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How train station name signs should be installed



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ABSTRACT

The legibility of train station name signs was analyzed with parallel (0°) and perpendicular (90°) installations regarding different speeds, different lateral offsets, and different widths of the signs. The theoretical analysis resulted in the superiority of perpendicular installations for short lateral offsets from the platform edge (3 m), and a superiority of parallel installations for large offsets (50 m). Sign width effected legibility nearly proportionally, higher speed reduced legibility inversely proportional. In the empirical part, the superiority of the perpendicular installation at short lateral offsets was supported. From a moving train, legibility of perpendicular signs is superior while during a full stop, parallel installations are advantageous. Thus, as a compromise, parallel installations should be used within the inner circle of a train station while at the entry and exit where trains are still moving, perpendicular signs should be preferred.

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1. Introduction

Train station name signs are important aids for better way finding. Particularly those railway passengers who travel to unknown places would like to be informed when the destination station is approaching. Stopovers at some stations are short and there may be not enough time to collect the luggage in the very last moment. Thus, train passengers need to be informed timely. Consequently, station name signs should not only be legible from a stationary position, however, they should be detectable and legible from a moving train as well.

Some research articles and reports are available regarding the usability mostly of on-premise signs (Bertucci, 2003; Garvey, 2006; Zineddin et al., 2005). Research has been done on size (Bertucci, 2006; Forbes and Holmes, 1939), color, and font of destination signs. It has been found that the maximum distance from which the names still can be read is 30 times the height of the capital letters of the name of the place (Arthur and Passini, 1992). As a result, most of these names are written in a font with a height of about 15 cm–30 cm, which makes the sign still readable at a distances of about 50 m and more (1 inch = 2.54 cm, 1 m = 3.28 feet). As well, the effects of the driving speed of cars (Bertucci, 2003) have been evaluated, as has the effect of parallel or perpendicular installation of the signs (Zineddin et al., 2005). In most of these cases, the signs could be viewed through the front window of cars. However, train passengers cannot look out of the front but only through the side window, and the window frame reduces the maximum distance for readability if one does not flatten one's nose at the windowpane.

Regulations for signage of station names mostly concern type fonts and letter size (FIS (Switzerland), n.d.; "Informations-und Wegeleitsystem (ÖBB Austria)," n.d.). Only one regulation was found regarding parallel or

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perpendicular installations. In 1930, a German provision recognized that parallel station name signs are less readable from fast moving trains and thus, some signs should be installed in a perpendicular way as well. These perpendicular signs should be mounted at the ends of the station platform and parallel signs in between (Naweba, 1930: §4). An older perpendicular and a more recent parallel example can be seen in Frankfurt (“Frankfurt perpendicular,” n.d.; “Frankfurt parallel,” n.d.). In Austria as well, it seems that in the recent past, parallel installations were preferred although there are examples of older perpendicular signs. A simultaneous installations can be seen from “Spittal” (n.d.). In Austria and Germany, however, parallel mountings seem to be more common these days. An exception is Switzerland where both parallel and perpendicular installations can be found frequently (“Rothenbrunnen parallel,” n.d., “Rothenbrunnen perpendicular,” n.d.).

These examples demonstrate the awareness of the installation problem, however, a thorough investigation has not been done yet. The contribution of this research note is the analysis of the legibility and readability of station name signs from moving trains with due regard to the installation angle. Both theoretical and empirical studies have been conducted. At the beginning, results from a survey in Germany regarding the importance of station name signs are reported. Thereafter, a mathematical analysis tries to find optimal solutions theoretically. Finally, results from the same Germany survey regarding legibility and readability of different sign installations will be presented.

2. The importance of station name signs

In a German online survey conducted in 2012, respondents were asked several questions regarding trains and train station name signs. A well-known German provider (promio.net) invited 5000 members out of his panel consisting of 150,000 consumers by emails. Panel members were distributed according to the demographic structure of Germany across gender, income, regions, and age. In total, 767 respondents participated (39.5% female, $M_{Age} = 43.7$ years, $SD_{Age} = 12.7$ years). Only 10% stated never to travel by train. Most of the others found station name signs important and looked out for them. According to their opinion, such signs could hardly be replaced by train crew messages or navigation tools on smartphones. Although only few stated that they had ever missed a station because they had overlooked that it was their destination, passengers occasionally did not know the name of the next station. Hence, station name signs are indispensable and they have to be legible from a moving train. If the signs are only legible in a stationary position and in case this station is the destination, it may be too late to collect the luggage and to leave the train in time. Distribution of answers can be seen from Fig. 1.

3. Theoretical model

The situation under investigation in this study is a passenger sitting near the left edge of a window facing the engine. Results will be valid for passengers with one's back to the engine as well, using reverse calculations. Fig. 2 depicts the situation assuming a passenger sitting facing the engine at a distance of 0.15 m from the left side of the train window having a width of 1.4 m, looking in the direction of a station name sign positioned at a lateral offset of 3 m from the embankment. It can be seen that the view is blocked due to the window frame, and detectability of the sign starts at around a 30-meter distance with a viewing angle of about 6°.

Fig. 3 shows the installation of a sign on an island platform.

As can be seen in Fig. 4, the tangent of the projection angle γ causes the sign to be depicted on the observer's retina, and thus the size of γ determines the visibility. The size of γ is the difference of the angle between the viewing directions toward the left (α) and right (β) edge of the sign. As has been discussed in the literature, signs can be installed parallel or perpendicular to the direction of traffic (Zineddin et al., 2005). Intermediate angles as depicted in Fig. 4 have not yet been analyzed.

The projection angle γ , however, is not the only determining measure for legibility. Because the train moves, the angular velocity increases during approach toward the sign, which leads to an inferior legibility. The angular velocity is defined as $\omega = \text{speed}/\text{radius}$.¹ The radius can be approximated by the linear distance from the observer to the sign's midpoint, according to the Pythagorean theorem. Thus, $\omega = \frac{v}{\sqrt{d^2 + b^2}}$.

As shown in Fig. 1, legibility starts at about 30 m from the sign. The decreasing size of the afterimage of the picture depending on higher distances can be neglected due to Emmert's law of size constancy (Boring, 1940; Edwards and Boring, 1951; Nakamizo and Imamura, 2004). Although the afterimage of a person at a distance of 30 m is much smaller than the one at only 3 m, the human visual system corrects for the distance, and the objects are perceived as equal in size. Thus, the legibility defined as the projection angle divided by the angular velocity is calculated for two situations:

¹ Correctly, the speed should be the orbital velocity on the circular path around the pivot which is only a component of the train speed v , defined by the sine of the viewing angle $\left(\overline{v} = v \cdot \sin\left(\frac{\alpha + \beta}{2}\right)\right)$. With longer distances, however, viewing angles are small and the sines are small as well. Thus, with this value in the denominator, the legibility will be overestimated for longer distances (see Equations (1) and (2)). Additionally, it is the train speed itself that diminishes legibility (with a speed of 100 km/h, the train passes 30 m within a bit more than a second, with only 10 km/h, more than 10 s remain to read the sign). For parsimonious reasons, the inclusion of an additional orbital speed was omitted. This means no disadvantage for short distances since there, the sine approaches 1 and the orbital velocity approaches v .

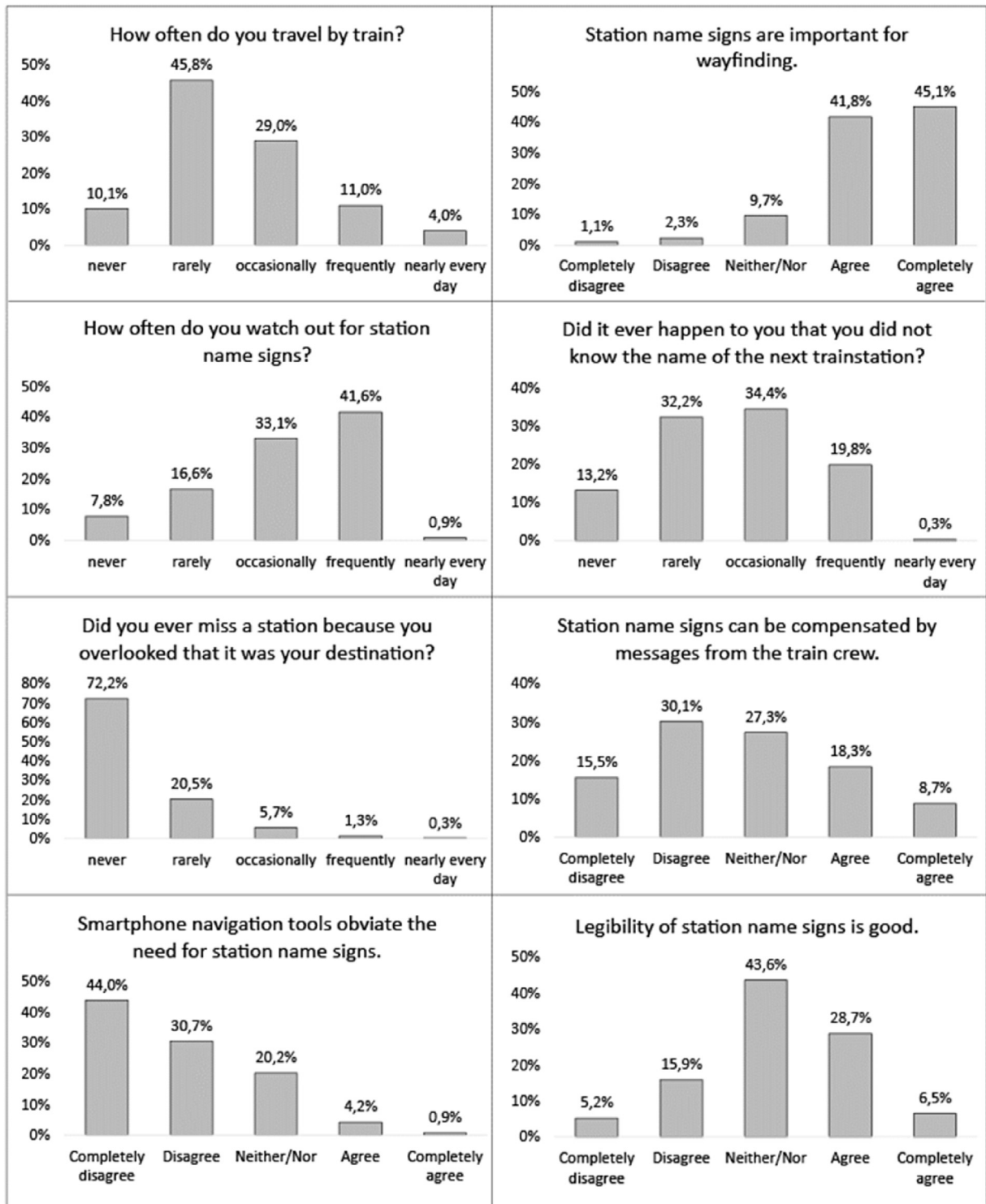


Fig. 1. Statements regarding trains and station name signs.
Source: Own survey conducted 2012

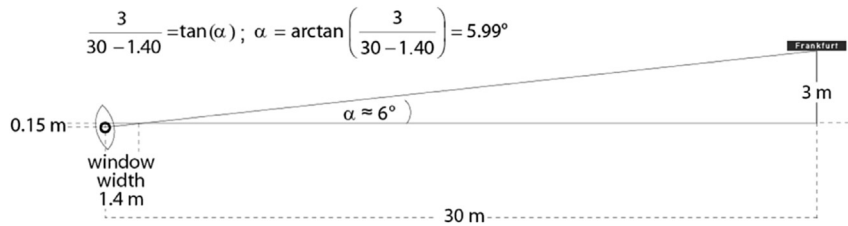


Fig. 2. View out of a train window at a station name sign.

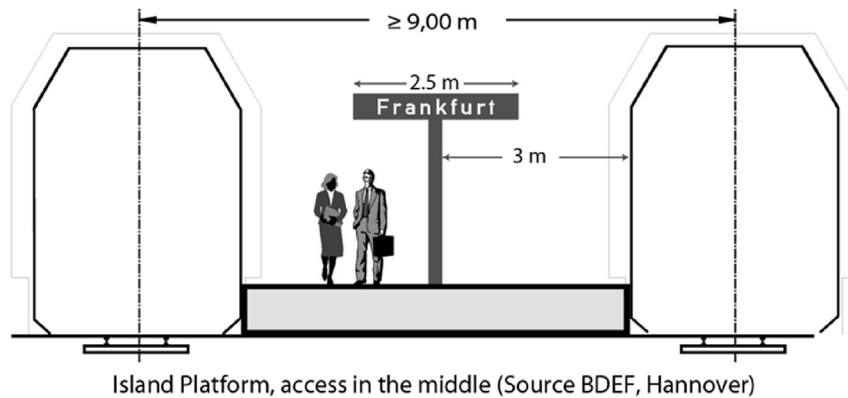


Fig. 3. Example of a 90° (perpendicular) installation.

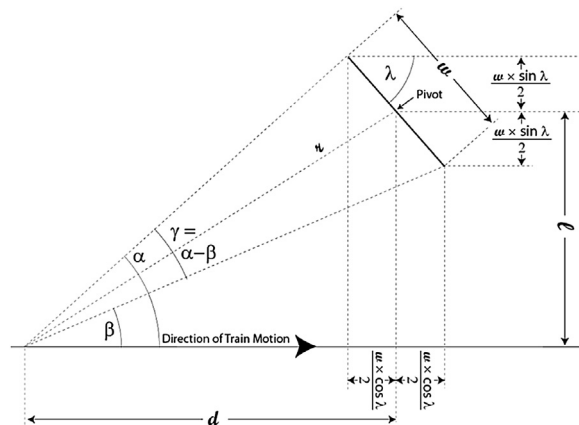


Fig. 4. Schematic of railway-station name sign installation and projection angle.

Note: γ = projection angle; d = distance from observer to station sign; l = lateral offset of sign midpoint; w = width of station sign, λ = angle against direction of motion, r = radius.

(1) Before passing the sign:

Interval from $+30m \rightarrow +\frac{w \cdot \cos \lambda}{2}$:

$$\text{Legibility} = \frac{\arctan \left[\frac{l + \frac{w \cdot \sin \lambda}{2}}{d - \frac{w \cdot \cos \lambda}{2}} \right] - \arctan \left[\frac{l - \frac{w \cdot \sin \lambda}{2}}{d + \frac{w \cdot \cos \lambda}{2}} \right]}{\frac{v}{\sqrt{d^2 + l^2}}}$$

After reaching the sign, it is assumed that the observer is able to recognize it just abeam of the left window frame, which is an angle α of 90°. The second interval after passing the sign ends where the sign's right edge is just abeam the passenger and thus cannot be seen anymore. This point is at $-w/2$ m in the case of a parallel installation (just half the width of the sign), at

0 m in the case of a perpendicular installation (left and right edge are in the same lateral position), and at $-(w \times \cos \lambda)/2$ m in the case of an installation with an angle different from 0° or 90° .

(2) Abeam sign:

$$\text{Interval from } +\frac{w \cdot \cos \lambda}{2} \rightarrow -\frac{w \cdot \cos \lambda}{2};$$

$$\text{Readability} = \frac{90^\circ - \arctan \left[\frac{l - \frac{w \cdot \sin \lambda}{2}}{d + \frac{w \cdot \cos \lambda}{2}} \right]}{\frac{v}{\sqrt{d^2 + l^2}}}$$

Legibility functions can be seen for various installations in Fig. 5.

Observers' accrued legibility can be calculated as the sum of the definite integrals over the two intervals. Because the integral is highly complex, the definite integrals were calculated numerically by use of appropriate software (Table 1).

The question whether the sign should be installed in a parallel or perpendicular orientation cannot be answered definitively. The answer depends on the lateral offset. When this distance is short, a perpendicular installation is superior. For larger offsets, legibility is better for a parallel offset. An angled position ($\lambda = 65^\circ$ for short offsets and $\lambda = 25^\circ$ for large offsets) even increases legibility. The relation between legibility and lateral offsets from 3 m to 50 m regarding parallel or perpendicular installation can be seen in Fig. 6.

For the width of the station name signs, the effect is approximately proportional:

$$\int f(w_2) \approx \frac{w_2}{w_1} \cdot \int f(w_1).$$

As an example, the legibility integral for a situation with a sign width of 2.5 m, a lateral offset of 3 m, a speed of 10 km/h, and an installation angle of 45° is 6.39. Thus, the integral for a sign width of 4 m is $4/2.5 \times 6.81 = 10.23$.

As can easily be seen from the formulas for the projection angles, the speed v has a reciprocal proportional effect. For two speeds v_1 and v_2 holds:

$$\int f(v_2) = \frac{v_1}{v_2} \cdot \int f(v_1).$$

As an example, the legibility integral for a situation with a sign width of 2.5 m, a lateral offset of 3 m, a speed of 10 km/h, and an installation angle of 90° is 6.81. Thus, the legibility integral for a speed of 50 km/h is $10/50 \times 6.81 = 1.36$.

4. Empirical analysis

As a proof of concept, an empirical study was conducted within the same survey as mentioned above. Different installations were tested with different speeds, different sign widths, and two signs for towns with differing long names. Field research in an environment with real trains would have been too demanding. Furthermore, an online study with computer videos was planned. Such videos are unable to render more than 25 frames per second. In this way, videos from shots in a real

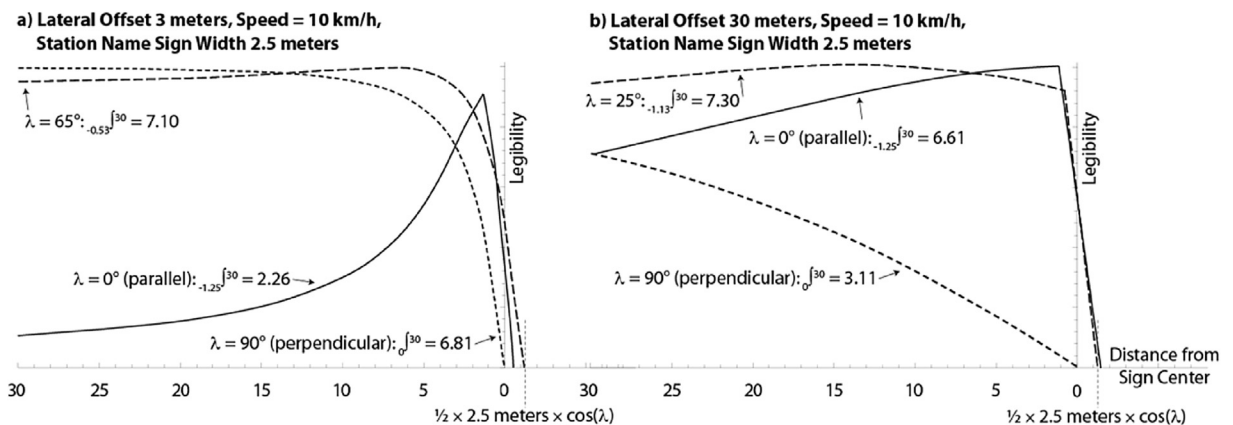
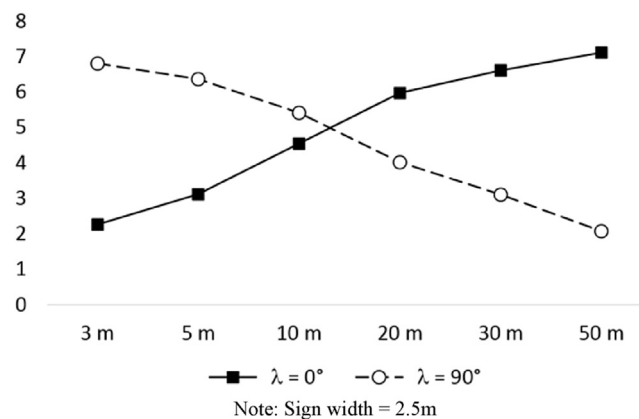


Fig. 5. Legibilities depending on lateral offset and installation angle.

Table 1

Legibility for several sign widths, lateral offsets, speeds (km/h), and installation angles.

Installation angle ($0^\circ \equiv$ parallel; $90^\circ \equiv$ perpendicular)								Installation angle ($0^\circ \equiv$ parallel; $90^\circ \equiv$ perpendicular)							
Width w	Lateral offset l	Speed v	$\lambda = 0^\circ$	$\lambda = 25^\circ$	$\lambda = 45^\circ$	$\lambda = 65^\circ$	$\lambda = 90^\circ$	Width w	Lateral offset l	Speed v	$\lambda = 0^\circ$	$\lambda = 25^\circ$	$\lambda = 45^\circ$	$\lambda = 65^\circ$	$\lambda = 90^\circ$
2.5	3	10	2.26	4.91	6.39	7.10	6.81	4	3	10	3.65	7.89	10.23	11.38	10.95
2.5	3	20	1.13	2.46	3.20	3.55	3.40	4	3	20	1.83	3.94	5.11	5.69	5.48
2.5	3	50	0.45	0.98	1.28	1.42	1.36	4	3	50	0.73	1.58	2.05	2.28	2.19
2.5	3	70	0.32	0.70	0.91	1.01	0.97	4	3	70	0.52	1.13	1.46	1.63	1.56
2.5	3	100	0.23	0.49	0.64	0.71	0.68	4	3	100	0.37	0.79	1.02	1.14	1.10
2.5	5	10	3.12	5.51	6.69	7.08	6.37	4	5	10	5.01	8.83	10.71	11.33	10.22
2.5	5	20	1.56	2.76	3.35	3.54	3.18	4	5	20	2.51	4.41	5.36	5.67	5.11
2.5	5	50	0.62	1.10	1.34	1.42	1.27	4	5	50	1.00	1.77	2.14	2.27	2.04
2.5	5	70	0.45	0.79	0.96	1.01	0.91	4	5	70	0.72	1.26	1.53	1.62	1.46
2.5	5	100	0.31	0.55	0.67	0.71	0.64	4	5	100	0.50	0.88	1.07	1.13	1.02
2.5	10	10	4.55	6.40	7.04	6.82	5.41	4	10	10	7.28	10.25	11.26	10.92	8.68
2.5	10	20	2.27	3.20	3.52	3.41	2.71	4	10	20	3.64	5.12	5.63	5.46	4.34
2.5	10	50	0.91	1.28	1.41	1.36	1.08	4	10	50	1.46	2.05	2.25	2.18	1.74
2.5	10	70	0.65	0.91	1.01	0.97	0.77	4	10	70	1.04	1.46	1.61	1.56	1.24
2.5	10	100	0.45	0.64	0.70	0.68	0.54	4	10	100	0.73	1.02	1.13	1.09	0.87
2.5	20	10	5.97	7.11	7.06	6.17	4.02	4	20	10	9.56	11.37	11.30	9.87	6.44
2.5	20	20	2.99	3.55	3.53	3.08	2.01	4	20	20	4.78	5.69	5.65	4.94	3.22
2.5	20	50	1.19	1.42	1.41	1.23	0.80	4	20	50	1.91	2.27	2.26	1.97	1.29
2.5	20	70	0.85	1.02	1.01	0.88	0.57	4	20	70	1.37	1.62	1.61	1.41	0.92
2.5	20	100	0.60	0.71	0.71	0.62	0.40	4	20	100	0.96	1.14	1.13	0.99	0.64
2.5	30	10	6.61	7.30	6.87	5.61	3.11	4	30	10	10.57	11.68	11.00	8.99	4.98
2.5	30	20	3.30	3.65	3.44	2.81	1.55	4	30	20	5.29	5.84	5.50	4.49	2.49
2.5	30	50	1.32	1.46	1.37	1.12	0.62	4	30	50	2.11	2.34	2.20	1.80	1.00
2.5	30	70	0.94	1.04	0.98	0.80	0.44	4	30	70	1.51	1.67	1.57	1.28	0.71
2.5	30	100	0.66	0.73	0.69	0.56	0.31	4	30	100	1.06	1.17	1.10	0.90	0.50
2.5	50	10	7.11	7.32	6.50	4.89	2.08	4	50	10	11.37	11.72	10.40	7.83	3.33
2.5	50	20	3.55	3.66	3.25	2.44	1.04	4	50	20	5.69	5.86	5.20	3.91	1.66
2.5	50	50	1.42	1.46	1.30	0.98	0.42	4	50	50	2.27	2.34	2.08	1.57	0.67
2.5	50	70	1.02	1.05	0.93	0.70	0.30	4	50	70	1.62	1.67	1.49	1.12	0.48
2.5	50	100	0.71	0.73	0.65	0.49	0.21	4	50	100	1.14	1.17	1.04	0.78	0.33

**Fig. 6.** Readabilities across lateral offsets and installation angles.

environment are not better than those of a virtual reality. Thus, a laboratory test situation in a scale of 1:30 was set up with a model railroad recording the train rides as movie files which could be presented in an online study. The signs were prepared for two German cities, “Frankfurt” with nine characters and “Mönchengladbach” with 15 characters (Figs. 7 and 8). Whereas Frankfurt is one of the three best-known German cities, Mönchengladbach is quite famous because of a successful nationwide

**Fig. 7.** Station name signs.

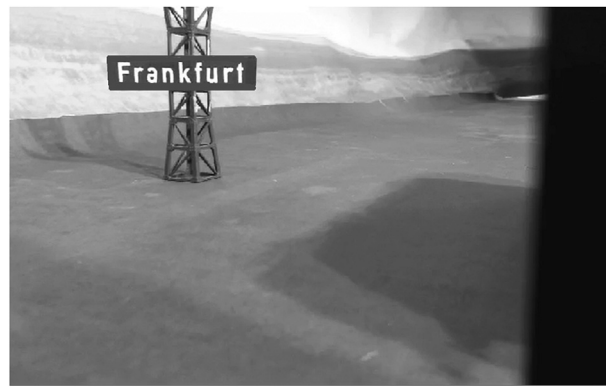


Fig. 8. Sequence from the video.

soccer team. Station signs were designed as models with a width of 2.5 m and a height of 0.26 m for the capital letters. Type fonts from the DIN 1451-family were used. These fonts are regularly used for technical, traffic and station name signs. Frankfurt was written in “Alte DIN 1451 Mittelschrift” and Mönchengladbach, since the name is much longer but has nevertheless to fit on the board, in the condensed “DIN 1451 Engschrift”.

Train speeds were simulated at 20, 70 and 100 km/h. To create the best quality digital film, the train rides were filmed at a simulated speed of 5.75 km/h. The files were then converted to higher speeds by film editing software. Station name signs were located in a simulated 5-meter distance in parallel (0°), perpendicular (90°) and 65° positions. Videos were also prepared for an offset of 30 m. The quality, however, was not sufficient due to only low resolutions for the small sign images. Consequently, the larger offset was not included in the study. The lengths of the periods during which the signs were visible corresponded nearly exactly to the theoretical times for an assumed 30-meter distance. A speed of 20 km per hour (km/h) represents 5.56 m per second (m/s), and the length of the visibility period was 5.4 s (similarly for 70 km/h with 19.44 m/s and a visibility length of 1.51 s, and for 100 km/h with 27.78 m/s and a length of 1.11 s).

This design resulted in a $2 \times 3 \times 3$ full factorial between subjects design with 18 stimuli (2 city names $\times$ 3 installations $\times$ 3 speeds). The videos were presented to survey participants online who were asked to write the city name in an open question field when they were able to read the sign. Only two videos were shown to every participant in order to avoid learning effects (one film per city with randomly chosen speed and installation).

Results are reported in Table 2. At the slow speed of 20 km/h, almost all participants could read the signs. The higher the speed, the lower was the readability. Frankfurt, with only 9 characters, was more readable than Mönchengladbach with 15 characters. The latter, however, is not only due to the number of characters but also to the condensed type font.

An analysis of variance (ANOVA) resulted in a significant effect of the city name ($F(1,1422) = 183.244$, $p < 0.001$) with 86% correct answers for Frankfurt and 58% correct answers for Mönchengladbach. The different installation modes were significant ($F(2,1422) = 4.876$, $p < 0.01$) with 68% correct answers for a parallel installation and 74% and 75% for a perpendicular and 65° installation, respectively. Speed was significant for legibility as well ($F(2,1422) = 122.376$, $p < 0.001$) with only 53% for a speed of 100 km/h, 73% for 70 km/h and 92% for 20 km/h.

Data was used to perform a logistic regression with the correct answers (yes/no) as the dependent variable. The three installations were used as factors. Additionally, the speed and the number of characters were added as predicting variables. Table 3 shows coefficients, significances, and odds ratios.

Compared to the parallel installation, perpendicular and 65° attachments improved readability significantly. The effects can be demonstrated with the odds ratios. Assuming that in a train with 100 passengers there are 50 who can read the station name sign vs. 50 who cannot in a parallel situation (i. e., an odds ratio of 1), this number increases significantly to 61 vs. 39 in a perpendicular situation (odds ratio $61/39 = 1.56$). With a 65° attachment, this ratio increases to $62/38 = 1.63$. The latter, however, is not significant.

As Table 3 shows, speed reduces the legibility significantly. For every km/h increase in speed, the odds ratio is reduced by the factor 0.967. This means that for a speed of 70 km/h the odds ratio is only 18.7% of the ratio for a speed of 20 km/h (=

Table 2
Percentages of correct answers.

Speed	Frankfurt			Mönchengladbach		
	Parallel	Perpen-dicular	65° angle	Parallel	Perpen-dicular	65° angle
20 km/h	94.5%	90.7%	91.7%	92.6%	89.3%	93.4%
70 km/h	80.2%	93.7%	93.8%	58.4%	40.7%	34.2%
100 km/h	69.6%	81.5%	80.2%	26.3%	30.0%	25.9%

Table 3

Coefficients, Significances and Odds ratios of the logistic regression.

	Coefficients	Significance	Odds ratio
Parallel	0		1
Perpendicular	0.432	0.009	1.540
65° angle	0.491	0.003	1.635
Speed (km/h)	−0.034	<0.001	0.967
Number of characters	−0.357	<0.001	0.700

0.967⁵⁰). Similarly, the number of characters reduces legibility. For the difference of six characters between the two town names, this results in a reduction of the odds ratio to 0.18. This, however, is also due to the narrower font.

5. Discussion, Conclusion and Limitations

One result from this study is unambiguous: an intermediate angled installation between 0° and 90° degrees does not strongly improve legibility. This can be seen from the analytical numbers in Table 1 and was confirmed by the insignificant difference between perpendicular and 65° angled installations in the empirical analysis. Where station name signs have to be mounted on a platform with a width of approximately 6 m (Fig. 2), perpendicular installations are superior to parallel attachments. It could be advisable, however, to add some parallel signs as well, because these offer good legibility at low speeds. For trains passing the station at higher speeds, however, perpendicular installations should be preferred. It could be a good compromise to install parallel signs within the inner circle of the station, and perpendicular signs before reaching and after passing the station. This can often be seen in Switzerland.

Station name signs installed at a larger offset from the platform are particularly interesting. There, a parallel installation is superior. The signs can be seen from several platforms and are thus more economical than separate installations on every platform. The disadvantage, however, appears when another train on a neighboring platform blocks passengers' view of the sign. As a rule of thumb, the legibility of perpendicular signs is superior to a parallel one when the lateral offset is small, and vice versa when the offset is large.

The empirical results, although convincing, deliver rough estimations only. This may have been caused by the artificial environment in a 1:30 scale where sometimes it is different to arrange everything in true scale. Computer movies work with 25 frames per second only, which is a strong disadvantage with high speeds (e. g., a 30-meter drive takes only 1.11 s, thus giving only 28 frames to look at the sign instead of a continuous view). Further research in real situations could help to verify the results. This could be a promising venue for railroad companies themselves because only they are able to control the installation and measuring processes.

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