



# The effects of ambient scent on olfactory comfort and attitude toward its use in a tramway: an on-board study

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## Abstract

Nowadays, cities are increasingly promoting active transportation modes and public transport to reduce car use. In parallel, the management of problematic ambient factors such as the odour in public transport systems is becoming a very important issue due to crowding that is constantly increasing. In this context, in order to contribute to public policies and to reduce olfactory nuisances, we evaluated the effects of ambient scent diffusers on the user experience and their attitude toward the use of such devices in public transport. We collected data among users of the tramway of Montpellier (France). They were questioned on-board about the ambient odour in two different situations. Users answered either in presence (70 users) or absence (97 users) of an ambient scent in the tramway carriage they were in. Our main results show that the presence of an ambient scent increased the pleasantness rating of the ambient odour and attenuated the perception of other odours inherent to public transport (perspiration, food, perfumes, etc.). Furthermore, the user attitude toward the presence of such a device in tramway carriages improved when the ambient scent was present. Thus, ambient scents might be a great tool in order to improve the olfactory comfort in public transport.

**Keywords** Transportation planning · Ambient scent · User experience · Olfactory comfort · Attitude · Tramway

## 1 Introduction

Urban mobility has become a critical challenge for society. As a matter of fact, cities are increasingly promoting active transportation modes (e.g. walking, cycling) and the use of public transport to reduce car use (Bojković et al. 2018; Nordfjærn et al.

2014). The aim is to limit air pollution, noise, accidents and increased traffic congestion due to the growing urban population. However, in parallel with the implementation of these public policies, growing crowding in public transport systems has multiple effects on the user experience and well-being (Haywood et al. 2017; Tirachini et al. 2013). In particular, it has been shown that users experiencing a crowded situation will react emotionally in a way that depends on (1) passenger density (2) the assessment of psychosocial aspects related to the situation (3) the assessment of environmental factors such as noise and odour (Mahudin et al. 2012). The impact of the latter on user comfort has been confirmed recently (Wang and Zacharias 2020). The authors studied the influence of perceived physical and human factors on users' comfort in the Beijing metro. As expected, the results show first that the crowd density has a negative impact on passenger comfort. More interestingly, apart from the fact that the level of perceived passenger density is related to the actual density, noise and odours play a major role in this perception. The authors conclude that it is important to address these two environmental factors in the short term and to deal with increasing crowding in the long term, especially during rush hours.

Managing odours, especially indoors, has been a major problem for centuries (for an historical review, see Spence 2020). Henshaw (2013) identified four different techniques to control and manage the environmental odours in cities. The first technique is called *separation* and it consists in isolating the odour source such as the implementation of smoking rooms or smoking areas in certain places. The second way to manage odours is *deodorisation*. It consists of removing odours by cleaning surfaces or collecting rubbish bins, for example. The third way described by Henshaw is *scenting* or the diffusion of an ambient scent. It aims to improve the olfactory experience by drawing attention to a newly introduced ambient scent. The fourth technique to manage odours is *masking* bad smells by adding an overlaying odour. While separation does not seem to be a technique that can be applied to the odours encountered in public transport, deodorisation is already in application since public transport systems are regularly cleaned. Nevertheless, cleansing only partially solves the bad smells issue and it can do nothing against momentary odours due to the presence of users in the area (perspiration, food, perfumes, etc.).

Consequently, the objective of our study will be to evaluate the effects of ambient scent on the experience of public transport users. In addition, this technique should produce a corollary masking effect that will attenuate the perception of other odours. This is why we wish to evaluate it in this study. Finally, in a prospective manner, we will evaluate users' attitudes regarding the use of ambient scent in public transport. Indeed, certain beliefs towards odours (Herz 2003) or a lack of knowledge regarding their potential consequences on health (Smeets and Dalton 2005) can negatively impact the way an individual will perceive and evaluate them.

In the following sections, we will present relevant works on the use of ambient scents, odour masking and attitudes towards ambient scents. We will then present the variables and hypotheses used.

## 2 Diffusion of ambient scents and masking of bad odours

Since the early '90s, the use of ambient scents has become more widespread (Krishna 2012; Spangenberg et al. 1996). Many researchers demonstrated the effects of ambient scents on a wide range of dimensions and factors (for a review, see Rimkute et al. 2015; Teller and Dennis 2012). Thus, a fragrance can affect behaviour, intentions, evaluations, memory and mood (Roschk and Hosseinpour 2019). Most of these studies address the diffusion of ambient scents in a commercial environment such as stores or shopping malls.

It is important to note that (1) very few scientific publications report on experiments that took place in public transport (i.e. de Lange et al. 2012; Girard et al. 2019; Jacquemier 2001), and that (2) these studies diverge on many points (i.e. the type of technique to control the olfactory environment, the diffusion method, the odour type, the mode of transport, etc.) making it difficult to compare them. Nevertheless, we can assume that they shared the objective of improving user comfort. It should be noted that the studies by Jacquemier (2001) and de Lange et al. (2012) focused on diffusing an ambient scent that evoked the notion of a cleaning product in order to improve the user comfort or perception of his or her environment. In this respect, these studies seem more in favour of a masking technique (i.e. diffusion of a clean odour) used to reduce the negative perception of the environment or the feeling of discomfort by being exposed to bad odours. To our knowledge, only Girard et al. (2019) aimed at diffusing an ambient scent in order to improve the user experience.

The study by Girard et al. (2019) conducted in collaboration with a major German railway company is the first to show that the effects of an ambient scent observed in the short term can be maintained in the medium term and even in the long term, after that the scent has been removed from the train. In their study, the authors demonstrate that the diffusion of an olfactory signature (i.e. a unique fragrance developed to represent the values and message that a brand or place wishes to convey) has a positive impact on the perceived value, the perceived quality, and the perceived experience of the service. Nevertheless, they chose to use a subliminal scent at a concentration below consciousness threshold. This methodological choice actually prevents the authors from questioning their participants on how they experienced this olfactory context. As a result, it is difficult to decide on a proper interpretation of the results observed by the authors. We may think that the diffusion of the olfactory signature actually improved the experience of users about the olfactory environment, which resulted in an improvement in their evaluations. In addition, as the authors stated, it can also be assumed that the olfactory signature masked other odours. As a consequence, it might have decreased the negative experience of users about the olfactory environment and produced the same results on their ratings (e.g. de Lange et al. 2012; Jacquemier 2001). Indeed, in the presence of several odorants in the air, a multitude of interactions can occur (Thomas-Danguin et al. 2017). The introduction of a new odour can completely or partially mask other odours in the environment, but it can also amplify or attenuate their perceived intensity, or even blend with them.

Like white noise that can cover a multitude of different sounds, the more complex a fragrance is (e.g. olfactory signature), the more likely it is to mask a wide variety of odours (Cain and Drexler 1974). Consequently, one of the first objectives of our study will be to clarify this point.

### 3 Users' attitude towards the use of ambient scents

The attitude of consumers and users towards ambient scents and fragrances in general is not clearly established in the scientific literature. A recent online study found that more than half of the respondents would prefer to travel on an aeroplane or stay in a hotel where no ambient scent is released (Steinemann 2016). This mistrust could be due to the fact that individuals are not aware of the consequences of scent diffusion on their health (Smeets and Dalton 2005). In this way, Herz showed that people judge "synthetic" odours to be more dangerous than "natural" ones (Herz 2003). Thus, a belief in the dangerousness of ambient scents, whether proven or not, could lead to a negative attitude towards their use. Nevertheless, studies on the formation of explicit attitudes towards an attitudinal object show that judgements are sensitive to the context (Schwarz 2007). Thus, olfactory management through a diffusion technique can be risky. Even if the primary intention is to enhance the user experience through the diffusion of a scent, it is possible that they try to avoid being exposed to the scent. The second objective of our study is to test whether user attitudes are dependent on whether or not they have been exposed to an ambient scent.

### 4 The current study

This research stems from a current issue (Mahudin et al. 2012; Wang and Zacharias 2020) and aims to clearly establish the link between scent diffusion and user experience with respect to their olfactory environment in a public transport mode. Unlike the study by Girard et al. (2019), we chose to diffuse the fragrance at a concentration level allowing passengers to detect its presence. This choice is in line with a more ethical and transparent approach towards users (Martin and Smith 2008). Furthermore, it will allow us to directly determine both the effects of an ambient scent on user experience and any corollary masking effects. Moreover, this clear positioning could prove to be a key factor regarding the acceptability of a diffusion device in a public transportation and its long-term sustainability (Martin and Smith 2008).

In order to meet our objectives, we designed an experimental protocol allowing us to compare users travelling or not in the presence of an ambient scent. From a methodological point of view and in order to verify that the fragrance was actually diffused at a concentration level that would allow its detection, we expected that some of the users travelling with the fragrance would spontaneously notice it. Furthermore, in order to account for a possible positive effect of the diffusion of an ambient scent on user experience, we chose to study two dimensions of the smell: pleasantness (i.e. also called hedonic tone) and familiarity. The former is undoubtedly the most salient dimension (Ehrlichman and Bastone 1992). Indeed, the perception of an odour is typically

accompanied with an emotional reaction, either positive or negative. This variable will give us a direct feedback on the valence (positive or negative) of the impact of the ambient scent. Furthermore, in order to ensure that pleasantness is not subject to any demand bias, we will investigate familiarity. It is closely linked with pleasantness (Distel et al. 1999). It refers to the concepts of evocation, recollection and similarity. Thus, if an ambient scent is familiar to you, it is either because you already smelled it in the past or because it is pretty similar to another scent you smelled. In any case, this fragrance will share some common features with what it evokes. It has been shown that in the presence of a pleasant scent, individuals produce more joyful memories than in the presence of an unpleasant scent (Ehrlichman and Halpern 1988). This will allow us to indirectly control the effect of the ambient scent on passengers. Specifically, we hypothesise that:

**H1** Users travelling with the fragrance will perceive the ambient odour as more pleasant than those travelling without it.

**H2** Users travelling with the fragrance will formulate more positive evocations than those travelling without it.

In addition, the ambient scent diffused is composed of several naturally occurring (i.e. essential oils) or synthetic molecules (i.e. artificial molecules or identical to nature). It therefore has a strong masking potential (Cain and Drexler 1974). For this reason, we hypothesise that:

**H3** Users travelling with the fragrance will perceive fewer odours (different from the ambient scent) than those travelling without it.

Finally, since an attitude is partly based on a priori beliefs, we predict that:

**H4** Users in the presence of the ambient scent will be more likely to wish to travel with a fragrance in the future than those who were travelling without it.

## 5 Method

### 5.1 Research background

The present research was performed as a part of a project that occurred in the city of Montpellier (France) and consisting in diffusing ambient scents in tramway carriages. This transport network consists of four lines with the characteristic of having been named after the four elements of nature (i.e. earth, water, air, and fire). Each line also has a strong and distinctive exterior visual identity, as shown in Fig. 1. The main objective of the project was to improve the experience of the users by diffusing a unique fragrance in each of the four lines. The project, the four fragrances and the diffusion device were designed and developed by Arthur Dupuy<sup>®</sup>, a company specialised in the design, development and diffusion of unique and custom-made scents (i.e. olfactory signatures).



**Fig. 1** The four lines of the tramway system of Montpellier (photos taken and owned by Olivier Octobre). **A** The first line was named after the element of nature *air*. It is covered with white swallows on a blue background. **B** The second line was named after the element *earth*. It is covered with yellow or green flowers on a red background. **C** The third line was named after the element *water*. It is covered with sea life on a black background. **D** The fourth line was named after the element *fire*. It is covered with baroque patterns on a gold background

## 5.2 The ambient scent pretest

Before performing our study, we had to ensure that the fragrance would be perceived as quite pleasant. Indeed, it was not conceivable to diffuse an unpleasant fragrance in a public transport carriage. The pretest consisted in rating the pleasantness of the ambient scent on an 11-point scale from 0 (very unpleasant) to 10 (very pleasant) and the perceived intensity on a similar 11-point scale from 0 (not at all intense) to 10 (very intense). The 14 participants ( $M=20.6$  years,  $SD=4.6$ ) of the pretest rated the ambient scent as rather pleasant ( $M=7.71$ ,  $SD=1.3$ ) and rather intense ( $M=7.4$ ,  $SD=0.9$ ).

## 5.3 Time 1—Data collection in the scented tram carriage

### 5.3.1 Background

Time 1 data collection took place during the first phase of the diffusion project which aimed to develop the dry fragrance diffusion devices (i.e. device location, quantity of fragrance, time between refills, etc.). The latter were fixed at different airflow exits of the air conditioning system of the tramway carriage. They are made

of a net containing small polymer beads loaded with the scent. They continuously release the fragrance as the airflow exits the air conditioner and goes through them. The fragrance was diffused in one of the 10 tramway carriages running on the line number 4. The diffusion system was set up in February 2018. Users were informed of its implementation via different communication channels: the internet, newspapers and TV. We collected data in May 2018. As we carried out Time 1 data collection before the COVID-19 pandemic, it was not influenced by this tragic episode.

### 5.3.2 The questionnaire

The used questionnaire consisted of only eight questions. It had to be quickly administered, because users usually do not travel over long distances in tramway carriages. We therefore wanted to avoid refusals due to the length of the questionnaire.

Each question is described in detail below.

*Question 1. Spontaneous perception of the presence of the ambient scent.*

Participants were asked to indicate whether they had noticed anything special when they entered in the tram carriage. There were three possible scenarios. In the first case, the user spontaneously perceived the presence of the ambient scent. In the second case, the user did not spontaneously perceive the fragrance and it was the experimenter who revealed its presence. If the user was then able to perceive it, the experimenter continued. In the third case, despite the revelation, the user was unable to perceive the ambient scent. Therefore, the experimenter would abort the survey.

*Question 2. Pleasantness ratings.*

Similarly to the pretest, participants were asked to rate the pleasantness of the ambient scent on an 11-point scale ranging from 0 (very unpleasant) to 10 (very pleasant).

*Question 3. Perceived intensity rating.*

Similarly to the pretest, participants were asked to rate the perceived intensity of the ambient scent on an 11-point scale ranging from 0 (not at all intense) to 10 (very intense).

*Question 4. Spontaneous evocation.*

Participants were asked to indicate what the ambient scent evoked in them.

*Question 5. Perception of other odours.*

Participants were asked if they perceived odours other than the ambient scent.

*Question 6. Travel preference in terms of ambient scents.*

Participants were asked if they would prefer to travel on a scented or unscented tramway.

*Questions 7 and 8. Socio-demographic data.*

At the end of the questionnaire, participants were asked about their gender and age group they belonged to.

## 5.4 Time 2—Data collection in unscented tram carriages

### 5.4.1 Background

The first phase of the project of olfactory signatures diffusion lasted for 16 months, from February 2018 to June 2019. We waited four months before collecting data from users in unscented tram carriages. Indeed, if we had done so while the experiment was running or shortly afterwards, we could not have been confident that the users' answers would not have been influenced by the fact that they had recently taken the scented train or that they were aware of the ongoing experiment. Like the first data collection, the second one took place before the COVID-19 pandemic.

### 5.4.2 The questionnaire

The questionnaire used in the unscented carriages was almost identical to the previous one except that for the first question, the experimenter did not have to mention anything about an ambient scent.

In the following section, we will first compare time 1 and time 2 data using Student tests regarding questions using Likert scales and  $\chi^2$  tests regarding the other questions. We will also complete our results by analysing correlation coefficients between our different factors.

## 6 Results and discussion

Descriptive statistics are summarised in Table 1. We used the free statistical analysis software Jamovi (The Jamovi Project 2019). An alpha significance level of 0.05 was used for all statistical tests.

### 6.1 Samples

It is 167 tramway users that took part in our study. 35.9% of the participants were under the age of 26 years, 13.2% were between the ages of 26 and 34 years, 20.4% were between the ages of 35 and 44 years, 15.6% were between the ages of 45 and 55 years of age, and 15% were over the age of 55 years. The proportion of adults under the age of 26 years may be explained by the numerous university students living in Montpellier. Indeed, in 2016, 31.4% of the city's inhabitants were between the ages of 15 and 29 years (Insee 2016).

Our experimental group consisted of 70 users, called hereafter the scented carriage group. The participants were interviewed in a tramway carriage in which the ambient scent was diffused. The control group consisted of 97 passengers, called hereafter the unscented carriages group and were interviewed on board of an unscented tramway carriages. 16 users of the control group declared that they heard about the scented carriage and five of them declared that they previously travelled on the scented carriage. All participants were randomly selected by the experimenter. They were asked for their



**Table 1** Descriptive statistics

Variable	Modality	Scented carriage group		Unscented carriages group		Total	
		Mean	SD	Mean	SD	Mean	SD
Pleasantness	From 0 to 10	6.99	1.95	5.27	2.18	5.99	2.25
Perceived intensity	From 0 to 10	5.96	2.06	4.35	2.28	5.02	2.32
Variable	Modality	N	%	N	%	N	%
Spontaneous perception	No	46	65.7	96.0	99.0	142.0	85.0
	Yes	24	34.3	1.0	1.0	25.0	15.0
Other odours	No	64	91.4	77	79.4	141	84.4
	Yes	6	8.6	20	20.6	26	15.6
Travel preference	No	7	10	53	54.6	60	35.9
	Yes	63	90	44	45.4	107	64.1
Evocation	Negative	7	10.0	16	16.5	23	13.8
	Positive	22	31.4	2	2.1	11	6.6
	Neutral	5	7.1	6	6.2	24	14.4
	None	36	51.4	73	75.3	109	65.3
Gender	Male	25	35.7	36	37.1	61	36.5
	Female	45	64.3	61	62.9	106	63.5
Age	-26	27	38.6	33	34.0	60	35.9
	26-34	9	12.9	13	13.4	22	13.2
	35-44	15	21.4	19	19.6	34	20.4
	45-55	9	12.9	17	17.5	26	15.6
	+55	10	14.3	15	15.5	25	15.0

consent before the questions were read aloud and the answers collected. Finally, the two groups were equivalent in age ( $p=0.50$ ) and in terms of male/female distribution ( $p=0.85$ ).

## 6.2 Statistical analyses

### 6.2.1 Manipulation checks

**Spontaneous perception and perceived intensity** While 34.3% of the participants in the scented carriage group spontaneously mentioned the presence of the ambient scent when asked if they had noticed anything special in the tramway, only 1% of the participants in the unscented carriages group mentioned that the ambient odour had caught their attention. The difference observed between these two groups is significant,  $\chi^2(1)=35.3$ ,  $p<.001$ . In addition, participants rated the ambient odour in the scented carriage ( $M=5.96$ ,  $SD=2.06$ ) as more intense than the ambient odour in the unscented carriages ( $M=4.35$ ,  $SD=2.28$ ),  $t(165)=4.68$ ,  $p<0.001$ . Finally, concerning the scented carriage group, the estimated correlation coefficient between

the two variables is significant and positive [ $r(68)=0.3$ ;  $p<0.05$ ], as opposed to the unscented carriages group [ $r(88) = -0.02$ ,  $p=0.88$ ]. As we wished, these first results suggest that the ambient scent was sufficiently concentrated in the air for the users to be able to notice its presence in the tramway carriage.

**Gender and age** Regarding socio-demographic factors, we found that only the age group is negatively correlated with the perceived intensity [ $r(68) = -0.27$ ;  $p<0.05$ ] for the scented carriage group. This is in line with the literature highlighting a decline in olfactory capacity with age (Attems et al. 2015; Wang et al. 2005).

## 6.2.2 Data analyses

**Pleasantness and evocations** Regarding pleasantness, participants rated the ambient odour in the scented carriage ( $M=6.99$ ,  $SD=1.95$ ) as more pleasant than the ambient odour in the unscented carriages ( $M=5.27$ ,  $SD=2.18$ ),  $t(165)=5.243$ ,  $p<0.001$ .

Regarding evocations, we first compared the responses of the participants in our two groups according to whether they formulated an evocation or not. We observe a significant difference between the groups,  $\chi^2(1)=29.2$ ,  $p<.001$ . 24.7% of the participants in the unscented carriage group formulated an evocation compared to 48.6% of the participants in the scented carriages group. Thus, almost twice as many participants formulated an evocation in the presence of the ambient scent than in its absence. The fragrance seems to facilitate the formulation of evocations. To better understand and interpret this initial result, we categorised the evocations according to their emotional valence. Participants formulated either (1) a positive-valence evocation (e.g. “flowers”) (2) a negative-valence evocation (e.g. “the toilet”), or (3) a neutral-valence or uncategorizable evocation (e.g. “the classroom”). Again, the observed difference between our two groups is significant,  $\chi^2(1)=19.1$ ,  $p<0.001$ . Among the participants in the unscented carriages group who formulated an evocation, only 8.3% were positive-valence evocations, while 25% were neutral valence evocations, and 66.7% were negative-valence evocations. In contrast, among the participants in the scented carriage group who formulated an evocation, 64.7% were positive-valence evocations, 14.7% neutral-valence evocations, and 20.6% were negative-valence evocations. Therefore, the presence of the ambient scent seems to favour the formulation of positive-valence evocations, whereas in its absence, mostly negative-valence evocations are formulated.

The result concerning pleasantness highlights the fact that the diffusion of an ambient scent that is a priori rated as pleasant in the laboratory is also perceived as being rather pleasant in a tramway carriage. Moreover, this is confirmed by the differences observed in terms of evocation since the presence of the fragrance seems to facilitate the formulation of evocations and more specifically, the formulation of positive-valence evocations. Consequently, these results validate our first two hypotheses.

**Perception of other odours** While only 8.6% of the participants in the scented carriage group reported having perceived at least one odour other than the ambient scent, it concerns 20.6% of the participants in the unscented carriage group,  $\chi^2(1)=7.21$ ,  $p<0.001$ . Thus, this result supports our third hypothesis. The presence

of an ambient scent seems to produce a masking effect. It reduces the chances that passengers perceive other odours in the tramway. Having no control over the presence or absence of odours other than the ambient scent, it cannot be excluded that the observed difference may be due in part to chance. It is possible that fewer odours were present in the scented carriage during data collection.

**Travel preferences: wishing to travel with or without ambient scents** On the one hand, 90% of the participants in the scented carriage group reported their wish to travel in a scented tramway, including 7.14% of participants with no preference and not opposed to the implementation of such set up. On the other hand, only 45.4% of participants in the unscented carriages group reported their wish to travel in a scented tramway. The observed difference between the groups is significant,  $\chi^2(1) = 35.19, p < 0.001$ .

This result confirms our fourth hypothesis. The presence of an ambient scent seems to influence users' explicit attitude towards the presence of an ambient scent in the tramway carriage. It is consistent with the idea that the formation of an explicit attitude depends on the context (Schwarz 2007). Participants in the scented carriage group found the ambient odour more pleasant than those in the unscented carriages group. This indicates a rather favourable context for the formulation of a positive attitude towards the presence of an ambient scent in the tramway.

**Interactions between pleasantness, perceived intensity, perception of other odours, and travel preferences** In order to better understand the interactions between pleasantness, perceived intensity, perception of other odours, and travel preferences, we conducted correlation analyses. We only found significant correlations regarding the scented carriage group. Firstly, pleasantness and perceived intensity are positively correlated with each other [ $r(68) = 0.26; p < 0.01$ ] which is not surprising given the scientific literature on the subject (Distel et al. 1999). The link between these two factors is dependent on the rated odour and cannot be predicted. Secondly, perceived intensity [ $r(68) = 0.39; p < 0.0001$ ] and pleasantness [ $r(68) = 0.54; p < .0001$ ] are correlated with travel preferences. Thirdly, travel preferences [ $r(68) = -0.24; p < 0.01$ ] and pleasantness [ $r(68) = -0.34; p < 0.001$ ] are negatively correlated with the perception of other odours. Thus, we can assume that, in the presence of an ambient scent, the wish to travel with or without ambient scents depends on the pleasantness and the perceived intensity of the fragrance, as well as the absence of perception of other odours.

## 7 Conclusions

The present field research was part of the implementation of the world's first project of ambient scents diffusion in tramway carriages. The company Arthur Dupuy® designed and developed the project, the olfactory signatures and the dry diffusion device set up in the pilot tramway carriage. We carried out the present study during the development phase. Only one environmental factor was manipulated: the presence or absence of an ambient scent in the tramway. The objective was to determine the impact of the diffusion of the fragrance on the user experience and on their attitude towards the use of such a diffuser. In order to collect

the data, we created a short questionnaire that we administered directly on-board tramway carriages. We collected the data at two different moments. At first, only users travelling in the scented carriage were questioned about the ambient odour. At the second time, users were questioned in the absence of the ambient scent.

Unlike Girard et al. (2019), we wanted to ensure that users were able to spontaneously perceive the presence of perfume for two reasons. Firstly, the scientific literature has shown that users' affective reaction in a crowded situation depends, among other factors, on the evaluation of environmental factors (Mahudin et al. 2012). Therefore, it seems necessary that users can consciously process the ambient scent when they evaluate the olfactory environment of the carriage on which they are travelling. Moreover, we wanted this project, intended for the general public, to be part of a more ethical and transparent marketing movement (Martin and Smith 2008). Among users that were asked to participate in the study, very few of them were not able to perceive the ambient scent, even after the experimenter has drawn their attention to the perfume. It was mainly because they were sick or they had another kind of olfactory dysfunction.

Moreover, the results showed that the presence of the ambient scent positively improved the users' olfactory experience (pleasantness, evocations). Due to the number of odorant molecules that make it up, the presence of the fragrance also seemed to reduce the perception of other odours, limiting their negative impact on users. These initial results raise questions about the notion of olfactory comfort in construction and building engineering as formulated in scientific literature. Until now, it was seen as being inseparable from the notion of air quality (Sarbu and Sebarchievici 2011). Olfactory comfort was then at its maximum in the absence of unpleasant and odorous molecules in the air (Henshaw and Guy 2015). However, this point of view does not take into account the fact that a pleasant odour can have an effect on olfactory comfort in an enclosed space. Through the diffusion of an ambient scent that is perceived as pleasant and its masking effects on odours inherent to public transport (perspiration, food odours, perfume, etc.), it seems possible to positively impact the olfactory experience of users and thus improve their olfactory comfort.

The second objective of this research was to study the explicit attitude of users towards the use of ambient scents in tramway carriages. We wanted to determine whether their attitude towards the presence of ambient scents would change if they explicitly stated their attitude in the very presence of an ambient scent. Our results suggest that their attitude was influenced by the presence of the fragrance. This is consistent with the studies highlighting the impact of context on the formation of an explicit attitude towards an attitudinal object (Schwarz 2007). This would mean that an a priori negative attitude towards the presence of an ambient scent would not necessarily reflect what users will think when exposed to an ambient scent on public transit.

Furthermore, a thorough analysis of the correlation coefficients between the main factors (pleasantness, perceived intensity, perception of other odours, and travel preferences) suggests that the presence of the ambient scent guides users' perceptual and attitudinal judgements since, in the absence of ambient scents, we found no significant relationship between these factors. The use of scent diffusers in transport

could then serve to unify the olfactory experience of users and this could in turn help to improve their experience by bringing coherence to it.

In order to facilitate the use of scents in public transport, it is possible to organise and understand the effects of this technique regarding the pyramid of customer needs (Van Hagen and Bron 2014). The latter sorts out the different needs of users that will facilitate their satisfaction and the subsequent adoption of a mode of transport. At the bottom of the pyramid are the fundamental needs of passengers, such as reliability, safety, speed, ease of use, or cleanliness. At the top of the pyramid are the complementary needs of comfort and experience. In this context, the present research has demonstrated the positive effects of the presence of an ambient scent in terms of comfort (i.e. masking of unpleasant odours) and experience (i.e. pleasantness, intensity, unified olfactory experience).

In the future, it would be interesting to extend these results by taking into account crowding, which is an important factor when studying the influence of environmental factors on well-being and comfort in public transport (Mahudin et al. 2012; Wang and Zacharias 2020). We can presume that the diffusion of an ambient scent will help to attenuate the deleterious effects of crowding on users' experience by improving their olfactory comfort. In addition, it would be interesting to use a multiple-item questionnaire. In this way, we would be able to perform a regression analysis and better understand the link between our main factors, although administering a longer questionnaire would not be as easy in tram carriages.

The project that should have been launched in Montpellier—but which was not finally deployed, probably for political and economic reasons—was not solely aimed at improving the olfactory comfort of users. The second objective pursued was to facilitate the identification of the four tramway lines by soliciting the sense of smell. Indeed, on platforms serving several tramway lines, if the audible signage is not working properly or if there is noise in the proximity, visually impaired or blind people are not able to identify which line belongs to the tramway carriage stopped alongside the platform. Thus, by using a unique fragrance for each tramway line, it would be possible to improve the ease of use for blind or visually impaired users by soliciting their sense of smell in order to identify the lines. This system could then contribute to improving social inclusion by promoting the integration of persons with visual disabilities. Naturally, this requires that they are consulted very early in the development process of the ambient scents to ensure that they can be easily discriminated from each other.

Moreover, if the developed fragrances are olfactory signatures, it could be a means of enhancing the positive effects and acceptance of the presence of an ambient scent in public transport by maximising its congruency with the place (Bone and Ellen 1999). Thus, the olfactory signatures developed for the project in Montpellier were intended to be fully consistent with the identity of the tramway lines, which are already strongly marked by their name and external visual identity. Each of the four fragrances had to evoke the element of the line for which it had been developed (see Fig. 1). In addition, the olfactory signatures were intended to be a showcase of the Mediterranean olfactory heritage through the use of odorant molecules present in this region of the world, further reinforcing the congruency between the fragrances and the diffusion location (i.e. the tramway, the city, the region).

Finally, ambient scents might be used in several ways in order to improve public transport planning and operations. If the main objective is to improve comfort or to reinforce the user experience by using an olfactory signature, we may consider permanently diffusing a scent in the carriages of one or more lines, as some airlines already do (Spence 2021). However, we are aware that this type of device, which has to be refilled periodically, can be expensive in the long term. This is why it may be worth considering using it on a one-off or targeted basis. From a marketing and brand image point of view, this type of device might be used in a similar way to a visual advertising campaign. It could also be used on a one-off basis at certain periods of the year such as summer, when unpleasant odours are more noticeable. Another possibility is to implement it on a targeted basis, on busy lines - if its use to mask odours during busy periods proves conclusive. Furthermore, it should be noted that 10% of the participants in the scented carriage group had a negative perception of the added scent. It might be worth considering either reducing the concentration of the scent to determine whether it has an impact on negative evaluations, or scenting only some sections of the carriage, leaving users free to travel without scent if they do not wish to do so.

In conclusion, the study of the diffusion of ambient scents in public transit is still in its early stages and could be an ambient factor of choice to improve the olfactory comfort and well-being of users, to promote social integration, and to help people discover the (olfactory) heritage of a region.

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**Author contributions** LB supervised the study and contributed to the writing of the manuscript. GD and SM supervised the study. IB collected data and contributed to the results analysis. AD and IP designed and developed the apparatus we used in the tram and contributed to the writing of the manuscript. FC designed the questionnaire, collected and analysed the data, and was a major contributor in writing the manuscript. All authors read and approved the final manuscript.

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**Data availability** The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Code availability** Not applicable.

## Declarations

**Conflict of interest** FC, AD, and IP are currently employed by the company Arthur Dupuy®.

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