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Transfers Perception Influence on Public Transport Route Choice

A Case Study of the Parisian Metro

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ABSTRACT

Transfers or connections between lines are a key element of public transport systems. Yet this aspect is not always sufficiently reflected upon, neither on the side of transport infrastructure designers nor on the side of its users. Related to a vast number of variables of multiple kinds, the literature has so far been unable to draw clear and consistent conclusions about the role that each element plays in users' perceptions. This study seeks to identify the factors that are most important for Paris Metro users with regard to transfers. To this end, a survey was conducted based on a real-case trip with 4 alternatives. Two semi-directed interviews were also conducted with two of the survey participants. The study concludes that the most relevant factor for Paris Metro users when it comes to transferring between lines is the time they have to walk between the arrival and boarding platforms. In addition, it identifies several key facts such as that: (i) the vast majority of passengers prefer to make a connection if it allows them to save travel time; (ii) the number of transfers plays a major role; (iii) there is an underlying concern about security conditions in stations; and (iv) a high percentage of users choose *a priori* less favorable transfer options simply to avoid passing through a particular station.

CCS CONCEPTS

• Human-centered computing~Interaction design~Interaction design process and methods~User centered design

KEYWORDS

Transfer, Metro, User Perception, Decision-making, Route Choice.

ACM Reference format:

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1 Introduction

A transfer or connection is a stage in a journey that involves moving from one public transport line to another. In the literature, the associated factors are many and varied, reflecting how difficult it is not only to identify but also to analyze and prioritize them. Transfers are also a highly personal aspect of urban mobility, since the evaluation of a transfer is linked to the conditions of the person and the journey they are making. Given the urgent need to move towards decarbonization and sustainable mobility, it is essential to maximize public transport ridership. This can only be achieved by ensuring the development of a more efficient and user-friendly public transport network. In this regard, understanding users' point of view is essential to improving the design of transfer nodes.

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Users' perception of transfer characteristics can lead to penalties in the evaluation of a connection. This penalty is defined as a loss of attractiveness of a route alternative, associated with one of its characteristics. It could also be associated with a loss of user satisfaction with this alternative.

This study aims to shed light on the factors to which Paris Metro users pay particular attention when defining their itinerary choices. This is a complex subject, the evaluation of which has been addressed in the past by several authors, without clear results. The conclusions drawn by these different studies are sometimes divergent, particularly depending on geographical factors or characteristics specific to the sample studied. Furthermore, the existing literature often focuses on estimating the penalty that a transfer entails in terms of user satisfaction or perceived travel times, without exploring in-depth the causes behind these phenomena.

Therefore, given the little information available about the subject, this study seeks to identify a list of criteria to serve as a basis for future studies. Additionally, it proposes a general hierarchy, keeping in mind that there will undoubtedly be exceptions to this classification, given the multidimensional nature of the subject. Part of the analysis differentiates between all users and those who use the metro at least 3 days a week. Moreover, the influence of gender in the evaluation of connections is also considered.

The objective is not to determine a method for accurately predicting the decisions of users of the Paris Metro, but rather to assist technical designers and policymakers in prioritizing certain characteristics or variables according to the purposes of the intervention they plan to implement.

2 State of the art

Public transport is a sustainable alternative to individual transport. However, it is impossible to design a mass transport network without transfers, which passengers may consider as offloading [3] as opposed to productive travel time [10]. According to Wardman and Hine (2000), a connection requires a physical, cognitive (when having to search to find a transfer) and emotional effort (anxiety about missing your correspondence and fears for your personal security) [16]. Consequently, the way in which users perceive these stages of their trip is crucial to creating transfers that encourage public transport use. Ergonomics has taken little interest in public transport beyond questions of accessibility [15], information systems [9], and the working conditions of transport employees [1]. From the user's point of view, connections have tended to be studied from an economic angle, with the aim of calculating a cost associated with connections.

Connections share a common characteristic: they tend to be negatively perceived by public transport users [7]. Despite this, transfer is preferred when it allows travel time savings or ensures greater reliability in the overall travel time [14]. In the case of metro systems, many users also use connections to avoid crowding, although these decisions may not be sensible in terms of travel time minimization. For this reason, improved transfers can significantly influence the attractiveness of public transport when passengers choose this travel mode [12].

Users' **perceptions of waiting times** when travelling by public transport are influenced by the waiting times objectively observed at the time of travel, as well as by the station and stop amenities [4]. When only one transfer is made, waiting times are perceived more negatively by commuters than in-vehicle and walking times [6]. Unlike riding on board, transfer requires efforts that cannot free travelers for other activities of their choice. Furthermore, travelers may find dealing with transfer a stressful task, which may bias the perceived duration upward [11]. Thus, connecting time passes more quickly because the user feels they are engaging in something more productive than waiting on the platform, but not to a high extent because this time cannot be combined with other activities. However, these relative values change when commuters make two transfers, as walking times are perceived as more onerous [6]. This suggests that the perception of connection characteristics varies according to the number of transfers.

Moreover, according to Li [11], for a constant number of commute stages, it is better to have one stage longer than the others, rather than all of the same duration. If the passenger needs to rest, work, or read a book, for example, it's more practical to plan this longer stage.

Regarding the **number of transfers**, Gris  and El-Geneidy (2019) find no statistical difference in user satisfaction between direct and one-transfer trips. However, satisfaction decreases significantly when users have to make at least two transfers, by 32% compared to single transfer trips [7]. Still, there is no clear consensus among authors. For example, Garc a Martinez et al. (2018) state that the penalty¹ for the first connection is between 15.2% and 17.7%, and it is 22% higher in the case of two transfers [6]. Consequently, a 20-minute non-stop trip would be equivalent to a 23-minute trip with one transfer and a 28-minute trip with two transfers. This difference may be partly explained by the fact that passengers' preferences change from one city to another, due to the different characteristics of transport networks, the configuration of the city or various cultural aspects. It should also be mentioned that a great share of the existing literature focuses exclusively on one-transfer trips, thus pointing out a need for a deeper understanding of travel experiences involving multiple connections [5].

The perception of transfers also varies between **transport modes**. Connections between high-frequency lines affect overall passenger satisfaction less than those involving low-frequency lines. As a result, there is a penalty associated with the connections between bus lines or between bus and metro that affects passenger satisfaction. There is no such penalty in the case of connections between metro lines [7], where users are more time-sensitive and perceive transfers less negatively [12]. Moreover, in the Paris region, transfers to guided modes –

¹ In terms of Equivalent In-Vehicle Time (EIVM).

in particular, the metro– take less time than transfers to bus lines. In the cases analyzed by Yi and Leurent (2022), transfer times do not exceed 10 minutes for the metro [17].

It is therefore crucial to identify which **aspects within the transfer process** have the greatest impact on the perception of users. Crowding [8], intermodality and traveler habits are among the key factors that determine the perceived transfer experience [6]. Likewise, improvements in service frequency and reliability are key to boosting user satisfaction. Studies show that service quality (availability and smooth operation of escalators, comfort, accessibility) has a greater influence on overall satisfaction regarding metro transfers than the ticket fare or direct cost and physical amenities (i.e., signage, shelters, etc.) [12]. It is thus essential to maximize the compactness of connections, minimizing walking distances.

The design of stations also plays a crucial role in the transfer experience, with important criteria such as the number and design of seats, cleanliness [7] and the availability of information.

Considering all of the above, Figure 1 summarizes the factors that, based on the literature, are linked to users' perception of transfers.

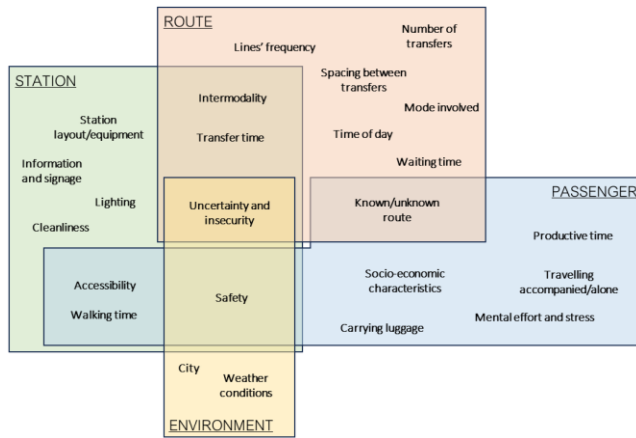


Figure 1: Overview of factors linked to transfers' perception.

For this study, the transfer-related factors identified in the literature will be grouped into three main categories:

- Permanent characteristics of connecting stations, which are specific to the station and do not vary from one moment to the next (number of steps up and down, walking time between arrival and boarding platforms, quality of lighting, number of bends in the corridors, quality of signage, etc.).
- Fluctuating characteristics of connecting stations, which depend on third parties and therefore vary from moment to moment (cleanliness, crowding in corridors or on platforms, whether the real-time information system is active, noise, etc.).
- Journey-specific characteristics (the reason for the journey, the time and day of the week of the journey, whether luggage is carried, whether the user is travelling alone or in company).

3 Methodology

To approach the answer to the research question, the triangulation of methods was adopted [13]. In this case quantitative and qualitative methods were combined. Therefore, the study proposes a between-methods triangulation design [2] in which the results of the methods are cross-validated but above all offer a more complete view of one phenomenon.

The study was limited to the Ile de France region. Only transfers between lines of the same mode were analyzed. According to the literature, the metro is the only mode of transport that does not have a penalty associated with connections. In addition, its average transfer time is the lowest, which allows the other factors to have a comparable importance, whereas for other modes it might seem that users only focus on reducing connection times at all costs, or even avoiding connections altogether. Therefore, it was decided that the study would address the case of the Paris Metro.

Likewise, certain simplifications were made. Firstly, the impact of the existence of escalators was not taken into account because of the uncertainty surrounding their reliable operation. On the other hand, it was considered that no external obstacles prevent the user from making the connection. Only people familiar with the Paris Metro network were included.

In order to determine the factors related to transfers that lead users of the Paris Metro to choose between the route options available during their journeys, the following steps were taken:

1. Selection of a trip as a case study.

2. In situ analysis of the connections in this case study.
3. Survey.
4. Pre-analysis of results.
5. Interviews based on the pre-analysis of the survey.
6. Analysis of results.

3.1 Case study

The selected case study is a trip between Montparnasse-Bienvenue and Danube stations. For this metro trip, Citymapper offers 5 different route alternatives of similar travel time (37-41 minutes). For simplicity's sake, only the first 4 will be considered. The maps of the options under study are shown in Figure 2 with transfers at the following stations:

1. Gare de l'Est and Louis Blanc.
2. Gare de l'Est and Jaurès.
3. Réaumur-Sébas., Arts and Métiers/République and Pl. des Fêtes.
4. Châtelet and Place des Fêtes.

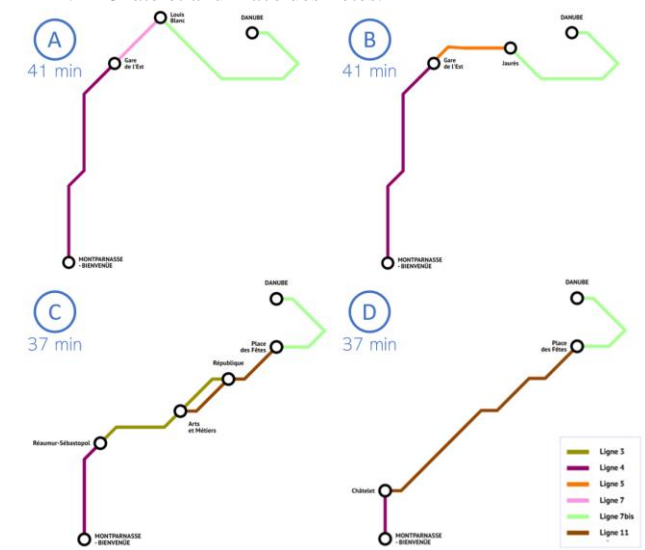


Figure 2: Maps of the route alternatives under study.

Transfer paths have been observed by the authors to record aspects such as walking times, the characteristics of the spaces and environment, the volume of passengers in the stations' facilities, etc. This helps to better understand the analysis carried out and enriches the content of the survey and the subsequent interviews. These observations were carried out on a Thursday morning rush hour, from 8:15 to 10:15 am.

3.2 Survey

The aim was to determine the level of importance and the order of priority of factors in users' perception of connections in the specific case of the Paris Metro. For this purpose, a survey was proposed and transmitted online via ENPC² mailing lists. The sample therefore mainly includes students and professors from this institution.

It was divided into four parts. The first one dealt with travel habits, with the aim of retaining only frequent metro users. The second part evaluated the effect of the presence or absence of connections in the chosen itinerary, their link with travel time, the importance of real-time information and the use of mobile applications. In addition, a hierarchy of the various (i) permanent and (ii) fluctuating characteristics of connecting stations and (iii) journey-specific characteristics was requested. Hereafter, they will be referred to as (i) permanent station characteristics, (ii) fluctuating station characteristics, and (iii) journey-specific characteristics, respectively.

In the third part of the survey, several questions were asked about a real trip in the Paris Metro. The goal was to identify how the following variables affect the decision: trip, walking and waiting times; stages of the journey; station crowding; number of steps up and

² École Nationale des Ponts et Chaussées (Paris region, France).

down at each transfer; and the quality of lighting and signage. To this end, each of the different options proposed was represented by an illustration such as Figure 3.

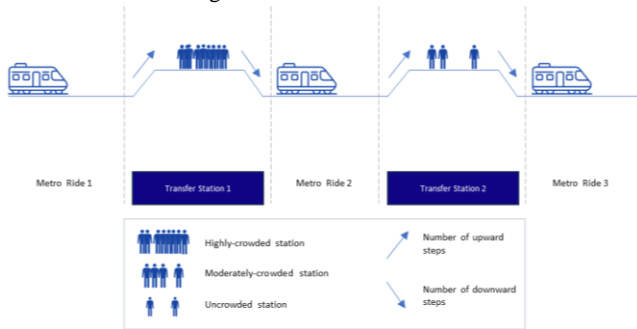


Figure 3: Illustration explaining the characteristics of the proposed alternatives.

Finally, questions were asked about fictitious transfer scenarios. In this case, some questions offered a choice between two apparently unknown options, that were in fact a selection of the alternatives previously described. The aim was therefore threefold: firstly, to compare transfer stations with similar characteristics that had not previously been proposed together; secondly, to analyze the influence of the context of the journey; thirdly, to determine the impact of the preconceived opinions of stations on user's choice.

3.3 Interview and video confrontation

With the aim of further refining the results obtained in the survey, two semi-structured interviews were conducted with two individuals whose responses had been deemed of interest to this study: despite having a similar user profile (they are aged 20-29 years, male, their main metro trip purpose is leisure and they use it less than 3 days a week), their answers were, to some extent, opposed to each other. A deeper analysis of their perceptions was then pertinent. In both cases, the same method and structure were followed, but the questions were adapted to each individual.

1. An opening question to introduce the subject.
2. The second phase was intended to explore in greater detail any interesting aspects or those preferences that did not follow the general trend of surveyed users, as identified from the subjects' responses to the survey. To this end, specific questions were asked revisiting the responses they had given in the survey and assessing if their answers would change depending on the context.
3. The third stage aimed to allow both participants to express their perceptions, feelings, and opinions about transfers. To facilitate this process, they were shown six videos of real rush-hour transfers at Louis Blanc, Jaurès, Châtelet, Réaumur-Sébastopol, République, and Arts et Métiers stations, grouped in pairs. The transfers shown in each pair had similar characteristics, which allowed for a better understanding of the key aspects that the interviewees were particularly sensitive to. They were asked to express their reactions, to verbalize what aspects caught their attention, to choose which alternative they would prefer and to explain why.

On average, the interview lasted 40 minutes, including the video confrontation.

4 Results

4.1 Survey results

A total of 46 complete responses were received. 71.7% of responses were from men, and 95.7% from people aged between 20 and 30 (the remaining 4.3% were over the age of 40).

85% of respondents use the metro every week, the largest group being those who use it between 1 and 3 days a week. 50% of respondents mainly use it for leisure trips, followed by those who use it for professional or study purposes.

Firstly, it can be stated that **most Paris Metro users prefer to make a transfer if it allows them to save time**: 81.8% of respondents prefer a 35-minute journey with one transfer to a 45-minute journey without transfers (15.9%). However, a quarter of the women surveyed would prefer not to have to transfer even if the trip takes longer, which is twice as many as for men.

Respondents were asked to order by importance a set of permanent station characteristics, another group of fluctuating station characteristics, and a set of journey-specific characteristics, as well as to list these three types of characteristics from most to least important. The results were analyzed not only for the entire sample, but also for users who travel by metro more than 3 days a week, to observe how preferences evolve when using the metro systematically.

Regarding the **permanent station characteristics**, there is a certain consensus that the walking time between the arrival platform of the first line and the boarding platform of the second line is the most important factor. Furthermore, even though signage quality is the second most relevant factor for the whole sample, frequent users attach a higher priority to the number of steps to climb and descend: they have less need to rely on signage to find their way around stations.

As for **fluctuating station characteristics**, the ranking order remains the same for the entire sample and for regular users: crowding is the most critical factor (on the platforms and in the corridors, in that order), followed by the availability of real-time information and cleanliness. The importance of noise is quite marginal, ranking far behind the other factors. For the whole sample, crowding on the corridors is much less important than in the platforms; however, this difference is much smaller for regular users. This could be because those users who know their itinerary are interested in moving fast in the corridors and feel less stress when standing on a busy platform knowing that a train is about to arrive.

When it comes to the **journey-specific characteristics**, there is a clear hierarchy for the sample as a whole –luggage carrying comes first, followed by the time and day of the week, and the trip purpose– which does not apply to those who use the metro more than 3 days a week. In the latter group, these three factors are fairly balanced.

To understand how to weigh the preceding information, the importance of each group of characteristics must be determined.

Permanent station characteristics are by far the most important, especially in the case of the most frequent travelers. This suggests that frequent users make long-term route selections so as not to constantly change their itinerary, and therefore unconsciously attach more importance to features that don't change over time. Journey-specific characteristics take second place, followed by fluctuating station characteristics, which are ranked last.

In any case, one fact should be considered when using this information: 82.6% of surveyed users use a mobility application on their smartphones on most of their metro trips, so their choices are at least partially biased. **43.5% use them to estimate the duration of their trips**, and 37% to guide their way when they are not familiar with the itinerary.

In addition, users state that there is certain information that could be precious to know once they are already in transit. There is some degree of consensus on the importance of knowing the time until the arrival of the next train on the line to which one needs to transfer, with more than 67.4% of participants giving it the maximum rating. This is not the case for the level of occupancy on that train, where the largest group rates the utility of having this information 3 out of 5 (32.6%), and there is quite a wide disparity of views: 26.1% rate it 5 out of 5 and 23.9% rate it 4 out of 5.

When comparing route alternatives for a given trip, surveyed users preferred the itinerary with less walking time, better signage, and fewer stairs to climb and descend. Slightly more than a quarter of the participants who chose this option would change their choice if the latter had more steps to climb, which is consistent with the order given to the permanent station characteristics, where the number of steps to go up or down was a factor of intermediate importance.

Moreover, given an alternative with two transfers and another one with three, with both itineraries involving the exact same total travel time, the vast majority (87%) chose the option with fewer connections and fewer steps to climb and descend, despite a considerably higher passenger flow. This seems coherent since, although crowding is the most determinant factor among fluctuating station characteristics, surveyed metro users attach more importance to permanent station characteristics and journey-specific characteristics. Additionally, among the 13% who chose the option with three connections, it can be observed that two-thirds did so to avoid Châtelet station. It is remarkable to find such a **high percentage of passengers choosing an a priori less favorable option simply to avoid passing through a specific station.**

Furthermore, a third question of this kind was proposed, in which a different itinerary with two transfers and a longer total travel time was compared to the aforementioned three-transfer scenario. In this case, three quarters of those surveyed chose the two-transfer option. However, 83% of them would not do so if it also involved a third connection. This suggests that **they prefer the transfer features of the three-transfer alternative, but the fact that an additional connection must be made relegates all these differences to the background.** Similarly, it indicates that what most users seek, at least in this case, is to reduce the number of connections. Thus, the number of connections is, to some extent, more important than total travel time. This is in line with the literature, which shows that the connection penalty increases progressively with the number of transfers made.

When analyzing the fictitious transfer scenarios, there are several conclusions that can be drawn from users' responses, which in some cases may seem surprising. To begin with, two-thirds of those surveyed prefer transfers with fewer bends and better lighting quality, even if they take longer. It should be noted that over 90% of female respondents prefer this option. It can therefore be concluded that, **even though metro users in general are concerned about security conditions, gender plays a role in the appreciation of these types of features.**

Secondly, for home-to-work journeys during the morning rush hour, a large majority (75%) of respondents prefer longer walking times at transfer stations, in exchange for reduced crowding on the platform. This is key to station design, as one might instinctively think that users would prioritize time savings over comfort at peak times, when in fact the opposite is true.

When it comes to journeys to get home after a holiday trip, connections with fewer stairs are prioritized (78% of survey participants state so), even if they require longer transfer times. Luggage carrying is probably the determining factor in this case.

4.2 Interview results

Certain **points of convergence** were identified in the interviews. Both individuals shared a **concern about crowding** in metro stations. Individual 1 expressed a sense of anxiety about the crowds, especially on the platforms, and Individual 2 indicated that he would prefer to make more transfers if it meant avoiding congested stations, which might even lead him to modify his usual schedules and routes to some extent.

As for bends, for both individuals, they were not a determining factor. In their opinion, the overriding aspect in terms of transfers' corridor design lies in the possibility of **making connections with direct paths**, continuous corridors, and few points where they must choose between different routes, because it is at these points where there are crossings between users, which are perceived as inconvenient.

When carrying luggage, especially large suitcases, they would prefer to **minimize the number of connections**, even if this implies a longer journey time.

In addition, the interviewees also shared several **complementary points of view**. For both, **travel time** was one of the main factors to consider when choosing their itinerary. However, Individual 1 was open to prioritizing other routes in certain situations, while Individual 2 prioritized rapidity in all cases.

Moreover, they concluded that **signage** is a very important element for non-routine itineraries. Thus, Individual 1 attached great importance to the immediate visibility of information, while Individual 2 focused on how excessive advertising can interfere with signage, making orientation difficult.

In the case of **lighting**, both individuals stated from the outset of the interview that this was a factor of little influence for them. However, Individual 1's argumentation varied according to the circumstances of the trip, notably whether it is an overnight trip or whether he is alone or accompanied. Individual 2, on the other hand, pays little attention to this element when traveling, regardless of the situation.

To conclude, some **additional points** made during each of the interviews are worth highlighting. For Individual 1, the priority variables were travel time and the number of transfers. However, this preference might be affected by journey circumstances. He also showed a strong **safety concern** regarding overcrowding, which was not envisioned as an issue by researchers in first place. The interviewee placed great emphasis on the combination of platform design and congestion: when platforms are narrow and overcrowded, he described feeling anxious and unsafe.

As for Individual 2, the permanent station characteristics were less decisive in his decision-making process than **fluctuating or journey-specific characteristics**. In addition, he concluded that the time spent inside the train or waiting at the station was not of crucial importance to him. However, this could change if waiting times were to be systematically very long, or if the reliability of the line were to be compromised. He also pointed out that he actively **avoided certain stations**, not because of one single characteristic, but rather in the combination of several unpleasant factors such as excessive crowding, dirtiness, unreliable escalators, and long walking times. All these made stations unattractive even if they allowed saving a few minutes.

5 Discussion

It is manifest that transfers are an elementary dimension of the travel experience of Paris Metro users. Their importance is well reflected in the international literature [12]. The factors that can influence passengers' perception of connections are many and varied. As a result, it is particularly challenging for passengers to establish a hierarchy, and preferences vary greatly from one person to another, from one trip purpose to another or from one time of the day to another.

This study reveals several noteworthy findings. Firstly, most Paris Metro users prefer to make a transfer if it saves them time –81.9% prefer a 35-minute journey with one transfer to a 45-minute non-stop journey. However, this trend is not sustained when additional connections are introduced, with the transfer penalty increasing progressively with the number of transfers made, as identified in the literature [6, 7]. Exceptions to this rule do exist, for example when traveling with luggage: in this case, the users interviewed showed a clear preference for minimizing the number of connections, even if this means a longer journey time, which is in line with the findings of Navarrete (2010).

The results obtained suggest that the average Paris Metro user utilizes the following process when evaluating a transfer between lines: firstly, they take into account the permanent station characteristics, i.e., the walking distance or the number of stairs to climb and descend; secondly, the journey-specific characteristics, i.e., whether they are carrying luggage or not, going to the cinema or to work, or traveling alone or accompanied; thirdly, the fluctuating station characteristics, i.e., the specific situation of that station at that time, in particular the number of people in transit.

Based on the information gathered during the survey and interviews, it emerges that the walking time between the arrival and boarding platforms is the main factor that users think about when making a connection. This would particularly penalize larger stations, such as République or Châtelet. Besides, in the case of regular metro users, the number of steps to climb and descend is also significant. The literature lacks differentiated analyses between the perceptions of all users and regular metro riders, as most studies only consider frequent

travelers. It was thus considered relevant to include all users in the analysis, since a substantial share of all public transport trips are made by people who use these services sporadically but still represent a considerable burden on the system.

Nevertheless, as previously mentioned, the matrix of factors associated with transfers is highly complex. The relationships between the variables by no means add up to a perfectly linear, standardized system, meaning that conclusions must be drawn with caution. Lighting, for instance, is ranked as one of the least significant permanent station characteristics, even by those interviewees who eventually revealed great concern for safety conditions. However, in the case of a night-time journey (a journey-specific characteristic), this becomes a much more decisive factor.

Security conditions are of particular concern to women, with a vast majority (over 92%) preferring a longer journey in which they feel less exposed. On the other hand, the idea of risk in stations, often linked to violent or intimidating acts, includes another aspect centered on accident hazard. This second aspect is barely covered in the bibliography, with very few exceptions [14]. Such accident risk, despite not being initially envisaged by the researchers, was mentioned as a major problem during the interviews and is directly linked to one of the factors revealed as most significant by surveyed users: crowding on platforms.

6 Conclusion and further study

This study aims to identify a list of transfer-related aspects prioritized by Paris Metro users when choosing a route. To do so, a survey was conducted, and two individuals were interviewed.

The analysis presents an additional challenge since users' decisions in favor of one connection over another are not always made voluntarily: the vast majority of users reveal that they use mobility apps to choose their route for at least half of their journeys. This suggests that they do not really make the decisions themselves but are guided by third parties, leaving their preferences "pre-selected".

The results obtained in this study are limited by: (i) the sample size (46 survey respondents and 2 interviewees); and (ii) the homogeneity of the profiles of surveyed users.

It is worth reflecting on the fact that walking time is the most significant factor for users. This contradicts the trend over the last decades of developing ever-larger transport hubs, where it is necessary to walk long distances. It is possible that the results obtained are influenced by the fact that only metro connections are considered: the penalty associated with longer walking times might be mitigated in the case of transfers between different modes, which is beyond the scope of the study. Therefore, the possibility of extending a similar study to connections between other modes of transport remains open for future exploration.

It is also encouraged that future studies on users' perception of mass transport stations include questions not only related to security but also to safety, as it is often overlooked.

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