Finding the Way at Katowice Railway Station: An Eye Tracking Experiment

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Abstract. A wearable eye tracker was utilised to study paths and observation of directional signs at main railway station in Katowice. For the purpose of identifying confusion points due to inadequate signage, the task of finding the railway station from a tram stop, finding train schedule, ticket office, and then platform was assigned to 16 young people who were either familiar or not familiar with the area. No meaningful differences were found between the two groups in terms of time to complete the task and the distance travelled. The simple and logical layout of Katowice railway station made the task easy, which is in stark contrast with prior similar experiment done at Kraków Główny railway station, where the differences were very significant and major confusions were recorded. Approximately 50% of directional signs and displays that were visible to test participants were observed, with no meaningful difference between the two groups, which is similar to the prior experiment. The outcome confirms that simplicity of transportation hub design is critical in minimising confusion amongst passengers.

Keywords: Eye tracker · Passenger · Transportation hub · Railway station · Wayfinding

1 Background

Travelling can be divided into daily commute and occasional travel. While some of the requirements for both types of travel are similar, there are additional needs associated with the infrequent travel. Amongst them is clarity and coherence of information, which can play profound role and increase the joy of visiting [1]. The navigation in an area that may appear simple to local inhabitants is often associated with significant stress for people not familiar with regional specifics [2]. Thus, appropriate signage
presented in a simple and comprehensive manner is critical. In our previous work, done at Kraków Główny railway station, it was demonstrated that inadequate sign locations and complex, apparently illogical, difficult to understand station layout, caused very significant confusions, particularly amongst people not familiar with the area [3]. Subsequent analyses, concentrated on specific areas and signs that solved their conundrums [4, 5], demonstrated weaknesses of directional signage. To confirm that poor design of Kraków Główny layout was responsible for the confusions, experiment was undertaken at equally new railway station, Katowice, but designed in a straightforward and logical manner. Selected parameters of Katowice and Kraków Główny railway stations are provided in Table 1. Both stations are adjacent to shopping galleries as well as coach and bus stations, both are locally accessible with tram and bus public transport. Somewhat smaller size of Katowice station is not believed to have played any role.

Table 1. Kraków Główny and Katowice railway stations.

|                     | Kraków Główny | Katowice |
|---------------------|---------------|----------|
| Year the first station opened (in parentheses: year moved to present building) | 1847 (2014) | 1846 (2012) |
| Number of boarding platforms (in parentheses: number of platforms) [in brackets: number of bypass tracks]
| Number of boarding platforms (in parentheses: number of platforms) [in brackets: number of bypass tracks]
| Daily average number of train departures (in parentheses: long-distance trains)
| Daily average number of train departures (in parentheses: long-distance trains)
| Passengers served annually [6] | 16.0 million | 11.9 million |
| Number of station levels (in parentheses: number of entrances) | 10 (9) | 4 (8) |

*a*In Poland, there is a double numbering (platform – track) of departure locations. Bypass tracks are those that have no boarding platform, serving for manoeuvring and cargo transport.

*b*To account for service frequency other than daily, given are averages from all departures during the current schedule period 14 June-28 August 2020. Note that the ongoing COVID-19 epidemic may have caused cancellation or limited service of some long-distance trains and that due to summer vacation local train operations may have been limited.

The directional signs at railway stations in Poland are blue with white lettering; in addition, there are pictograms and bilingual descriptions (larger in Polish and smaller italicised in English). Features outside of the railway station are identified on white background with blue lettering. In our previous study, major inadequacies in location and visibility of directional signs was noted; their ambiguity and complexity, along with occasional errors, were adding to the confusion. In this work, which is a direct continuation of the effort done at Kraków Główny, the same equipment and analytical protocols were utilised. In addition, previously established sign identification scheme is employed, with the division of signs into directional to station, directional within station, and schedule signs [3]. The presented outcome can serve as a guideline for design engineers involved in planning of transportation hubs. To the best of our knowledge, this is the first assessment of Katowice railway station and first such field comparison of wayfinding between transportation hubs.
Eye tracking is a well-known technique used in many fields [7]. However, it is not frequently utilised for analysis of pedestrians in natural environment. Amongst the paucity of wayfinding field experiments with mobile eye trackers, one must list work done in a busy urban environment associated with recollection of observed objects [8], and navigation with the use of a map [9]. A study that was done at Vienna railway station, which could be considered as comparable to work presented herein was done under laboratory conditions [10].

2 Experiment

All of the data was collected with Tobii Pro Glasses 2 (Tobii AB; Danderyd, Sweden) and processed with Tobii Pro Lab software. The test participants were recruited amongst students of Politechnika Śląska (Katowice, Poland) and Politechnika Krakowska (Kraków, Poland); all of them were volunteers not compensated for their work, natives of Poland, and stated to have uncorrected or corrected 6/6 vision. Based on their claimed knowledge of the railway station, they were divided into test group and control group. The test group comprised 5 people (3 males and 2 females, average age 22.0 ± 0.7 years) while the control group had 11 participants (7 male and 4 female, average age 22.0 ± 1.6 years). Ethical guidelines set by the participating academic institutions were followed at all times and appropriate consent was obtained from the test participants. No meaningful differences between sexes were recorded during the task.

The experiment started at a tram stop located about 150 m from the entrance to the train station. After correct operation of the eye tracking device was confirmed, test participants were instructed (in Polish) “Go from here to the railway station, find a departures schedule, a ticket counter, and at the end enter platform 4.” and allowed to find their way, while research assistants were discreetly following and observing any confusions. The study was performed during daytime, with average flow of passengers and normal railway station operation (e.g. no reconstructions, temporary closures etc.). Queries about the ease of the task and comments related to the station layout and possible difficulties were collected after completion of the task.

3 Results

3.1 Route Selection

All of the test participants, regardless of their knowledge of the area, completed the task effortlessly. The differences between the test group and the control group were marginal, as shown in Table 2 (standard deviations are given in parentheses). There were no issues with finding the way through the shopping gallery before entering the station hall, even though confusions were recorded for all test participants not familiar with the railway station layout (average 25 s, standard deviation 23 s) and for two of the people familiar with the station layout (average 15 s, ± 8 s). This outcome is in stark contrast with measurements from Kraków Główny, where the differences were significant [3].
Layout of Katowice train station and the paths taken by the test participants are schematically provided in Fig. 1. Amongst notable features are location of the station hall at two levels and three tunnels under the tracks. Tunnel 1 provides access to the platforms only with stairs, tunnel 2 with escalators and lifts (except access to platform 4 by lift, which is only from a street at another side of the station), and tunnel 3 with stairs equipped with wheelchair stairlifts. During the experiment, 7 (44%) of the test participants (2 from test group and 5 from control group) selected tunnel 1 (access to platform through stairs) and 9 (56%; 3 from test and 6 from control group) chose tunnel 2 (access to platform through escalator). The choice of tunnel 2 seems to be caused by its location directly ahead of the stairs to level 2; to enter tunnel 1, test participants would have to return a few metres. Nobody selected tunnel 3, quite likely because it was more remote.

Table 2. Selected routes.

| Task                  | Average | Minimum | Maximum | Test group | Control group |
|-----------------------|---------|---------|---------|------------|---------------|
| Route length [m]      | 373 (26) | 338 | 438 | 366 (16) | 377 (29) |
| Time to complete [s]  | 266 (42) | 194 | 357 | 268 (39) | 265 (45) |
| Speed [m/s]           | 1.4 (0.2) | 1.1 | 1.8 | 1.4 (0.2) | 1.5 (0.2) |
| Confusions            | 0.6 (0.7) | 0 | 2 | 1.4 (0.6) | 0.2 (0.4) |

Fig. 1. Schematic map of Katowice railway station and selected routes. Source: Authors.
3.2 Signs Observation

In addition to the route selection, alike the prior study, analysed was observation of signs [3]. In the studied area, the authors counted 124 signs and displays that were visible to the participants, amongst which 62 (50%) were observed at least once. To perform the analysis, the signs are divided into those directing to station entrance (sign category Z), schedule signs (signs category X and Y), and various directional signs within the station (sign category W, V, U, and T).

For the presented outcome, observation distance is the average distance, from which a sign was observed, observation time was calculated from an average fixation time per observation. For the ‘other signs’, provided is average number of observers. Standard deviations are given in parentheses. All of the pictures were taken by the authors. Location of the analysed mentioned signs is shown in Fig. 1.

Entrance to the Railway Station

There were 7 directional signs to the railway station (sign category Z) that the test participants could observe, 2 above the entrance from the street side (identical, 1AZV01* and 1AZV02*) and 5 inside the shopping gallery; 5 (71%) were observed. However, only 3 (19%) of test participants looked at them. Apparently, other test participants assumed, based on the assigned task and the movement of people, that they were on the correct path. Noteworthy is that there are no signs directing to the railway station at the neighbouring streets, which may confuse potential passengers. Moreover, the signs located outside are limited to only large word “entrance” and the indication that it is an entrance to a railway station is provided only through small pictograms. Details are provided in Table 3.

| Sign picture | Sign number | Observers | Observation Distance [m] | Time [s] |
|--------------|-------------|-----------|---------------------------|---------|
| 1AZV01* and 1AZV02* | 2 | 11.6 (9.4) | 0.64 (0.29) |
| All other 3 signs of category Z | – | 1 (-) | 19.0 (5.3) | 1.80 (0.66) |

Schedule Signs and Displays

Amongst 56 train departure schedule signs and displays (signs category X and Y) that were visible to the test participants, observed were 24 (43%): 15 (27%) dynamic (category X) and 9 (16%) printed, static (category Y). The observation times of these signs were quite long in comparison with other signs; in addition, there was a noticeable variations between the shortest and the longest times, as evidenced by large standard deviations. It can be attributed to the presence of both arrivals and departures in one sign, in the same layout, in the same colour, which force the passengers to read
the overhead information first, instead of finding the correct schedule based on other features – comparison of observation times of 1DX01* and 2DX03* confirms this. In case of paper schedules (sign category Y), like 3EY04*, the use of yellow background for departures and white background for arrivals makes it much easier and may eliminate some of the errors. Nonetheless, the paper schedules have other drawback that is discussed below, which is likely to be responsible for long observation periods (0.78-23.75 s) also in this case.

The most prominent schedule display, 1DX01*, clearly visible ahead immediately upon the entry to the station hall, was observed by 14 (88%) test participants, from a distance of 14.3–31.9 m, for 0.26–42.72 s. Similar display above the entrance to tunnel x, 2DX03*, was observed by 8 (50%) of the test participants, for 0.78–16.90 s. A dynamic train departure display, 2CX08*, situated in the tunnel by the entrance to the platform, was observed by 6 (38%) of the test participants; due to its simplicity, observation time was only 0.52–2.82 s. The observed schedule signs are shown in Table 4.

### Table 4. Observed train schedule signs (categories X and Y).

| Sign picture | Sign number | Observers | Observation Distance [m] | Observation Time [s] |
|--------------|-------------|-----------|--------------------------|----------------------|
| 1DX01*       | 14          | 26.7 (5.3) | 11.56 (10.14)            |
| 2DX03*       | 8           | 20.4 (4.3) | 5.41 (4.80)              |
| 3EY04*       | 6           | 2.3 (0.9)  | 14.29 (7.40)             |
| 2CX08*       | 6           | 12.8 (0.8) | 1.60 (1.00)              |
| All other observed 20 train schedules | – | 2 (1.5) | 9.7 (7.1) | 4.31 (5.21) |

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Directional Signs within Station
There were 60 signs of categories W, V, U, and T that were visible to test participants. Amongst them, 32 (53%) were observed by at least one person. Four most frequently observed signs attracted attention of 6–9 (38–56%) test participants; they were observed from a distance of 8.1–19.6 m and the total fixation time per participant varied from 0.60 to 1.82 s. Three of them, directing to the platforms, are located overhead in the tunnels. Surprisingly, two most observed (2CWU08* and 2CWU04*, which are identical, but located in different tunnels) were those informing of platform 3, whereas the wayfinding task called for entering platform 4. Due to station layout, visibility distance of sign 2CWU08*, in tunnel 2 is only 13.0 m, whereas sign 2CWU04* in tunnel 1 has visibility distance of 26.7 m. Hence, the difference in observation distances. The fourth most observed sign, directing to the platforms, is located at the entrance to the tunnel; it is clearly visible from the entrance to the station hall, from a distance of 34.0 m. Summary regarding the most observed directional signs within the station is presented in Table 5.

| Sign picture | Sign number | Observers | Observation Distance [m] | Observation Time [s] |
|--------------|-------------|-----------|--------------------------|----------------------|
| 2CWU08*      | 9           | 10.7 (1.5) | 1.44 (0.66)              |
| 2CWU04*      | 7           | 19.6 (5.8) | 1.82 (0.69)              |
| 2CWVU12*     | 6           | 8.1 (1.8)  | 0.60 (0.35)              |
| 2DU01*       | 6           | 17.7 (12.7)| 0.88 (0.52)              |
| All other observed 28 directional signs within the railway station | – | 14.5 (6.1) | 1.78 (1.62) |

4 Discussion
Feedback from the test participants regarding their wayfinding experience was rather positive, with noted easiness of finding the checkpoints. However, absence of signs directing to the railway station itself was consistently noted (similar complaint was also recorded in case of Kraków Główny: “where is the station?” [3]). Such inefficiency
demonstrates very poor coordination of signage between the city, the public transportation, and the railways station administrators.

As inconvenient the test participants also pointed out the lack of clear schedule information. On the large displays 1DX01* and 2DX03*, only the next 12 trains are displayed – it might be adequate during normal operation, but may be insufficient in case of delays, when some trains could be displayed only occasionally. In addition, with numerous local trains, passengers waiting for a long-distance connection may be unable to easily find information about their departure. The absence of visual differentiation between the arrivals and departures, both shown in in the same layout and colour was already pointed out and seems to be the reason for prolonged observation time; this could be a very significant difficulty for people from other cultures. The use of static schedules, like 3EY04*, could be convenient if the scheduled departures did not change very frequently. An example is given in Fig. 2: a daily train departing at 10:24 is shown as three trains because for the period of 26 days it does not carry a minibar service, during 44 days it does, and during 7 days it does but arrives to four intermediate stations 7 min later. As such, finding the information may be really difficult and always demands detailed readings and understanding of various symbols.

The current detailed departure poster at Katowice contains 146 specific and 38 general endnotes. Amongst the average 176 local and 66 long-distance departures from Katowice during the current schedule period, only 62 (35%) local and 8 (12%) long-distance are daily without schedule modification.

![Static departure schedule showing a daily train separated into three departures with minor differences. Source: Authors.](image)

Amongst highly inconvenient features being a significant barrier for elderly, people with large luggage, and those with reduced mobility is the difference in station levels: level 2 is approximately 1.5 m higher than level 1. Level 2, where the tunnels are
located, is accessible from level 1, where there are ticket sale windows, through stairs, as shown in Fig. 3, but an escalator and an incline are also available. Through such design, mobility of those vulnerable users of infrastructure may be significantly limited. Reason for making this type of complication is beyond our comprehension.

Fig. 3. Station hall. Difference in levels 1 and 2. Source: Authors.

5 Conclusions

The presented results, objectively measured with a mobile eye tracker, clearly demonstrate that relatively simple design of Katowice railway station eliminated the significant confusion that occurred at Kraków Główny. Thus, our hypothesis that straightforward and logical design of a transportation hub eliminates confusion and wayfinding errors was confirmed. Unlike at Kraków Główny, which was described by test participants as resembling a maze, at Katowice the wayfinding task was completed effortlessly. The confirmation came from similar route length and time to complete the assigned task for local inhabitants using the station on everyday basis and people who were there for the first time. Another validation could be the task of locating the ticket counters, which was obvious because of their logical location (one person from the control group signed toward the ticket counters, which was considered as finding them), while in Kraków it was one of the difficulties [5]. Convenient and appropriate location of signs and schedules eliminated search for visual cues amongst incorrect signs: unlike at Kraków Główny, signs pointing to exits were mostly ignored. Katowice station is, however, rather unfriendly for passengers due to multi-level layout of the station hall. It is very likely that repeating such test on an elderly or mobility-impaired test participants would only emphasise the described infrastructural inefficiencies. Outcome of this study should be used by engineers designing transportation hubs and signage.

Amongst easy to implement and inexpensive improvements, installation of appropriate signage directing to the railway station at the local public transportation stops is proposed. In addition, differentiation in layout and colour between the arrivals
and departures at the dynamic schedule displays may be highly advantageous and easy to accomplish – simple reversal of colours and layout (arrivals on white background instead of blue) may be sufficient. At the planning stage, removal of obstacles in form of unnecessary levels of transportation hubs should be mandatory to furnish appropriate and equal access to infrastructure and services and thus improve quality of life for everyone [11, 12]. Furthermore, even though it was not analysed herein, double numbering of the departure location (i.e. platform – track) may be confusing and incomprehensible for foreigners; simpler and more effective would be furnishing just the track number.

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