 1 and 2.

3.3.3. Analysis of variance

To assess the apparent trends noted previously for few VA scales, a multivariate analysis of variance (MANOVA) with repeated measures was conducted on twelve dependent variables, using a complete factorial design, with the following one between group factor: Condition (3 levels). A MANOVA was performed instead of an ANOVA to take into account correlations between rat-

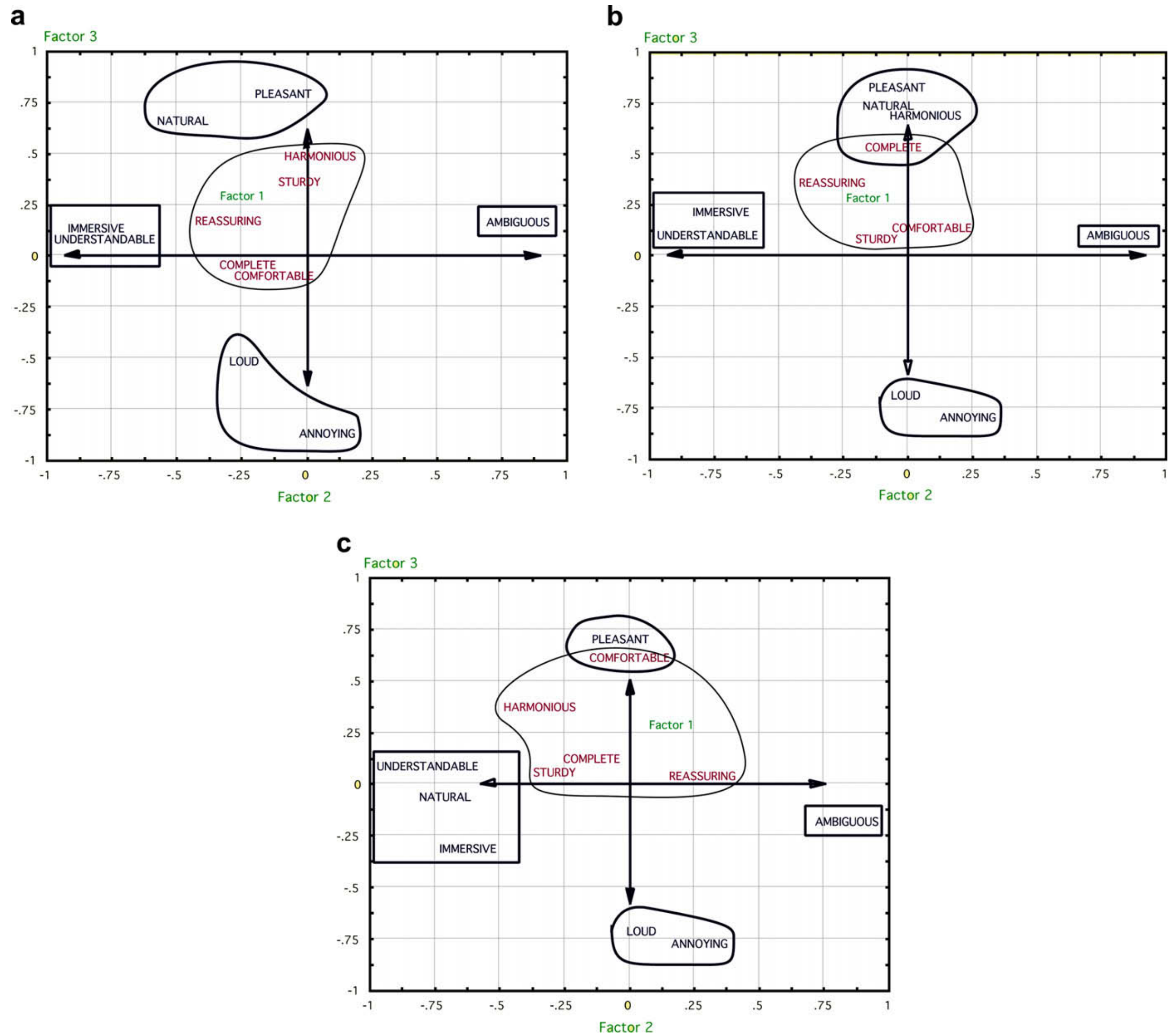

Fig. 5. Presentation of the three factors obtained by the principal components analysis (PCA) for conditions 1, 2, and 3 (respectively (a), (b) and (c)).

ings on similar scales such as VA1 (*pleasant*) and VA2 (*annoying*), for example (see Fig. 4).

The main interest of this study is to compare ratings obtained for the three conditions in order to examine effects of additional information on perceptual judgments. Thus, the main null hypothesis tested is: "the experimental condition does not have any effect on perceptive judgments". In other words, the aim is to determine whether instructions given to the participants can influence their ratings on VA scales. No important significant differences were expected between conditions as the sound sequence is the same across the three conditions, so it was decided to reject the null hypothesis for a higher level of significance ($p < 0.1$) than typically considered as borderline statistically significant ($p < 0.05$).[4] The multivariate analysis of variance (MANOVA) reveals an overall significant effect of the condition factor (Wilks' lambda value, $F(24, 326) = 1.41$, $p < 0.1$). For each VA scale, a Post-Hocs analysis was performed to examine for which VA scale and between which conditions the effect is significant (Fisher's Protected LSD, $p < 0.1$). Results are summarized in Table 3 for the significant effects and are represented in Figs. 5a–e, respectively for scales VA1 (pleasant), VA4 (harmonious), VA9 (understandable), VA10 (ambiguous), and VA12 (immersive). The analysis confirmed the results described above. The effect of the factor condition is significant for five scales (VA1, VA4, VA9, VA10 and VA12) and changes with the type of scale. The sound sequence was judged significantly more pleasant in condition 3 than in conditions 1 and 2, and more harmonious in 3 than in 1. Events were judged more comprehensible in conditions 3 and 2 than in condition 1. On the other hand, events were judged more ambiguous in 1 than in 2 and 3. Finally, participants felt that they were more immersed in conditions 3 and 2 than in condition 1.

[4] The level selected involves a fairly high probability of error (10%), but one should remember that there is neither a right nor a wrong answer in this study, as the aim is to examine the influence of additional information on perceptive judgments in order to put forward a format of instructions that could be in favour of a more realistic experimental laboratory situation.

3.3.4. Factor analysis

The KMO (Kaiser–Meyer–Olkin) index is higher than 0.5 for the three conditions indicating that the correlation matrices are suitable for factor analysis. Thus, principal components analyses (PCA) were performed for each condition. The decision criterion for the choice of the number of factors was based on the Kaiser–Guttman rule. Respectively 3, 4, and 3 factors were retained for conditions 1, 2 and 3, but it was decided to keep three factors for each condition in order to compare the results. Results show that the first three factors account for 71.2, 73.5, and 70.3% of the variance, respectively for conditions 1, 2, and 3. Fig. 5a–c represent the three factors, respectively for conditions 1, 2, and 3, with a varimax rotation of the factor loadings. Factor F1 is perpendicular to the 2D space formed by F2 and F3. Tables of factor loadings are presented in Appendix D. According to the factor representatives (factor loadings >0.65, seeAppendix D):

- the verbal attributes associated to the description of the vehicle (groups III and IV) such as *comfortable* (VA5), *reassuring*(VA6), *complete* (VA7) and *sturdy*(VA8) have large loadings on factor F1 (39, 42 and 36% of the variance resp. for C1, C2, and C3),
- the verbal attributes associated to the state of the participant (group V), *understandable* (VA9) and *ambiguous* (VA10), have large loadings on factor F2 (18, 18, and 18% resp. for C1, C2, and C3),
- the verbal attributes concerning the sound description (group I), *pleasant* (VA1) and *annoying* (VA2), have large loadings on factor F3 (15, 14, and 16% resp. for C1, C2, and C3).

Scales VA6, VA7, and VA8 are distributed on F1 in the same direction as VA5 (*comfortable*). Thus descriptions such as *reassuring* (VA6), *complete* (VA7) and *sturdy* (VA8) are positive in terms of comfort. In condition 3, VA5 (*comfortable*) is also distributed on F3 related to the sound description (group I). This result will be discussed more in details in the discussion. VA9 (*understandable*) and VA12 (*immersive*), on one hand, and VA10 (*ambiguous*), on the other, are opposed on F2 in conditions 1 and 2, which means that when the participant judges the sound sequence understandable and non ambiguous, he/she feels immersed in the sound sequence. Surprisingly, it is less clear in condition 3 (when visual information are added) since VA12 (*immersive*) is not representative of F2. The more important change across the three conditions is obtained for VA11 (*natural*) that seems to have different meanings depending on the condition; VA11 is distributed on F3 and slightly on F2 in condition 1, on F3 in condition 2, and on F2 in condition 3. Finally, it appears that the three factors are mainly explained by the same verbal attributes.

4. Discussion

The aim of this study was to compare ratings obtained on semantic scales between three conditions in order to examine effects of external information on perceptual judgments by minimizing the effect of misinterpretation of the verbal attributes among the participants. To do so, all participants received the same descriptions of the verbal attributes in the three experimental conditions by means of a sentence that clarifies the meaning of the labels for each participant. One could not agree with the definitions provided for each attribute, but the definitions were elaborated in order to obtain perceptual judgements that were in agreement with the psychological dimensions expected by the automobile manufacturers. In addition, no participant reported having any problems with the comprehension of the verbal attributes except for the labels *completed* and *natural*. Of course, the results presented have to be taken into account only in the case of the definitions proposed in this article.

The multivariate analysis of variance (MANOVA) reveals that the factor Condition is significant ($p < 0.1$) for five semantic scales, which means that instructions do have an effect on ratings for several verbal attributes. As expected, the effect is significant for VA scales *understandable* (VA9) and *ambiguous* (VA10): in conditions 2 and 3, the sound sequence is judged more comprehensible and less ambiguous. This result is coherent with the results of tasks 1 and 2 which shows that the scores of identification and recognition were higher for a few sound events in conditions 2 (“parking assistance signal”, “self-locking”) and 3 (“parking assistance signal”, “magnetic card”). On the other hand, the results do not reveal any significant difference between conditions 2 and 3 for those scales (VA9, VA10) and for the scores obtained in tasks 1 and 2, which means that the use of verbal information is sufficient, and in this case, visual information are maybe redundant and thus do not increase performances in terms of identification and recognition. As for VA9 (*understandable*) and VA10 (*ambiguous*), the effect of the factor Condition is significant on the VA scale *immersive* (VA12). In other words, participants judged they were more immersed in conditions 2 and 3 than in 1. It looks like the increase of comprehension (VA9) of sound events, from condition 1 to conditions 2 and 3, makes the participants like they are more immersed (VA12) in the sound sequence, but it should be noted that the words *immersed* and *real* are linked in the description of VA12 (Appendix B), thus the meaning of VA12 was maybe misunderstood by the participants considering the possible association between the two words. This hypothesis could explain the good correlation between the scales VA9 (*understandable*) and V12 (*immersive*). However, it must be stressed that the participants were informed verbally that VA12 was associated to the sensation of immersion in the sound sequence when they were listening to it. During a quick survey performed at the end of the experiment, the three groups of 30 participants were asked if they felt acting in the scene. Three answers were proposed: 1/ “not at all”, 2/ “a little”, 3/ “totally”. Twelve participants did not feel that they were an active participant in the scene in condition 1 to 2 and 4 in the conditions 2 and 3. Finally, those responses confirmed the judgments obtained on the scale VA12, which reflects a greater feeling of immersion for the participants in conditions 2 and 3. To end on this point, it should be added however that VA12 (*immersive*) is only slightly distributed on factor F2 related to the verbal attributes *understandable* and *ambiguous* in condition 3. The scale VA12 was in fact based on a description related to a visual context (“He feels *immersed* in the movie as it was so real”). Thus, the small displacement of the verbal attribute *immersive* in condition 3 showed in Fig. 5.c could be related to the pictures presented as well as to the sound sequence.

Ratings on verbal attributes concerning the sound description, *pleasant* (VA1) and *harmonious* (VA4), are significantly different between conditions 1 and 2 on one side and condition 3 on the other side. Thus, verbal information did not influence judgments on the scales related to sound quality (VA1, VA2) and timbre (VA3, VA4), but the visual information added to verbal information significantly influenced judgments obtained on the scales *pleasant* (VA1) and *harmonious* (VA4). In other words, when the visual information was presented, the judgments made on the sound sequence on the scale *annoying* (VA2) and *loud* (VA3) were not affected meaning that the sound sequence was not judged louder or softer (respectively more or less annoying), but was judged more *pleasant*[5] and *harmonious*. Visual information presented to the participants during instructions showed a Vel Satis model, an executive car manufactured by Renault. At that time, in 2003, it was the most recent modern car of the brand with a nice and high-quality appearance. It seems that ratings associated to the sound were influenced by the ''nice and high-quality appearance'' of the vehicle. This result is in accordance with another study on cars [21]. This is also coherent with many studies on food quality. One well-known study is the work done Lange et al. [22] on the impact of the information provided to consumers on their preference for a different brand of Champagne. Five brut non-vintage Champagnes were tested under three different conditions: participants first had to evaluate each product after tasting without seeing the bottles (condition 1), then, they evaluated their expectation after handling each bottle but without tasting the Champagnes (condition 2). Finally, participants had to evaluate each product seeing the bottle while tasting a glass of the corresponding Champagne (condition 3). The result of this study showed that no significant differences appeared between the Champagnes when consumers had no external information (condition 1). On the contrary, in condition 2, external information led to higher scores for the three high-end and the mid-range brands, and to significantly lower scores for the Champagne with the lowest prices. Except for the lowest price Champagne, condition 3 (full information) tended to induce a decrease in evaluation compared to the condition 2 (bottle), suggesting an impact of sensory characteristics on external information about the brand. Lange et al. came to the conclusion that preference judgment in a blind condition seems to be better adapted to examine sensory dimensions.

Principal components analyses (PCA) were carried out to reveal the factors accounting for the participants' perception across the three conditions. The analysis shows that relationships between the factors and the verbal attributes are almost identical in the three conditions except for few verbal attributes: *natural* and *comfortable*, and to a lesser extent, *immersive*. Indeed, the verbal attribute *natural* was associated with the verbal attribute *pleasant* on factor F3 in conditions 1 and 2, and with the verbal attributes *understandable* and *immersive* on factor F2 in condition 3. This result shows that the verbal attribute *natural* was understood differently by the participants in condition 3. The visual information shifts the meaning of ''natural'' from ''pleasant'' in condition 2 to ''understandable'' in condition 3. In conditions 1 and 2, the verbal attribute *comfortable* was associated with the factor F1 correlating with the vehicle description, while in condition 3 it is related both to F1 (vehicle description) and F3 (sound description). So in condition 3, global attributes *comfortable* and *pleasant*were put together. It seems that sound quality plays a part in the global *comfort* of the vehicle when the visual information is added.

5. Conclusion

The effect of external information (verbal and visual) on the perception of a sound sequence was examined in this study for a sequence of interior car sounds. The aim was not to compare the effect of visual versus verbal information, but the effect of the external information by comparing three conditions (respectively, no external information, verbal information, and, verbal and visual information). More than 70% of the variance was explained by three factors, whatever the instructions are. Relationships between the three retained factors and the twelve scales are nearly the same across the three conditions. However, even if the structure is not changed, external information do influence perceptive judgments. To summarize, results obtained for the script ''the engine is started'' show that, on one hand, verbal information positively influence the comprehension of the sound sequence and thus the feeling of immersion in the sound sequence, but do not modify ratings on the scales related to the sound sequence. On the other hand, visual information added to the verbal information influenced the perception of the sound sequence judged more pleasant and harmonious, but did not provide any further significant advantage in terms of comprehension and immersion. More generally, the results show that the effect of the external information on judgments depends on the verbal attribute attached to the scale. In conclusion, this study reveals that the format of instructions given influences ratings of the sound sequence tested: verbal information provided alone improve the identification scores without inducing any significant judgments' modification on the scales related to the sound properties; visual information added to the verbal information do not modify the identification scores, but affect the judgements on scales related to sound appraisal, which means that visual cues have influenced participant's judgments. This result concurs with results obtained by Abe et al. [7] for everyday sounds.

In the line of Lange et al's study [22], a development of the study presented in this article could be to examine the influence of the brand on the sound quality of several car sounds, in order to evaluate the influence of the external information (e.g. economic) on internal information (auditory) using preference judgements as well as expectancy evaluation.

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Appendix A. Text presented in condition 2 and 3

A.1. Vehicle description

The vehicle used for the sound sequence has some particularities that you perhaps don't know. The vehicle has a new system to switch on the ignition. This new system uses a magnetic card instead of a key. Like the key, the card has to be inserted in to start the car. One can start the car by pushing a ''Start'' button, instead of turning the key. The car has also a parking assistance signal, that sounds when the car is put in reverse; its tempo gets quicker as the car comes closer to an obstacle.

A.2. General description

In the scene you will hear imagine that you are settling down in a car as the driver, and that you will then move back to drive out of a parking place and drive away.

You are sitting in the car in the driver's seat; you are slamming[6] the door to close it.

[5] Different studies have shown that ratings on different scales such as loudness, noisiness, and annoyance do not give necessarily the same results. So it is not surprising that ratings on the scales *annoying* (VA2) and *pleasant* (VA1) are different in the present study [19,20].

[6] The words underlined in the text correspond to the ten events presented in Table 1.

Now you are pulling out and fastening your seat belt.

You are inserting the magnetic card in its place and are pushing the Start button. The car is starting.

The car doors are automatically locked.

You are putting the car in reverse.

You are driving backwards, the parking assistance signal is sounding, the rhythm gets quicker when you come closer to the obstacle.

You are putting on the turn signal.

You are putting the car in first gear and are leaving the parking place.

Examples of the pictures presented in condition 3 (prior to the listening test).

Pulling out and fastening the seat-belt.

Inserting the magnetic card in and pushing the Start button.

Appendix B. Description of the verbal attributes (English and french versions)

Scale	Verbal attribute	Meaning
Type I		
VA1	Pleasant	I like to hear him talking, his voice is **pleasant** *J'aime l'entendre parler, il a une voix **agréable**>*
VA2	Annoying	The music is nice, but I cannot concentrate, it's **annoying** *Sa voix est agréable, mais elle est **gênante** pour me concentrer*
Type II		
VA3	Loud	The TV is **loud**, he can no longer hear himself on the telephone *La télé est **forte**, il ne s'entend plus parler au téléphone*
Type IV		
VA4	Harmonious	The sound of all instruments is **harmonious**, they give an impression of a coherent whole *Le son des instruments est **harmonieux**, ils donnent l'impression d'un ensemble cohérent*
Type III		
VA5	Comfortable	My living room is **comfortable**, I feel good in it. *Mon salon est **confortable**, je m'y sens bien*
VA6	Reassuring	The atmosphere is **reassuring**, I feel secure *L'ambiance est **rassurante**, je me sens en sécurité*
VA7	Complete	The design of this object is successfully **completed**. They thought of everything *Le design de cet objet est **abouti**. Ils ont pensé aux détails*
VA8	Sturdy	That doesn't sound chincy, to the contrary it seems solid and **sturdy** *Ce bruit, ça ne fait pas "toc" ! Au contraire, ça fait solide et **robuste***
Type V		
VA9	Understandable	I was listening with closed eyes,[a] everything was perfectly **understandable** *J'écoutais dans le noir, j'avais une **compréhension** parfaite de tout ce qui se passait*
VA10	Ambiguous	He did not understand what's going on because the noises were **ambiguous** Il n'a pas compris ce qui se passait car le bruit était **ambigu**
Type VI		
VA11	Natural	I forgot he was made by image synthesis because I found him so **natural** *J'oubliais que c'était un personnage en images de synthèse, je le trouvais **naturel***
VA12	Immersive	He feels **immersed** in the movie, as if he were there Il s'est senti **immergé** dans le film comme s'il y était

[a] Readers should note that V9 is not linked to the visual modality despite the fact the sentence used to introduce its meaning contains the visual instruction'"close your eyes".

Appendix C. Summary of the free verbalizations produced to name events present in the sound sequence, Task 1

Summary of the verbalizations produced by participants for each event. Numbers indicate the number of participants given each verbalization. Label **Ob** correspond to verbalizations categorized as "Object description", label **Ac** correspond to verbalizations categorized as "Action description" and label **On** correspond to verbalizations categorized as "onomatopoeia". **Tot** indicates the total number of verbalizations corresponding to each event.

Events	Slaming door	Belt (General)	Seat-belt	Hauling seat-belt	Magnetic card	Start button
Ac	Slamming door *Claquement porte/portière* Slammed door *Portière/porte claquée* **17** Closing door *Fermeture porte/portière* Closed door *Portière/porte fermée* **10** Noise of a slamming door *Bruit de portière qui claque* **1**	Put on the belt *Mettre la ceinture* **4**	Pulling out /pulled out belt *Déroulement ceinture /ceinture déroulée* **4** Sliding *Glissement* **5** Pulling/pulled belt *Tirage ceinture/ceinture tirée* **3** Hold belt *prise ceinture* **1**	Interlocking *Enclenchement* **4** Closing *Fermeture* **1** Attached *Attachée* **1** Clic/Clac/Click belt *Clic/clac/cliquer ceinture* **5**		Ignition (motor) *Allumage (moteur)* **3** Start up motor *Faire démarrer moteur* **1**
Ob	Door *Portière* **1** Door noise *Bruit de portière* **1**	Seat belt *Ceinture de sécurité* **13** Belt *ceinture* **6** Belt Sound *Bruit de ceinture* **2**			Ignition key *Clé de contact* **1**	
On				clic **1**		
Tot	**30**	**50** = 25 Belt General + 13 Seat-belt + 12 Hauling seat-belt			**1**	**4**

Events	Engine	Self-locking	Reverse gear	Parking assistance signal	Blinker	Others (no classification Ac/Ob)
Ac	Starting up/start up (motor/vehicle) *Démarrage/démarrer (moteur/véhicule)* **21** Motor (on) *Moteur (mise en route)* **2** Starting Noise *Bruit démarrage* **1**	Closing door/doors *Fermeture porte/portes* **4** Locking door/doors *Vérouillage porte/portes* **2**	Gearshift *Changement de vitesse* **2**		Blinker on *Mise en route/ Lancement clignotant* **3**	Door sound (opening, lock, case) *Bruit de portières (ouverture, serrure, coffre)* **8** Motor (acceleration, restarting, ...) *Moteur (accélération, démarrage, ...)* **17** Human sounds *Bruits humain* **2** Signals *signaux* **11** Clutch *Embrayage* **1** Others *Autres* **3** Handbrake *Frein à main* **8**
Ob	Purr/roar motor *Ronflement /grondement moteur* **2** Motor *Moteur* **1**	Door *porte* **1**	Reverse gear *Marche arrière /vitesse AR* **5** Clutch *embrayage* **1** Gear Lever *levier vitesse* **2**	Warning *alerte* **2** Radar *Radar* **2** Backward (signal / alarm) *Recul (signal / avertisseur)* **2** Bip (reverse gear/proximity) *Bip (marche arrière/proximité)* **2**	Blinker *Clignotant* **20** Blinker signal *Signal clignotant* **2** Blinker noise *Bruit clignotant* **2** Blinker Clic *Clic clignotant* **1**	
On				bip **6**	tic tac **1**	
Tot	**27**	**7**	**10**	**14**	**29**	**50**

A - Condition 1

Events	Slaming door	Belt (General)	Seat-belt	Hauling seat-belt	Magnetic card	Start button
Ac	Slamming door *Claquement porte/portière* Slammed door *Portière/porte claquée* **20** Closing door *Fermeture porte/portière* Closed door / door closing *Portière/porte fermée/fermerture* **9**	Put on the belt *mettre la ceinture* **2** Attach the belt *attacher la ceinture* **2**	Pulling out/pulled out belt *Déroulement centure /ceinture déroulée* **13** Sliding belt *Glissement* ceinture **1** Friction belt *frottement ceinture* **1**	Interlocking belt *Enclenchement ceinture* **3** Closing belt *Fermeture ceinture* **3** Attached belt *Attachée ceinture* **2** Hanging/hung belt *Accrochage/accrochée ceinture* **2** Locking on belt *Bouclage/blocage ceinture* **2**	introduction/insertion card *introduction/insertion carte* **2** Put in the key *Mettre la clé* **1**	Contact motor *Contact moteur* **1** Starting *Mise en marche/contact démarrage* **3**
Ob	Door / *Portière* **1** Dull Door noise *Bruit sourd de portière* **1**	Seat belt *Ceinture de sécurité* **6** Belt *ceinture* **4**		Fixation belt *Fixation ceinture* **1** Clic belt *Clic ceinture* **1**	key *Clé* **1**	
On				clic **2**		
Tot	**31**	**45** = 14 Belt General + 15 Seat-belt + 16 Hauling seat-belt			**4**	**4**

Events	Engine	Self-locking	Reverse gear	Parking assistance signal	Blinker	Others (no classification Ac/Ob)
Ac	Starting up motor/vehicle *Démarrage moteur/voiture* **22** Motor (on) *Allumage/mise en marche moteur* **2** Starting up gazol (motor) *Démarrage (moteur) diesel* **2**	Closing door/doors *Fermeture porte/portes* **10** Locking *Vérouillage* **1** Locking on door/doors *Bouclage/blocage porte(s)* **2**	Gearshift *Changement/passage enclenchement vitesse* **12** Switching reverse gear *Enclenchement marche arrière* **1** Car moves back *Voiture recule* **2**	Backward *recul* **1**	Blinker on *Clignotant en marche/ fonctionnement/ enclenchement mettre clignotant* **5**	Motor (acceleration, restarting, ...) *Moteur (accélération, démarrage, ...)* **28** Human sounds *Bruits humain* **1** Signals *signaux* **2** Clutch *Embrayage* **4** *Handbrake Frein à main* **2** Others *Autres* **2**
Ob	Motor *moteur* **2** Motor noise *Bruit de moteur* **1**	Doors *portes* **1**	Reverse gear *Marche arrière* **5** Clutch *embrayage* **1**	Signal/warning backward *Signal avertisseur marche arrière recul obstacles* **7** Radar (bakward) *Radar (recul)* **3** Bip backward/radar *Bip recul/radar* **5** Warning sinal *Signal d'alerte* **1** Assistant distancy noise *Bruit d'aide distance* **1**	Blinker *Clignotant* **19** Noise (blinker) *Bruit clignotant* **2**	
On				bip **4**		
Tot	**29**	**14**	**21**	**22**	**26**	**39**

B – Condition 2

Events	Slaming door	Belt (General)	Seat-belt	Hauling seat-belt	Magnetic card	Start button
Ac	Slamming door *Claquement porte/portière* Slammed door *Portière/porte claquée* **22** Closing door *Fermeture porte/portière* Closed door / door closing *Portière/porte fermée/fermerture* **5** Closing door noise *Bruit de portière ferme* **1**	put on the belt *mettre la ceinture* **5**	Pulling out belt *Déroulement ceinture* *Enroulement ceinture* **11** Sliding belt *Glissement ceinture* **3** Friction belt *frottement ceinture* **1** Pulling /pulled belt *Tirage ceinture Ceinture tirée* **2**	Interlocking (belt) *Enclenchement (ceinture)* **2** Closing (belt) *Fermeture (ceint.)* **3** Attaching Attached (belt) *Attachée attachement (ceint.)* **3** Hanging/hung (belt) *Accrochage/accrochée (ceint.)* **2** Locking on (belt) *Vérouillage/fermeture/blocuée (ceint.)* **3** Clic lock *clic emboitement* **1**	insertion card noise *bruit insertion carte* **1**	Contact motor *Contact moteur* **1**
Ob	Door / *Portière* **1**	Seat belt *Ceinture de sécurité* **2** Belt *ceinture* **8**		Clic belt *Clic ceinture* **1**	Card *Carte* **1**	Contact *contact* **1** Bip on/off touch *Bip de touche on/off* **1**
On				clic **1**		
Tot	**29**	**48** = 15 Belt General + 17 Seat-belt + 16 Hauling seat-belt			**2**	**3**

Events	Engine	Self-locking	Reverse gear	Parking assistance signal	Blinker	Others (no classification Ac/Ob)
Ac	Starting up motor/vehicle *Démarrage moteur/voiture* **23** Motor (on) *Mise en marche moteur* **1** Noise of Starting up motor *Bruit de démarrage moteur* **1**	Closing door/doors *Fermeture porte/portes* **10** Locking door(s) *Vérouillage porte(s)* **7**	Gearshift *Enclenchement/passage vitesse* **6** Reverse gearshift *Enclenchement/passage vitesse arrière* **3** Move back *reculer/recul* **2**		Blinker on *Clignotant en marche* **5** Blinker noise (on) *Bruit clignotant mise en marche* **1**	Door opening *Ouverture porte* **1** Motor (acceleration, restarting, ...) *Moteur (accélération, démarrage, ...)* **24** Human sounds *Bruits humain* **1** Signals *signaux* **5** Clutch *Embrayage* **6** Others *Autres* **6**
Ob		Doors *portes* **1**	Reverse gear *Marche arrière* **2** *Gear vitesse* **1**	Backward (signal / alarm) *Recul (signal / avertisseur)* **6** Radar (bakward) *Radar (recul)* **2** Bip (backward, sécurity) *Bip (recul, sécurité)* **4** Noise backward *Bruit déclenchemenent marche arrière* **1** Noise obstacle *bruit obstacle* **1**	Blinker *Clignotant* **17** Clic bip tic tac (blinker) *Clic bip tic tac clignotant* **4** Blinker noise *Bruit clignotant* **1**	
On				bip **6**		
Tot	**25**	**18**	**14**	**20**	**28**	**43**

C - Condition 3

Appendix D

Tables of factor loadings showing the correlations between the VA scales and the factors respectively for condition 1 (a), condition 2 (b) and condition 3 (c). Bold numbers are the values higher than 0.65. They are considered as the lower limit to represent the factors (the factor representatives).

	Factor 1	Factor 2	Factor 3
Pleasant	0.39	−0.08	**0.79**
Annoying	−0.10	0.11	**−0.87**
Loud	0.03	−0.24	−0.52
Harmonious	**0.71**	0.03	0.48
Comfortable	**0.91**	−0.00	−0.07
Reassuring	**0.82**	−0.30	0.16
Complete	**0.67**	−0.25	−0.04
Sturdy	**0.77**	−0.02	0.36
Understandable	0.03	**−0.92**	0.11
Ambiguous	−0.17	**0.78**	0.16
Natural	0.07	−0.47	**0.66**
Immersive	0.27	**−0.83**	0.13

a – Condition 1: factor loadings.

	Factor 1	Factor 2	Factor 3
Pleasant	0.45	−0.04	**0.79**
Annoying	−0.12	0.26	**−0.83**
Loud	0.21	−0.01	**−0.72**
Harmonious	0.44	0.04	**0.65**
Comfortable	**0.80**	0.13	0.07
Reassuring	**0.82**	−0.30	0.33
Complete	**0.67**	0.00	0.50
Sturdy	**0.85**	−0.09	0.05
Understandable	0.07	**−0.92**	0.12
Ambiguous	0.24	**0.82**	0.07
Natural	0.30	−0.08	**0.70**
Immersive	0.32	**−0.74**	0.18

b – Condition 2: factor loadings.

	Factor 1	Factor 2	Factor 3
Pleasant	0.42	0.03	**0.69**
Annoying	−0.18	0.26	**−0.77**
Loud	0.31	−0.05	**−0.71**
Harmonious	0.63	−0.38	0.37
Comfortable	**0.65**	0.03	0.62
Reassuring	**0.85**	0.29	0.03
Complete	**0.76**	−0.18	0.09
Sturdy	**0.83**	−0.28	0.06
Understandable	0.13	**−0.86**	0.08
Ambiguous	0.19	**0.79**	−0.18
Natural	0.29	**−0.71**	−0.06
Immersive	0.56	−0.52	−0.31

c – Condition 3: factor loadings.

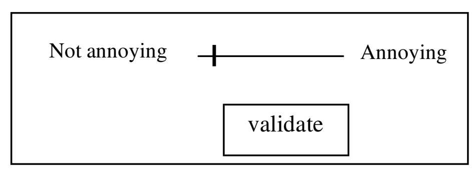
Appendix E

Experimental instructions

E.1. Perceptual experiment of sound vehicles Groups 1, 2, 3

You will listen to sound sequence which lasts roughly 30 s. You task consists of carrying out judgments on this sequence:

1. Identification: after listening to the sequence a first time, you will have to name, in writing, the different events which you have recognized in a simple manner. For example "noun + complement", i.e. if you hear:
   - *Applause*, you could write "clapping hands"
   - *A skid car*, you could write "screeching tyre"
2. Recognition: after a second listen, a list of events is presented on the screen computer. For each event, you will have to indicate if you have well recognized it using a number between 0 and 2:
   - 0: Not recognized at all
   - 1: Hard to recognize (but recognized)
   - 2: Well recognized (without ambiguity)
3. Evaluation: to finish, you will judge the sound sequence on different scales corresponding to the 12 words which we have communicated to you. For example, for the word "annoying", the question will be:
   - "Judge in which proportion you find this sound sequence annoying".



For each scale, you will have to move the cursor relating to your judgment. The sound sequence will automatically be replayed at certain times.

4. A the end of the experiment, a questionnaire will be proposed to you.

Thanks for your participation.

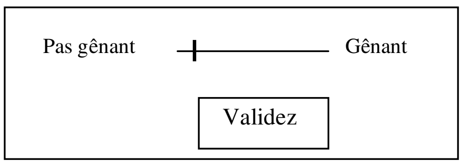
E.2. Expérience perceptive de sons de véhicule Groupes 1, 2, 3

Vous allez écouter une séquence sonore d'environ 30 secondes. Votre tâche consistera à effectuer des jugements sur cette séquence:

(1) Identification: après avoir écouter une première fois la séquence, vous devrez nommer par écrit les différents événements que vous aurez reconnus de la manière la plus simple possible. Par exemple "nom + complément du nom" c'est-à-dire si vous entendez:
   - des applaudissements, vous pourriez écrire: "claquement de main"
   - le dérapage d'une voiture, vous pourriez écrire: "crissement de pneu"

(2) Reconnaissance: puis, après une deuxième écoute, une liste d'événements sonores vous sera présentée à l'écran. Pour chaque événement, vous devrez indiquer si vous l'avez bien reconnu en le notant de 0 à 2, sachant que:
  - 0: Pas du tout reconnu
  - 1: Difficilement reconnu (mais reconnu)
  - 2: Très bien reconnu (sans ambigüité)

(3) Evaluation: pour finir, vous allez juger la séquence sonore sur différentes échelles qui correspondent aux 12 mots qui vous ont été communiqués. Par exemple pour le mot "gênant", la question posée sera: Jugez dans quelle proportion vous trouvez la séquence sonore <u>gênante</u>



Pour chaque échelle, vous devrez déplacer le curseur selon votre jugement. A certains moments, la séquence sonore sera rejouée automatiquement.

(4) A la fin de l'expérience, un questionnaire vous sera proposé. Merci pour votre participation.

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