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"Why were you speeding?": A self-confrontation study on awareness and reasons for speed behaviour

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ABSTRACT

Despite extensive prevention, speeding remains a major contributor to traffic casualties. Understanding drivers' perceived awareness and the subjective reasons for their speed behaviour could improve intervention strategies, and specifically inform the potential of speed feedback. A self-confrontation study was conducted in which 25 regular drivers recorded one of their drives using GoPro cameras, capturing both the road view and their speed, and selected video excerpts were later discussed with these participants. The study explored participants' awareness and reasons for their speed behaviour, as well as general attitudes towards speeding, perceptions of its problematic nature, the acceptability of exceeding speed limits, and decision-making in speed choice. This study design aimed to provide an objective basis for the interviews and reduce recall biases. The results revealed that drivers show a latent awareness of their speeding behaviour, which they most often justified as usual, normal and safe. This general tolerance towards speeding suggests the normalisation of speed violations. As a result, individual safety interventions, such as feedback on driving behaviour, may not be effective. Prevention efforts should focus on changing norms, common beliefs and systemic factors regarding speeding.

1. Introduction

Reducing risks on the roads has been a decades-long effort in the field of traffic research, and it continues to be a challenge. Contemporary approaches aim to increase safety and reduce human error with the help of advanced driver assistance systems (ADAS) (Brookhuis et al., 2001; Haas et al., 2020; Marti et al., 2019). These systems make it possible to monitor and assess drivers' behaviour and provide feedback accordingly (see, e.g., Bell et al., 2017; Dijksterhuis et al., 2015; Farah et al., 2014; Karimpour et al., 2021; Malekpour et al., 2023; Mase et al., 2020; Molloy et al., 2023). Existing driver feedback systems are highly versatile in terms of modality and temporality: Feedback systems exist as in-car devices, and can provide visual, auditory, or haptic alerts (e.g., Azzi et al., 2011; Saffarian et al., 2013), or can be used as post-trip interventions (e.g., Toledo et al., 2008), delivering information via a smartphone app or by weekly emails, with some systems even including both real-time and delayed feedback. Often, incentives or gamification elements are added to stimulate drivers' motivation and engagement (e.g., Degirmenci & Breitner, 2023; Mullen et al., 2015). Feedback can also entail less manifest information than speed behaviour, for example, g-force data (Shimshoni et al., 2015) or fuel consumption (Gonder et al., 2012; Zhao et al., 2015).

The common denominator in most, if not all, monitoring and feedback interventions is that it is expected that drivers will improve

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their behaviour upon receiving feedback. This expectation can rely on multiple premises, among them the fact that feedback can alert drivers immediately when they adopt a risky behaviour (e.g., speed alerts in intelligent speed adaptation; Brookhuis & De Waard, 1999), making them aware of their behaviour or drawing more attention to it. Feedback may also help rectify over-optimistic self-assessments of driving behaviour (De Craen et al., 2011; Nees, 2019; Sundström, 2008) by presenting information that is factual, helping drivers realise they should modify their behaviour. The overall premise is that informing drivers of their behaviour would make them more aware of their behaviour, and thereby induce a change in said behaviour. However reasonable the expectations are and however promising feedback may seem, experimental and experiential data suggest limitations to the potential of the approach.

Monitoring and feedback approaches do indeed face some drawbacks. Although interventions are generally well-regarded in acceptability studies (Chu et al., 2023; Picco et al., 2023) and can yield positive results in experimental settings (Lotan, 2016), they can experience a decreasing engagement rate (e.g., a decrease in log-ins to access feedback, as seen in Farah et al., 2014, or in Farmer et al., 2010), and the effects of feedback tend to decrease after a few months of intervention (e.g., Beusen et al., 2009; Toledo & Lotan, 2006). Additionally, feedback shows the best results in terms of behavioural change when it is combined with monetary incentives, as feedback alone does not yield lasting effects (e.g., Marciano et al., 2015; Mullen et al., 2015). The observed drawbacks of monitoring and feedback approaches can be explained by the fact that not all risky behaviours are a result of mistakes that drivers need to be informed about.

It has been argued that not all deviant driving behaviours are issues of lack of skill, unawareness, or inattention (i.e., errors), but that some are issues of motivation and deliberate choice (i.e., violations) (Hatakka et al., 2002; Rothengatter, 1997). According to Reason et al. (1990), risky behaviours on the roads can be classified as errors or violations, which differ in terms of the driver's intent and awareness of the deviation from the norm. This distinction, shedding light on different psychological mechanisms, suggests the need for the tailoring of feedback interventions (De Winter et al., 2007): Considering that errors are defined as unwitting (Reason et al., 1990), informative feedback could prove useful in their reduction, while violations involve some degree of intentionality (Reason et al., 1990) and could better be prevented on the motivational level (Hatakka et al., 2002). Identifying whether drivers are aware of the deviant behaviour they adopt would help in understanding whether they can benefit from informative feedback, but also in tailoring future and more effective safety interventions.

Speeding is one such behaviour that could either be the result of errors or violations: Some arguments point to drivers being both aware and intentional about their speeding, while others indicate the contrary. Speeding could easily be considered a conscious process: It could be argued that the presence of speedometers in cars leaves no room for unawareness, as the information is constantly available. The multitude of tools and speed regulation supports, such as ISA and cruise control, reinforce this point, suggesting that speeding is a matter of free will. Moreover, the fact that some drivers report their speeding behaviour (e.g., De Winter et al., 2015; Norton et al., 2021) or would categorise themselves as "excessive speeders" (Fleiter et al., 2010) clearly indicates awareness of their speeding. However, there is some contrary evidence: drivers often overestimate how frequently they check their speedometers (Denton, 1969), and speeding was found to be associated with fewer speedometer glances (Lehtonen et al., 2020). Although technical solutions exist to reduce speeding, the social influence others have on one's driving behaviour cannot be ignored (Festinger, 1954; Fleiter et al., 2010). Finally, although some drivers seem to be aware that they speed, self-reports are not always reliable (Kaye et al., 2018): Self-reported speeders may not be fully aware of the extent of their speeding, and self-reported non-speeders may, in fact, be speeders.

Speeding is among the most common (Breen et al., 2020; Høye, 2020) and riskiest behaviours on the road (Aarts & van Schagen, 2006; Imprialou et al., 2016). This is despite the numerous research results obtained over the past decades and the diversity of safety interventions developed. Indeed, speeding is now better understood and can be attributed to individual factors, such as gender, age or personality traits (Ahie et al., 2015; Sârbescu & Rusu, 2021), as well as environmental or external factors, such as road design or feeling of time pressure (Gabany et al., 1997; Theeuwes et al., 2024; Yadav & Velaga, 2021). Safety interventions targeting speeding have proliferated, from personal devices (ADAS) such as adaptive cruise control, ISA or traffic sign recognition, to more global approaches, such as more adapted road design, speed bumps, law enforcement or prevention campaigns. Tirla et al. (2024) provide a *meta*-analysis of such safety interventions and, after comparing the effects of various approaches, conclude their analysis by highlighting the effectiveness of feedback to address speeding behaviour. Yet, considering the aforementioned drawbacks of feedback interventions, and the uncertainty regarding drivers' need for improved self-awareness, it is still uncertain whether informative feedback can be considered an effective tool to reduce speeding.

To help determine the relevance of feedback, and especially to understand its working mechanisms better, it is necessary to investigate how drivers react when confronted with their own speed behaviour. The main focal point of this self-confrontation is the drivers' gain in self-awareness. If being able to review one's behaviour proves to be insightful and helps drivers to identify unintentional behaviour, their speeding would be considered unwitting and be classified as an error. In that case, informative feedback would be deemed relevant to increase self-awareness, and as such would be seen as an effective tool to reduce speeding behaviour. Otherwise, if drivers do not gain insights when reviewing their behaviour, this would suggest existing and accurate speed self-awareness and informative feedback is unlikely to be effective in changing behaviour. The drivers' views on their own behaviour and their general attitudes about speeding can help understand how informative feedback on speed would be received and how safety interventions can be improved. Indeed, should speeding not be caused by errors, but performed more consciously and intentionally, insights into the reasons for a drivers' behaviour could prove useful. Even more importantly, if drivers can justify their behaviour, regardless of the subjectivity of that justification, informative feedback is unlikely to influence their reasoning and their behaviour.

The present study confronts participants with their own speed behaviour: It combines objective recordings of speed behaviour with a qualitative inquiry into those recordings. This combination allows for a focus on the drivers' subjective self-assessment and self-awareness, opinions and attitudes towards speeding, and behaviour justifications while ensuring that the behaviour discussed is

indisputable. The study expects results regarding (1) drivers' potential reaction upon receiving speed feedback, both in terms of gained awareness and justification formulations, and (2) further insights into speeding in general, as it is viewed and accepted or not by regular drivers.

2. Method

The method of self-confrontation (also known as auto-confrontation, see Mollo & Falzon, 2004; Rix-Lièvre, 2010 for a description of the method) was used in this study. This approach involves confronting participants with their own activity using video or audio recordings as memory prompts. Participants can reflect, discuss their decisions, and verbalise their actions (Vermersch, 1994). Theureau (2010) further describes the method, and specifies that it allows for a delayed expression of the "pre-reflective consciousness". This term refers to a level of implicit awareness, before reflecting upon the action conducted (Vermersch, 1994). Although developed initially in the field of occupational psychology and used to analyse and understand work activities, self-confrontation methods have also been applied in driving research. For example, Bellet et al. (2009) investigated driving strategies and decision-making, and Cahour and Forzy (2009) used self-confrontation to investigate trust in cruise control systems. Barbier et al. (2019) investigated whether self-confrontation was applicable in naturalistic driving studies, and found that it was particularly suitable to discuss risky driving situations. In the present study, self-confrontation was used to discuss participants' speed choice and the underlying cognitive processes, including awareness and decision-making.

This research was approved by the Ethics Committee of the Faculty of Behavioural and Social Sciences of the University of Groningen (research code: PSY-2223-S-0510).

2.1. Participant recruitment and sample characteristics

Participants were recruited through convenience sampling, social media, flyers, and from two subject pools. Inclusion criteria were: 18 years or older, considering themselves a regular driver, and being able to communicate in English. Participants were compensated for their time, car use, and fuel costs with €25, or with credits for those from the 1st-year students' subject pools.

Twenty-five participants took part in the study. They completed a short demographic questionnaire, and the results are as follows: The sample consisted of 15 women and 10 men, with a mean age of 26.2 years (SD = 11.6, range 18–65), who held their driving licences for an average of 7.9 years (SD = 11.4, range 0–47). Further sample details are provided in Table 1.

The demographic questionnaire also explored certain opinions about driving using a 7-point Likert scale. The findings are depicted in Fig. 1, which presents the distribution of responses to four statements, using a colour-coded representation of the scale, ranging from "Strongly disagree" in red on the left, to "Strongly agree" in blue on the right. On average, participants were positive towards driving a car (M = 5.9, SD = 1.1), they believed they were good drivers (M = 5.0, SD = 1.1) but not better than the average driver (M = 4.1, SD = 1.5), and they believed they could improve their driving ability (M = 5.7, SD = 1.1).

Reported enjoyment of driving and belief in being a good driver align with data collected in a questionnaire study with 628 Dutch respondents (Picco et al., 2023) that used the same Likert scale items (enjoyment of driving: M = 5.9, μ = 5.3, and belief good driver: M = 5.0, μ = 5.3). However, the present study's sample holds a more positive view about the possibility of improving their driving (statement 4, M = 5.7) compared to the general population (μ = 4.1), indicating they may be more certain they can change and improve their driving.

Table 1
Demographic Characteristics of the Sample.

Variable	Category	*n*	%
Gender	Man	10	40
	Woman	15	60
	Other / Non-binary	0	0
Age	18–20 years	8	32
	21–30 years	13	52
	31–65 years	4	16
Annual average mileage	1–1000 km	6	24
	1001–5000 km	9	36
	5001–10 000 km	5	20
	10 001–50 000 km	4	16
	More than 50 000 km	1	4
Frequency of driving a motorised vehicle	Every day	1	4
	4 to 6 days a week	6	24
	1 to 3 days a week	9	36
	1 to 4 days a month	8	32
	Less than once a month	1	4

Note. There were originally nine response options for "annual average mileage", which were merged into 5 categories for reporting purposes.

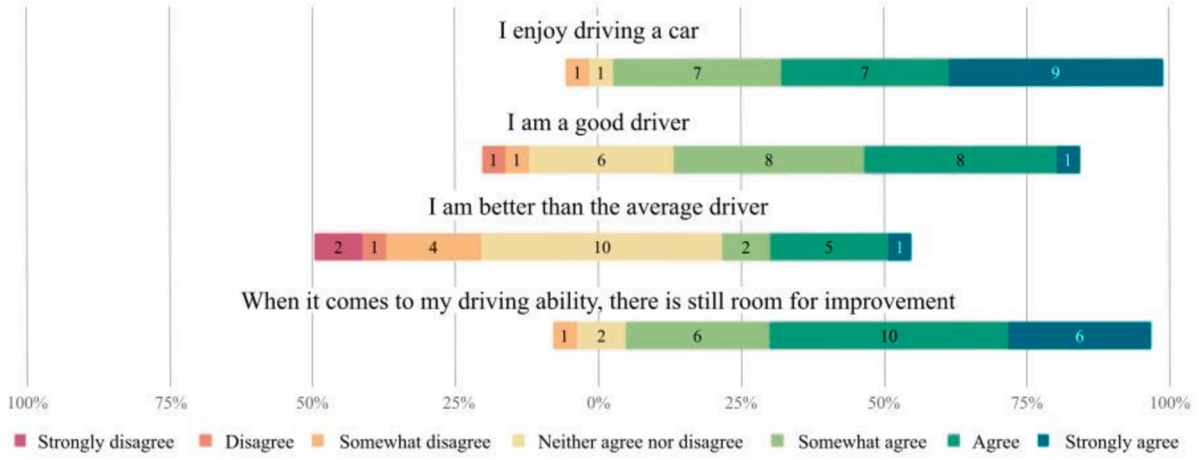

Fig. 1. Distribution of Responses to the Four 7-point Likert Scale Items.

2.2. Protocol and materials

The study consisted of two main parts for the participants: Recording a road-view video during one of their drives and participating in an interview scheduled two or three days later. Between the recording and the interview, the first author of this paper reviewed the recordings and selected video excerpts to be used in the interview.

2.2.1. Video recording process

Participants were instructed to record the road-facing view during one of their usual or planned drives for at least 15 to 20 min. They were asked not to drive specifically for the experiment, and instead to record any drive they would be taking, as well as to drive alone, to observe their most typical and usual behaviour. GoPro Hero11 cameras, which deliver reliable speed and GPS recordings (Petroskey et al., 2020), were used to record the footage. These cameras were lent to participants for up to a day to allow them to record at their convenience. Participants received instructions on how to install the camera on their windscreen, how to operate it, and the required recording duration. They were told that the experiment focused on decision-making in driving and were assured that their behaviour would not be judged, to encourage them to drive as they usually would.

There were no requirements regarding the type of roads or situations participants had to encounter, nor was there a maximum amount of footage they could provide. This choice was made to affect participants' driving activity as little as possible.

Fig. 2. Example of Footage with Virtual Speedometer.

In total, participants recorded around 16 h of footage, averaging 40 min per participant. Only excerpts of the footage were kept for use in the rest of the experiment. The selection process and a description of the excerpts are reported in the next subsection.

2.2.2. *Selection of excerpts of interest*

The purpose of the excerpts was to guide the interviews by serving as memory prompts for participants. As this research specifically investigates awareness of speed(ing) behaviour, the excerpts were selected, as described below, based on the speed behaviours observed (including both speed compliance and speed excesses). To provide enough material for discussion while keeping the interviews duration reasonable, five to eight excerpts were selected per participant.

The footage was imported into the GoPro Quik app, which provided access to the speed data. An initial overview of the speed throughout the video helped the researcher identify different types of situations (e.g., in the city centre, on the motorway, accelerations and decelerations). A virtual speedometer was then added to the footage (see Fig. 2) and the researcher reviewed the videos (in some cases, in accelerated viewing mode).

Similar to the approach used by Barbier et al. (2019), the excerpts were chosen based on their significance and interest regarding the aim of the research. In this study, excerpts of interest were parts of the video where the participants were speeding or displayed abnormal speed compared to their usual behaviour or that of other drivers observed in the excerpts. These instances were flagged, and the selection of excerpts used for the interview was dependent on the type of behaviour observed:

- For participants with multiple speeding events and/or extreme speeding, the researcher selected multiple examples of such speeding behaviour to discuss it in different situations and different speed-limit roads. Additionally, if they drove at or below the speed limits on some road segments, these excerpts could also be selected as they could be considered unusual.
- For participants with very few to no speeding events, the researcher selected multiple examples of such compliant behaviour in different situations and different speed limit-roads. Additionally, if they drove above the speed limit, albeit a little (e.g., exceeding the limit by 2 or 3 km/h for a few seconds), these excerpts could also be selected as they could be considered unusual.
- For participants with some speeding events but with overall compliance with speed limits, the few instances they were speeding were selected. To ensure enough material and to understand speed choice, some situations where it was physically possible to drive faster than they did (e.g., the speed limit was higher than their speed, other drivers were overtaking them, or there was no traffic) were selected as well.

Overall, the excerpts do not aim to be a representation of driving behaviour in the general population, nor can they indicate how

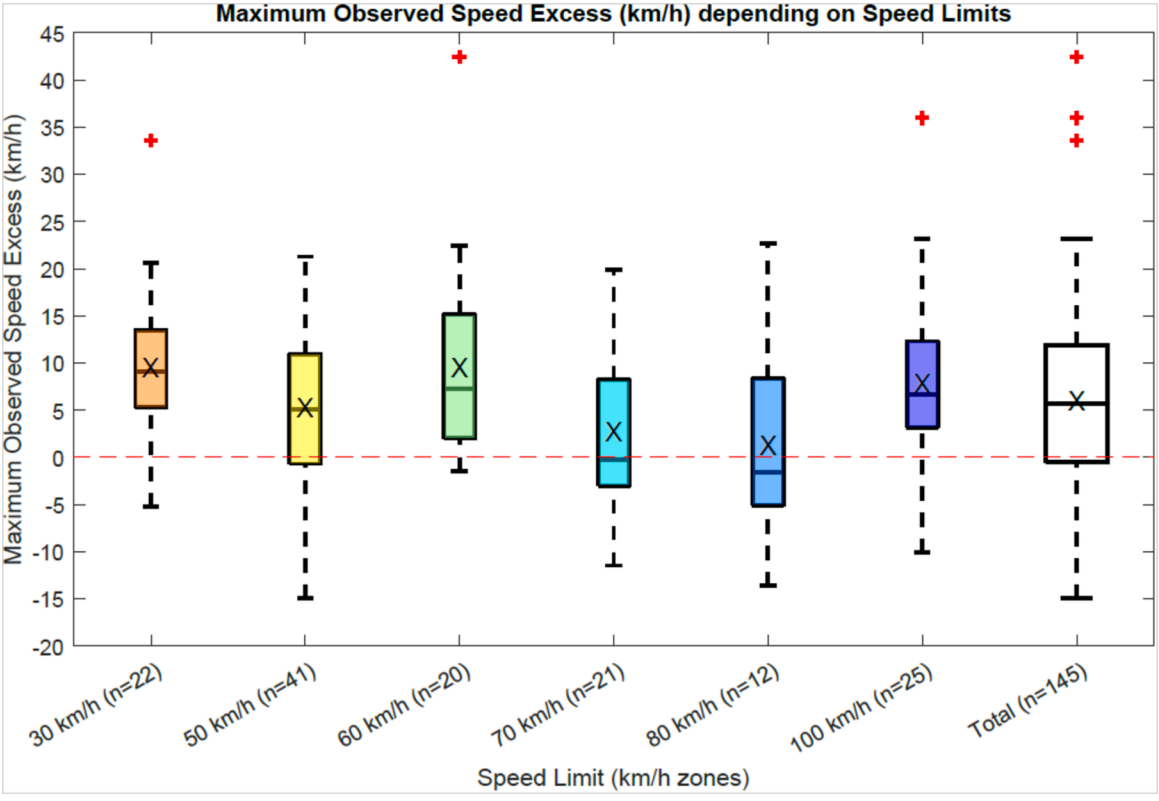

Fig. 3. Maximum Observed Speed Excess (in km/h) Depending on Speed Limits.

often people drive over or under the speed limit, as there is a deliberate selection bias towards speeding instances. The data on speeding frequency should not be interpreted as representative but can only demonstrate the existence of speeding instances. However, the excerpts display a wide variety of speeding behaviours, including some of the most extreme speed behaviours observed in the 16 h of footage collected in this study. Therefore, the types of speeding and the extent of speeding can be interpreted as behaviours that occur on the roads.

Depending on the variety of driving situations and the frequency and variability of speeding, five to eight ($M = 5.9$) excerpts were selected per participant. These excerpts had a duration between 15 and 104 s ($M = 49.5$, $SD = 18.4$). Of the 148 excerpts, 105 (70.9 %) showcased speeds above the speed limit (i.e., with a maximum speed of at least 0.1 km/h above the limit for at least 0.5 s). Most excerpts were recorded during the day ($n = 117$), with clear/sunny ($n = 92$), cloudy ($n = 29$), rainy ($n = 26$), or foggy ($n = 1$) weather conditions. The count of excerpts per speed limit is as follows: 30 km/h ($n = 22$), 50 km/h ($n = 41$), 60 km/h ($n = 20$), 70 km/h ($n = 21$), 80 km/h ($n = 12$), 100 km/h ($n = 25$), 120 km/h ($n = 2$), and 130 km/h ($n = 1$), and three excerpts included more than one speed limit.

The maximum speed excess for each video excerpt was recorded, calculated as the difference between the highest speed observed in the excerpt and the speed limit. These data illustrate the type and extent of speeding observed and forms the materials used in the interviews. Fig. 3 shows the maximum observed speed excesses, grouped by speed limits (for each speed limit which had at least four excerpts).

2.2.3. Self-confrontation interviews

After their excerpts had been selected, participants took part in an interview lasting between 30 min and an hour. Interviews were scheduled and held two or three days after the recording of the drive took place, except for one participant, who was interviewed on the same day as the recording. This timeframe was chosen to be the shortest possible, to ensure the video excerpts could be used as probes (Mollo & Falzon, 2004), while also accounting for practical constraints. The interview was preceded by a short introduction where the researcher explained that the topic of the research was speed choice and speeding behaviour, not broad decision-making as previously implied. Participants were reassured that their behaviour would not be judged and that the goal of the study was to understand speed behaviour. Special attention was given to this reassurance, both in the introduction and during the interviews, to ensure participants would not feel self-conscious about their driving performance or their traffic rules violations, to avoid social desirability bias, and to encourage an open discussion.

All the interviews followed a similar structure: After an opening question, the excerpts were discussed one by one, followed by more general topics. While the first part of the interview aims at confronting the participants with their behaviour, the second part of the interview aims to understand the more general views and behaviours of the participants, to draw more informed conclusions. The researcher employed the following interview grid:

Q1: *Do you sometimes drive over the speed limit?*

For each video excerpt:

- **Q2A:** *Can you describe what you see?* (specified: What is happening, what is the context, the situation, the type of road, the speed limit, your speed?)
- **Q2B:** *Do you remember driving at this speed?* (follow-up question in case of doubt: Are you surprised to see this speed?)
- **Q2C:** *Why were you driving at this speed?*

At the end of the excerpts discussion, participants were given the chance to share their thoughts with the question: *What did you think of these excerpts?,* before moving on to the second part of the questions:

Q3: *Did watching the videos make you more aware of your speed?*

Q4: *In general, how do you choose the speed at which you drive?*

Q5: *Would you say that you are often mindful of the speed at which you drive?*

Q6: *Do you think that speeding, in general, is problematic?*

Q7: *Is there an acceptable margin over the speed limit?* (specified: do you think it is acceptable to drive above the limits, and if so, by how much, to what extent?).

Q8: *Do you think that your speed is problematic sometimes?*

Q9: *How would you feel about receiving feedback about your speed?* (specified: This can be any type of feedback, but we can imagine an app on your phone that provides you with objective data, for example, your average speed/ number of times you were above the limit/ etc., which gives you insight into your driving behaviour.).

The interviews were audio recorded and transcribed.

2.3. Data analysis

To organise the analysis of the transcripts and clarify the results section, the content of the interviews was grouped into four main themes:

- Awareness of speed(ing)
- Rationalisation and justification
- Choice of speed and attitudes towards speeding

- Potential of speed feedback

The interview content was analysed thematically (Braun & Clarke, 2006). The themes and types of answers were identified, categorised, and condensed, and the frequency of the most relevant themes was recorded. Additionally, transcript extracts were used to illustrate or contextualise a result or to define a theme.

Each quote or transcript extract is presented with a participant identifier and the participant's average maximum speed excess: The maximum speed excess was recorded for each video excerpt (maximum speed minus speed limit), and averaged per participant to obtain an average maximum speed excess. For example, "P10 (+13.0)" indicates that the quote belongs to Participant 10, who showcased maximum speed excesses that averaged 13.0 km/h. If the quote belongs to a specific video excerpt, the excerpt identifier will be displayed as well, along with the maximum speed excess of that excerpt. For example, "P10, E1 (+21.3)" means the quote refers to the first video excerpt of Participant 10, in which they exceeded the speed limit by 21.3 km/h. A negative speed excess value indicates that the maximum speed was lower than the speed limit.

To refine the results, the speed excesses can be categorised into three categories: (1) no speeding (i.e., a maximum speed that was less than 0.1 km/h above the speed limit; n = 40), (2) "minor" speeding (i.e., a maximum speed between 0.1 and 10 km/h above the speed limit, n = 57) and (3) "major" speeding (i.e., a maximum speed more than 10.1 km/h above the speed limit, n = 48). The threshold of 10 km/h that distinguishes both categories of speeding is the average speed excess of the 105 excerpts that did not fit in the "no speeding" category.

3. Results

3.1. Awareness of speed(ing)

3.1.1. Latent awareness

The results of the interviews indicate a latent, or implicit, awareness in participants. Upon viewing their behaviour, the large majority recognised their behaviour, mentioning they either remembered it or found it usual and representative of their driving. Participants' latent awareness seemed to appear on a continuum, rather than being a dichotomy between aware and not aware: Some excerpts elicited a more precise memory (e.g., remembering the setting on the cruise control) while some reminded participants of their speed range or made them recognise their behaviour as usual.

> P34, E4 (+10.4): *"This is my usual driving behaviour for sure."*
> P20, E5 (+16.0): *"I went from 65 to 55 and now I'm around 60. So I did, that I do remember, I did it consciously."*
> P11, E4 (+9.0): *"It's generally probably not very surprising for you to see yourself act out in behaviour that you're used to anyways, right?."*

Being confronted with the excerpts elicited a feeling of surprise in only 9 % of the cases (14/148), with participants expecting a different speed, though by a small margin.

> P27, E3 (+9.1): *"It's just a 50 road. […] Oh, I'm going almost 60. Oh. I didn't realise that. I thought I was going 55."*
> P12, E2 (+2.7): *"I do remember that it was like 90-ish because I remember we were driving slower than 100. But I didn't know I was decreasing to like 90."*

3.1.2. Factors of latent awareness

Degrees of latent awareness did not appear to depend on type of speeding, and seemed rather consistent per participant. The 14 instances of participants being surprised by their speed were indeed spread out in all three categories of speeding, with five instances in major speeding, five in minor speeding and four in no speeding. Participants were, most of the time, consistent in their latent awareness, some of them mentioning they pay a lot of attention to their speed, while some pay more attention to the road environment, and as such do not register the speed at which they drive.

> P21 (−4.6): *"No, I'm really aware of my speed, because I check every 10 s"*
> P22 (+9.1): *"I just drive on, like, okay, I think this is fine. I don't really pay attention to the actual speed and speed limits."*
> P13, E3 (+12.4) *"I'm not [the] type of driver that looks at the speedometer all the time. I look at the traffic around me"*.

Nine of the 25 participants were surprised by their speed once, one was surprised twice (out of eight cases, both times by a lower speed than expected) and one was surprised three times (out of five cases, two times by a higher speed and one time by a lower speed than expected).

3.1.3. Acknowledging speeding

While participants displayed a good latent awareness of their speed behaviour, it did not necessarily translate into acknowledging driving over the speed limits. When asked to explain their behaviour, participants mentioned reasons for not going faster 35 % of the time. This concerned seven cases of major speeding (7 out of 48: 15 %), 15 cases of minor speeding (15 out of 57: 26 %) and 30 cases of no speeding (30 out of 40: 75 %). By explaining why they would not drive faster, participants highlighted that speeding is not always acknowledged as a behaviour that should strictly be avoided.

Table 2
Definition, Examples and Counts of the Categories of Justification.

Category	*	Definition and examples of justifications	*n*
usual behaviour		Participant describes the behaviour as usual or normal, or mentions that they often do that or that it is a habit. *"It just kind of became a habit to speed a bit more"(P22), "That's usually how I would get on a highway: as fast as possible. […] That's how I learned how to drive"(P15)*	37
feeling of safety		Participant mentions elements that make them feel safe to drive that speed or that it is safer to drive that speed. *"Because it's like a really long road and you can see everything and it's really straightforward. So I just feel safe driving this speed." (P26)*	22
traffic flow		Participant mentions adapting to the traffic flow, or having to match other drivers' speed. *"I saw a lot of cars go through [overtake] me and I saw behind me, it was very busy, so I thought, okay, I go with them."(P23), "Here I'm trying to follow the rest of the traffic." (P13)*	18
anticipation	*	Participant mentions their speed is dependent on an event coming up on the road (having to exit soon, a turn, a change in speed limit, a traffic light) or on another driver's behaviour. *"I get the next exit. So then I slowed down in advance."(P31), "And the speed limit here is 70. But I drive 80 because that's what you can do later on and no traffic ahead."(P32)*	17
speed limit	*	Participant mentions following the speed limit or taking into account the speed limit. *"The maximum was 60 and I was around that speed."(P21), "Because 100 was the maximum here." (P12)*	17
feeling of risk	*	Participant mentions a feeling of risk or a risk factor that influences their speed. *"It feels not safe to drive 50 there. So in that way, I'm driving way slower than 50."(P33), "Best to take it a little bit slower because it's also like a school district […] to expect all situations"(P29)*	14
knowledge of the road		Participant mentions knowing the road and/or driving there often. *"I see it every day, I know there's a roundabout. So I know at what time [I need] to brake."(P18)*	13
not on purpose		Participant describes their speed behaviour as unintentional. *"I do not try to speed on purpose in this particular ride. I did not speed on purpose."(P33)*	13
weather / conditions	*	Participant mentions the weather or road conditions as determinants of their speed. *"Because it's dark and it's raining, I have quite bad vision. Therefore I drive a bit slow."(P10), "It rained before this, so I would be a bit more careful"(P14)*	12
norm		Participant justifies their speed as being a (/the) normal behaviour and that other drivers do the same. *"Not only because other cars are going the speed, although it's not very visible here. But usually it's like that."(P20), "You may drive 30 on that part. But everybody is like driving like 50 or so."(P26)*	10
speed limit uncertainty		Participant either wrongly knows the speed limit ($n = 6$), is unsure ($n = 3$) or does not know it at all ($n = 1$). *"I didn't know that. I thought it was 70."(P29)*	10
tolerance / margin		Participant refers to the speed cameras tolerance and/or to the margin of their speedometer. *"My standard speed is 107 because I think it should subtract 4 from it and then 2 or 3 for the speed cameras. So I don't get a fine when I drive 107."(P16) "The calibration of the speed monitor is also a little bit lower."(P33)*	10
overtaking		Participant attributes their speed to an overtaking manoeuvre. *"We're passing the car. […]I try to speed up to make the manoeuvre shorter."(P17)*	9
questions the speed limit		Participant discusses the fact that the speed limit should be changed or that it is not appropriate for the road. *"I see no reason indeed why I could not drive 50 over there."(P26), "It used to be faster [on the motorway] it changed about two years ago or something. And I don't know, I think 100 is a bit too slow."(P34)*	8
hurry		Participant mentions being in a hurry or wanting to reach their destination fast. *"Because of the time pressure, I have to catch the train."(P10), "I just want to get home as quickly as possible."(P18)*	8
no hurry	*	Participant mentions not being in a hurry or having the time to drive more relaxedly. *"I was not in a rush or anything. There's no reason for me to go quicker than I have to."(P11)*	7
feeling slow		Participant explains that the speed limit felt slow (often mentioned with: "not on purpose") *"You see me speeding again. Because it does not feel like a 50 km road."(P33)*	6
keeping distance	*	Participant mentions having to keep their distance with the vehicle in front of them. *"I maintain safe distance from the person in front of me. […] that's probably again only reason why I'm going the speed I'm going."(P11)*	6
traffic	*	Participant mentions being hindered by traffic (usually, a car directly ahead). *"This was a bit slower, but it is because of the cars in front."(P10)*	5
no traffic		Participant mentions not being hindered by traffic (usually, no car directly ahead). *"There's nobody here. There will be not many people here because it's late."(P20)*	5
comfortable speed	*	Participant mentions being more comfortable driving that speed. *"I'm just a lot more comfortable at the 90 speed. I should go faster technically, but it feels nicer like this."(P30)*	5
others	*	This category includes: enjoyment ($n = 4$), no need to speed up ($n = 4$)*, no car behind ($n = 3$)*, not easy to overtake ($n = 3$)*, under overpass ($n = 2$), possible to speed ($n = 2$), car behind ($n = 2$), speed bumps ($n = 2$)*, worry speed cameras ($n = 2$)*, cruise control ($n = 1$)*, foot positioning ($n = 1$), road type ($n = 1$)*, no knowledge of the road ($n = 1$)*, unaware own speed ($n = 1$), start of ride ($n = 1$)*, boring ($n = 1$), not possible to speed ($n = 1$)*, compensates for traffic jam ($n = 1$), gears ($n = 1$) and does not know why ($n = 1$).	35

Notes. a. Multiple justifications could be used for one case. *b.* * indicates that the keyword was associated more than 50 % of the time to the participant explaining why they do not drive faster.

P34, E4 (+10.4): *"I always drive around 50 on this street because many people, when it's less busy, they tend to drive very fast on this road because it seems fun. But I've heard about accidents and that kind of stuff, and I don't want anything happening to me."*

3.2. Rationalisation and justification

When asked why they were adopting the speeds observed in the excerpts, participants provided on average 1.9 reasons for each speed behaviour. Cases of major speeding were slightly more justified with 2.4 reasons on average; cases of minor speeding received 1.7 reasons, and cases of no speeding 1.9 reasons. Out of the 287 explanations provided, there was only one instance when the participant could not provide a reason for their behaviour. The remainder 286 explanations were categorised across 40 different keywords. Twenty of these categories had less than five occurrences and are grouped as "Others". The categories are displayed, defined, exemplified, and tallied in Table 2. The second column of Table 2 includes an asterisk (*) when the justification was used more often to explain why participants were not going faster than why they were driving at that speed. The results are examined in more detail and per recurring theme below.

3.2.1. Types of justification

The different types of justification displayed in Table 2 are analysed here, grouped by recurring themes. Mainly, three observations are made: justifications seem to (1) differ in terms of intent, (2) be attributed either to the participant's driving style (habitual) or be context-dependent (situational), and often (3) result from a safety and risk assessment.

3.2.1.1. Intent of speed(ing) behaviour. The large majority of the justifications include a notion of intentionality. In only a few cases, the participant explained their behaviour by it being "not on purpose" ($n = 13$, or 5 %) or by being "uncertain about the speed limit" ($n = 10$, or 3 %). The remainder 92 % of the justifications position the driver as in control of their speed choice, with participants being able to contextualise, rationalise and justify their speed.

3.2.1.2. Habitual vs situational. A quarter of the 148 speed behaviour observed in the excerpts were qualified by the participants as being their "usual behaviour". This represents 13 % of all justifications (or $n = 37$). A second type of justification adds to the habitual character of the speed behaviour: it being the "norm" ($n = 10$, or 3 %), where the speed is considered the normal behaviour for both the driver and the rest of the traffic. On the other hand, more types of justification were context-dependent: adapting to the traffic flow ($n = 18$, or 6 %), anticipating an event or having knowledge about the road (resp. $n = 17$ and 13, or 6 and 5 %), there being traffic or no traffic on the road (in total, $n = 10$, or 3 %) or simply taking into account the road or weather conditions ($n = 12$, or 4 %).

3.2.1.3. Safety-risk assessment. Another large part of the justifications relied on the participant's safety assessment: Having a "feeling of safety" was the second most-used justification ($n = 22$, or 8 %) for the participants' speed behaviour. Participants would sometimes even question the speed limit, with their own assessment of the road situation ($n = 8$, or 3 %). Having a "feeling of risk" was also used to explain their behaviours ($n = 14$, or 5 %). Assessing the level of risk or safety accounted in total for 13 % of justifications (or $n = 36$).

3.2.2. Justification per type of speeding

To better understand reasons for speeding, and not only reasons for any speed, the data can be split into the three types of speed behaviour (major speeding, minor speeding, and no speeding). Speed justifications have been classified per type of speed behaviour in Table 3.

Cases of speeding, both major and minor, are for the most part justified with 'habitual' reasons (i.e., usual behaviour, norm) and a feeling of safety; when it is the opposite for cases of no speeding, with more 'contextual' elements (i.e., anticipation, weather and conditions) and a feeling of risk. Major and minor speeding also showcase differences in terms of justifications. Minor speeding received more types of justification: With a total of 57 excerpts, the most used explanation is 'usual behaviour' with 13 instances (or 23

Table 3
Speed Justifications per Type of Speed Behaviour.

Major speeding (> 10 km/h)	*n* 48	%	Minor speeding (0.1–10 km/h)	*n* 57	%	No speeding (< 0.1 km/h)	*n* 40	%
usual behaviour	21	44	usual behaviour	13	23	anticipation *	9	23
feeling of safety	14	29	speed limit *	11	19	feeling of risk *	8	20
norm	8	17	traffic flow	10	18	weather/conditions *	6	15
overtaking	8	17	feeling of safety	7	12	speed limit *	4	10
questions speed limit	8	16	not on purpose	7	12	traffic flow	4	10
hurry	7	15	anticipation *	6	11	no hurry *	4	10
knowledge of the road	6	13	knowledge of the road	5	9	speed limit uncertainty	4	10
feeling slow	6	13	tolerance/margin	5	9	keeping distance *	4	10
traffic flow	4	8	feeling of risk *	4	7	no need to speed up *	4	10
speed limit uncertainty	4	8	weather/conditions *	4	7	usual behaviour	3	8

Notes. a. Multiple justifications could be used for one case. *b.* * indicates that the keyword was associated more than 50 % of the time with the participant explaining why they do not drive faster.

%), when the same explanation accounts for 44 % of the major speeding (or $n = 21$). Minor speeding justifications seem more varied, and include, for example, more discussions around the possibility of driving faster, as well as more 'contextual' reasons than major speeding instances. There appears to be a trend where larger speed excesses are more frequently justified by habitual reasons, and smaller speed excesses, and in particular cases of no speeding, are more frequently justified by contextual reasons.

3.3. Choice of speed and attitudes towards speeding

A few questions were asked with regard to speed choice and attitudes towards speeding, to further understand the rationale behind drivers' behaviour beyond what was observed in the excerpts. Speed choice seems determined based on a reference point, a basis for the drivers' behaviour (i.e., a baseline speed they adopt), which can or will be influenced by contextual and habitual factors, as described below.

3.3.1. Baseline speed

Most participants determine their speed based on the speed limit, but rather than aiming to drive exactly at the limit, they calculate a margin above the limit that they consider acceptable. The most common 'calculation' takes into account the difference between the information provided by their speedometer and the actual speed they drive at.

> P34 (+8.1): *"I usually just do the speed limit and then plus about 10 %. Maybe a little more."*
> P14 (+8.6): *"According to the rules that I think are there."*
> P33 (+4.5): *"Depending on the speed limit itself, I calculate in my head how much I can go over it in my speed monitor. For 80 for example, it's six kilometres and for 100 it's almost ten kilometres."*

Most participants also consider that, beyond this margin due to the speedometer deviation, it can be acceptable, or even normal, to drive above the speed limits, in certain circumstances. Acceptable margins ranged from 2 to 3 km/h, as it can happen accidentally while still considering speed limits as strict, to an excess of 50 km/h (on the motorway), or even the consideration that there could be no limits. Despite the range of acceptable margins, most participants indicated a margin of 10 km/h (more often, on the motorway) or a margin of 10 % of the limit.

> P14 (+8.6): *"Legally, I think six [km/h] over the speed limit is just that you not would get a really big fine for it."*
> P12 (+4.8): *"I would say within ten km/h. Not when it's like within the city […] outside, on the highway, when there are two lanes, then I don't mind, ten is okay."*
> P18 (+27.9): *"On the highway I don't mind people that go 150."*
> P11 (−1.8): *"But given the circumstances that you're not putting anyone else but yourself at risk, I guess go as fast as you like. I don't really care."*

3.3.2. Factors of speed choice

Both the speed choice and the acceptable speeding margin depend on contextual factors, grouped by recurring themes here.

3.3.2.1. Driving environment: Residential vs motorway and other road users. Participants almost systematically made a difference between speeding in residential areas and on the motorway. They consider it more important to adhere to the speed limits where there might be vulnerable road users. Often, the rationale behind this distinction is that speeding is more acceptable when the driver does not put other people at risk.

> P23 (+7.5): *"When you are in a village […] and there you have to drive 30 or 40, I think, and when you drive like 80 or 90 there, then it's a problem because it's more dangerous. […] on the highway and there's nobody around you, then it's your own choice. Because there's nobody around you that you can hurt."*
> P18 (+27.9): "*It depends, like if you're going 80 in a 30 zone where there's a lot of families and kids or animals, then I think it's a problem because it's dangerous. But when people are speeding, like on the highway, I don't think it's really that big of a problem."*

This distinction between residential areas and motorways included also the mention of other road users: It is more acceptable to speed when there is no one else on the road.

> P10 (+13.0): *"But if you speed on roads where there's no real dangers that can happen and not that busy, then I would say it's not that big a problem."*

3.3.2.2. Traffic flow and cultural aspect. While the presence of other road users is mentioned as a reason to not speed, it can also be seen as an encouragement to speed, when trying to match the traffic flow. This is especially true when speeding is considered cultural, as is done by a few participants, and can be exacerbated by the presence of passengers and the drivers' education.

> P34 (+8.1): *"I think many other people drive faster. I think it's also safe to go with the traffic instead of holding it back and getting more people agitated"*
> P16 (+8.7): *"Technically everything above 100 is speeding, basically, but culturally, many Dutch people drive a bit faster than the speed limit I think."*

P14 (+8.6): *"So if other people are behind me I might speed up because otherwise, I feel like they'll be cursing at me"*
P27 (+5.0): *"My driving instructor actually at one point told me that I should go like a little bit faster […] you just kind of adjust your speed to what other people do."*
P17 (+6.6): *"I think it depends on who is with you in the car. So I think I definitely drive differently when I'm alone"*

3.3.2.3. Risk assessment and driver abilities. As observed in Tables 2 and 3, speed choice is often rationalised with a risk assessment. Assessing the level of safety and risk, often based on familiarity with the road, influences the speed choice and the acceptable margin over the speed limit. This element is further developed by some participants who specify that the driver's abilities should play a role in the assessment of risk.

P33 (+4.5): *"It's a combination of how the road feels, how safe it is and the speed limit that is there. And, for example, in the first clip, the speed limit was lower than the feel of the road and the safety of the road. And therefore it is harder to adhere to the speed limit that is there."*
P27 (+5.0): *"There's a really big difference between a 50-year-old man speeding a little bit because he knows that his car is fast and he's paying attention to the road and he's in the left lane. Or like 18-year-olds that just got their licence"*

3.4. Potential of speed feedback

A few results offer insights into the potential of speed feedback to influence behaviour. Factors that would influence the potential of speed feedback are the potential in awareness gain, the participants' critical view on their own behaviour, and the acceptability of feedback.

3.4.1. Awareness gain

Participating in this study and being confronted with their speed behaviour could potentially increase participants' self-awareness and help them see their behaviour in a more objective way, yet only two participants explicitly indicated that watching the videos made them more aware of their speed excesses. The large majority of participants did not express any gain in self-awareness, mentioning they were already aware of their behaviour, while some of these participants were still reconsidering their behaviour. Another few participants expressed that being able to review their behaviour confirmed their view or helped them see that they drive slowly enough.

P10 (+13.0): *"It does. I usually think like "oh I've got an old car so the speedometer will be like ten kilometres too fast". But when I see this then, it turns out it really is [accurate]…"*
P24 (−0.7): *"Yes, I didn't know I was driving that often above the limit."*
P20 (+7.0): *"It was what I already knew. So, not really more aware. Like I already knew I was going. It's kind of normal."*
P15 (+8.44): *"I honestly think my driving would have been worse. I'm kind of satisfied with my speed and how I was driving. […] I wasn't going all that fast."*
P35 (+6.5): *"I know that I always speed a bit on the highway, and I don't always [drive] exactly [at] the speed limit, so I already kind of knew that. […] I was thinking, like, I didn't really need to go that fast, so it's better, I guess, just to go a bit slower because you never know what can happen."*

3.4.2. Critical views on own behaviour

Feedback would be most effective if drivers consider their behaviour as necessitating change, which appears, most often, to not be the case. Most participants stated that their speed was not problematic, or not problematic anymore. A few participants still recognised that their driving could make other drivers uncomfortable, although they would not consider it problematic. Only three participants judged their own speed as being sometimes problematic. Still, all three indicated that it happens when they drive alone and/or at night, and only put themselves in danger.

P33 (+4.5): *"If I have to be honest, I don't think it is problematic because, as you can see, there's still people speeding way more than me. And I try to mind it. And I have other things that I'm also very mindful of, like the distance between the car in front of me and myself."*
P18 (+27.9): *"I will say no because I always […] I always try to be mindful of the situation. I try to not drive like an idiot. […] When I started working and doing deliveries, I was going a little bit harder [faster]. Also in 30 zones, which is not good and I know that now. And I don't do that anymore."*
P23 (+7.5): *"I think sometimes people will think that I'm driving too fast. […] But most of the time I think in general I drive safely. And my speed is not the problem then."*
P28 (+4.7): *"Especially when the roads are empty, I would say I'm pretty much tempted to drive faster. I mean, it's not problematic for anyone else since I'm taking good care of my surroundings, I would say. But, as I said, when the streets are empty, it could be potentially dangerous for me as well."*

Not one participant explicitly mentioned that their speeding should be addressed and their behaviour changed, and a few participants even specified they do not think they should change.

P26 (+12.2): *"It depends if you want to change, I think. Like I think I'm driving fine. And then the app would say I speed too much. But then I just would do this [gestures dismissal] and not pay attention to it"*
P17 (+6.6): *"As I said, I think my deviations from the limits are within reason. So I'm generally satisfied with my driving behaviour regarding speed. So I don't think I would value the feedback."*

3.4.3. Acceptability of feedback

Most opinions about feedback were quite positive. Participants mentioned being "open to it", that they would "not mind it", or that it would be "fine" or "okay". A number of participants were even more positive, saying that "it would be great" or that they were "totally open" to it. Another few participants were quite negative, finding the idea "not fun" or that they would "find it annoying". Overall there was interest and open-mindedness, and all participants, although first reactions could be negative, were open to discussing the idea of feedback. A few recurring elements were discussed and are grouped thematically here.

3.4.3.1. Objective data and new insights vs assessment. Participants were enthusiastic and curious about receiving objective data about their behaviour, especially if it can offer them new insights into their habits, while being assessed and receiving advice based on data was disliked.

P30 (+0.6): *"I would like it a lot. I like to watch stuff like that. […] I like data, I like looking at that. And I would be very curious, honestly. Like, what are my driving habits?"*
P16 (+8.7): *"I don't like when an app is like, oh you can't do that or it's way too fast. So telling me what to do basically. […] Constantly being watched and being rewarded for good behaviour. Feels too much like babysitting I think."*
P34 (+8.1): *"Just receiving feedback, I think it helps. Everyone. But if it gets to, like "you cannot drive this fast", this and that, I probably might just rip the paper apart. […] Maybe if it kind of can notice certain parts of the road where you regularly drive too fast, okay, that it gives you advice on those parts […] it's more specific to the parts of the road, then it might help me."*

New insights could rely on location data, or include contextual clues in the feedback, but could also pertain to the consequences of the behaviour, and not only the behaviour itself.

P18 (+27.9): *"If it [the app] educates you on the dangers and stuff, maybe it might be effective. […] when it tells you why it's bad and what the consequence might be. That might be effective."*
P34 (+8.1): *"If it's about the speed limit only, then I wouldn't be too excited about that because I know I drive over the speed limit sometimes […] But if it's actual information which provides me with how to improve my driving, then I would be open to it, and I would like it."*

3.4.3.2. Perceived usefulness. Although participants do not seem to need better self-awareness and do not see their behaviour as necessitating change, they acknowledge that feedback has some potential for behaviour change. For most, receiving feedback could make them, or others, more aware of their speed, which could influence their behaviour. Some participants also specified that feedback might influence their speed behaviour if it were somewhat forced upon them, although this is not something they would want.

P15 (+8.4): *"An app that keeps track of how you drive. So if you don't think about it, then maybe your phone reminds you."*
P17 (+6.6): *"There's a difference between what people like and what they need. Of course. But, yeah, it might have an effect because it more frequently lets you make the comparison between actual speed and current speed limit."*

3.4.3.3. Immediate vs delayed feedback. Both types of feedback were discussed throughout the interviews. Immediate feedback was considered useful to prevent unintentional speeding, and it was suggested to select a higher threshold than the speed limit, to only alert on extreme speeding. Delayed feedback also appeared useful, as it can help drivers pay more attention to their speed in the long term.

P33 (+4.5): *"I think a speed alarm would help.[…] it is nice when you have this alarm because then you can just think like, now I am indeed speeding without noticing it"*
P22 (+9.1): *"I don't really pay attention to my speeding. If I see the notification or something afterwards. I'm like, oh, maybe I should pay attention to it. So I think because of it, I would pay more attention to the speed limit while driving."*

4. Discussion

This study investigated the potential for speed feedback, through an investigation into drivers' latent speed awareness, their subjective justifications for their behaviour, as well as their more general considerations towards speeding. The self-confrontation method allowed for interviews to be supported by objective traces of the activity, using video recordings to observe actual behaviours. The one hundred forty-eight recordings discussed throughout the study revealed a wide range of speed behaviours, ranging from 15 km/h under the speed limit to almost 45 km/h above the speed limit, on urban and rural roads as well as motorways, and in diverse driving conditions. The semi-structured interviews used neutral and both closed and open-ended interview questions to let participants express themselves as much as possible. As a result, this study offers insights into regular drivers' relationship to speeding behaviour and leads to recommendations for road safety interventions.

4.1. Awareness of speeding

The study's first aim was to determine whether drivers can improve their self-awareness upon receiving feedback, or upon being confronted with their behaviour, particularly in the event of speeding. Different factors indicate that drivers have a good latent awareness of the speed at which they drive: Participants were rarely surprised by their own speed behaviour, they most often claim to remember, or at least, recognise their speed behaviour, and the majority of them stated not having gained insight into their speed behaviour when discussing their video recordings, with only two participants realising they drove too fast. Moreover, participants were never entirely surprised by the speeds they were driving at, and it appears unlikely that there is a need for increasing drivers' speed self-awareness. An important conclusion is that drivers, in general, seem to be aware of their speed behaviour, to a certain degree.

According to Reason's research (Reason et al., 1990), speeding is classified as a violation, meaning that speeding is a conscious and deliberate choice, in most cases. Our findings confirmed previous findings on the self-reported awareness of speeding (Alonso et al., 2013) and seem to indicate that drivers remain conscious and aware of their speed. This result sheds light on the limited usefulness of informative feedback on speed behaviour: Regular drivers already know the speed at which they drive. This may explain why some feedback interventions are effective if combined with incentives (e.g., Mazureck & Van Hattem, 2006) but do not lead to a long-term behavioural change, as they do not improve drivers' self-assessment but temporarily influence their motivation. Although informative feedback may prove useful in certain conditions and with some populations (e.g., with novice drivers, Molloy et al., 2023), it should not be considered for a large-scale intervention for the general driving population.

4.2. Justifiability of speeding

Participants did not only seem aware of their behaviour, they also had no difficulty contextualising and justifying their speed behaviour. Although participants were prompted by the interviewer to rationalise and explain their behaviour, and they may not do so naturally, they were able to produce 40 different types of explanations, an average of 1.9 reasons per behaviour, and only one of the 148 excerpts discussed could not be rationalised. This justification ability further limits the usefulness of informative feedback, as drivers seem not only cognisant of their speed but also of the reasons behind their behaviour. Note that this almost infallible justification capacity may highlight a post-hoc rationalisation phenomenon (Summers, 2017): Participants may not have had specific motivations or justifications when speeding, but they can still produce such justifications afterwards, when confronted with their behaviour. This post-hoc rationalisation would mean that the justifications provided by the participants are not objective, but are the type of subjective reasons or excuses participants produce post hoc. But if this rationalisation method is at play in this self-confrontation study, it is likely to also be at play when drivers would receive feedback on their behaviour, which would again constitute a drawback of informative feedback as a safety intervention.

Furthermore, participants seemed never to consider their own speeding behaviour as potentially dangerous. Twenty of the participants knowingly exceeded the limit by more than 10 km/h at least once, yet not one participant considered their speed behaviour a potential risk factor for other drivers. Most participants also considered themselves to be good drivers (see Fig. 1). Drivers' self-assessment does not appear to rely on adherence to traffic rules: Drivers are unlikely to believe they are bad drivers because they speed. In fact, Reason et al. (1990) observed that subjects reporting the most violations rated themselves as particularly skilful, suggesting a belief that a good driver should have the ability to "bend the rules". In a previous study (Picco et al., 2023), about 30 % of the participants would not select "following traffic rules" as a criterion for being a good driver. Similarly, Doubek et al. (2021) interviewed drivers on what makes a good driver, and following the rules was only mentioned by a third of their participants. This raises questions about how traffic violations are perceived by drivers, but also points to another recommendation for traffic safety interventions. If the intervention nudges drivers towards a behaviour that does not fit their definition of a 'good driver', they are more likely to reject it. Safety interventions would either need to be tailored to drivers' definition of 'driving well', or influence that definition.

4.3. Normalisation of speeding

The study's second aim was to investigate how speeding is viewed and justified and how drivers choose their speed in general. The most salient result is how *normal* speeding is perceived to be. Almost half of the major speeding cases were regarded as usual behaviour, and it is also the most commonly used justification for speeding up to 10 km/h above the limit. Two other types of justifications add to this perceived normal aspect of speeding: Driving with the flow and considering that speeding is the norm, as everyone else does it. Participants also spontaneously explained why they were not driving faster in about 20 % of the speeding cases (15 % of the major and 26 % of the minor speeding cases), revealing that driving even faster was considered conceivable. Normalising speeding further, some drivers do not aim to drive at the speed limit, but calculate their own acceptable speed, mostly based on the theorised margin of error of their speedometer and of speed cameras. In this sense, speeding is not only a conscious violation but can also be considered a "normal violation".

The distinction between ordinary and aggressive violations was first made in 1997 (Lawton et al., 1997; Parker et al., 1998), and categorised (highway) speeding as an ordinary violation. This categorisation relied essentially on speeding not being a hostile behaviour towards other road users. In light of the present study's findings, it seems this definition can be extended: Speeding is not only not directly hostile to others; it is also considered normal driving and, in some instances, necessary to go with the traffic flow. Speeding was also often justified by a feeling of safety (almost 30 % of the major speeding cases). In this respect, speeding seems to be

considered a "normal-illegal violation", as defined by Amalberti et al. (2006) in a healthcare context. Labelling some speeding, or other traffic violations, as "normal-illegal" is rarely observed in the literature (e.g., Haué et al., 2022; Haué & Merlhiot, 2024), yet the data obtained in this study support this idea. Normal-illegal violations, labelled "borderline tolerated conditions of use" (BTCUs) (Polet et al., 2003), are viewed as a non-compliant but safe way to better performance or to access individual gains, and are characterised by the tolerance they receive. BTCUs can be considered acceptable, and such flexibility in the rules may even be required for a complex system to work (Amalberti et al., 2006), but to maintain safety, the challenge lies with the borders of the tolerated conditions of use.

Based on the results of the present study, the borders of the tolerated conditions of use are problematic. The first issue is the large inter-individual variability. When asked about an acceptable margin over the speed limit, some participants defined it as little as two or three km/h above the limit, while others were inclined to accept speed excesses of more than 30 km/h. These different perceptions of an acceptable speed are likely to lead to larger speed differences on the roads, which is a known risk factor (Aarts & van Schagen, 2006). A second issue is how extensive the BTCUs seem to be for the average driver, with driving 10 % over the speed limit declared acceptable for most of this study's sample. Similarly, Peterson and Gaugler (2021) found in a sample of 309 Americans that exceeding the speed limit by 10 mph (about 16 km/h) was viewed as safe and as the norm, and more studies have shown that there is less societal expectation to comply with speed limits than other traffic rules (Nieuwesteeg, 2020). Although a speed excess of 10 to 15 km/h may be relatively safe in certain situations, the general acceptance of such excesses increases risk, as higher speeds are associated with a greater likelihood of accidents (Nilsson, 2004), and accepting such freedom around speed limits undermines their effectiveness (Elvik, 2010). Finally, the normal-illegal concept should be considered in relation to Vaughan's normalisation of deviance (Vaughan, 1996): There is a systemic phenomenon of pushing the boundaries of which rules are considered acceptable to transgress, often as an answer to increased pressure and demand. It is therefore likely that, unless an external factor prevents it, the borders of the tolerated conditions of use may expand as the deviant behaviour gets normalised.

Speeding being considered a normal-illegal violation implies that speed reduction interventions cannot rely only on individual behaviour but also require a systemic approach. This element echoes recent approaches in safety and traffic safety research, for example, the Vision Zero policy (Johansson, 2009; Lie & Tingvall, 2024) and the Just Culture approach (Dekker, 2016; Dekker et al., 2011): To achieve better speed prevention, the blame cannot be solely on the driver. While it may remain effective to provide individual feedback, it is also necessary to tackle the issues identified with the normalisation of speeding on a more global scale. Attention should be paid to (1) homogenising drivers' views on speeding, (2) reducing the BTCUs (i.e., lowering the margin considered acceptable), and (3) maintaining an acceptable threshold for the BTCUs (i.e., preventing further normalisation of deviance). Suggestions to achieve these objectives are described in the next section.

4.4. Recommendations

Our recommendations for safety interventions are based on three main results: Drivers' latent awareness of their speeding behaviour (Result 1), their ability to justify this behaviour (Result 2), and the normalisation of speeding (Result 3). These findings indicate that individual informative feedback has limitations, as drivers appear to be already aware of their actions and able to rationalise them (Results 1 & 2). Therefore, a more comprehensive systemic approach may be required (Result 3). We recommend combining individual and broader systemic strategies to maximise effectiveness.

4.4.1. Individual approach

The present results still provide more specific recommendations for individual interventions. Informative feedback's main drawbacks were already discussed (Results 1 & 2), but this study also highlighted that drivers are not keen on having their behaviour assessed and being told to slow down. Switching from informative feedback (i.e., objective speed data) to assessment feedback (i.e., an evaluation of speed behaviour) is therefore also not advisable. Feedback could instead be used to address drivers' views on their own speeding, and their behaviour being normal and judged as safe. For example, a risk assessment could be provided (e.g., "A speed excess of *x* km/h increases crash probability by *y* %"), which could reduce drivers' feeling of safety, and by extension, reduce the BTCUs and their expansion. Similarly, a comparison with other drivers (e.g., "On this section, you drove *x* km/h faster than the average driver" or "On this section, 90 % of drivers do not speed") could be relevant to reduce the belief that speeding is the norm and could help homogenising drivers' views on speeding. Attention should, however, be paid not to provide data that could justify speeding (i.e., relying on data from drivers who speed to formulate advice), and as such, the comparison could be done with a pre-selected sample of drivers (e.g., "On this section, you drove *x* km/h faster than the average good driver"). Still, considering the better-than-average effect (Alicke & Govorun, 2005), drivers may be inclined to believe they are more skilled than others and could bend the rules more. A better understanding of drivers' individual and subjective reasons for speeding could allow for better tailoring of interventions, which should improve their effectiveness (Delhomme et al., 2009): Individual feedback could be tailored based on the particular reasons a driver gives to explain their speeding, to challenge those misconceptions.

4.4.2. Systemic approach

In addition to individual feedback and prevention, it is also necessary to influence global opinions about speeding. Peterson and Gaugler (2021) suggested learning from campaigns on distracted driving (e.g., phone use), which has become American drivers' top safety concern. Similarly, impaired driving (i.e., driving under the influence of alcohol or other drugs) was perceived as very or extremely dangerous by almost the entire sample of respondents in a Traffic Safety Culture report (AAA Foundation for Traffic Safety, 2023), compared to only half the sample ten years earlier (AAA Foundation for Traffic Safety, 2013). It seems therefore possible to change the public's perception on traffic safety topics, and it appears necessary to do so on the topic of speeding. Attention could be

paid, for example, in campaigns and in driver education to highlighting the strict character of the speed limits, with the aim to reduce the BTCUs. Besides influencing general opinions, existing approaches can reduce speeding, by making it less comfortable (e.g., with speed bumps or rumble strips), more natural not to speed (e.g., with self-explaining roads; see Charlton et al., 2010; Theeuwes & Godthelp, 1995), more conscious (e.g., with intelligent speed adaptation and speed sign recognition, both becoming mandatory in the EU), or even more costly (e.g., with police enforcement and fines).

4.5. Limitations, strengths and future research

There are a few limitations to take into account for the discussion and generalisation of these results. The study took place in the Netherlands, where traffic safety is relatively strong (SWOV, 2021): results may differ in different safety cultures. The sample selected for this study was also not exempt from biases; there were, for example, more women than men, which could have influenced the results considering gender differences in driving (González-Iglesias et al., 2012), and more participants in their twenties than other age groups, which could also have had an influence (Begg & Langley, 2001). These biases may have influenced the results, for example, regarding participants' latent awareness, which may differ based on the age and experience of the driver. The sample was also more inclined to believe they could improve their driving than the general population, which is likely to make them more open to the idea of receiving feedback and to question their own behaviour. Another important point is that participants volunteered to participate in a study about their driving, and it can be hypothesised that drivers with the riskiest driving style would not be interested in joining. The sample size was small relative to other studies conducted on the topic of speeding (see e.g., Perez et al., 2021 with a naturalistic study), but can be considered sufficient in interview studies (Francis et al., 2010) to reach data saturation.

The external validity of this study may suffer from these sampling biases, and different participant recruitment could have been beneficial. Nonetheless, this study relies on a quite strong and cost-effective methodology: With a few cameras, objective driving data could be collected and viewed with participants, guiding context-dependent and open discussions. This naturalistic and observational study ensures the ecological validity of the results and should be easily replicable.

Future research could further investigate drivers' self-awareness, and not only their latent awareness, to reinforce the results obtained here. One option would be to specifically investigate the relation between self-reported and actual speeding behaviour. Another option, which also relies on self-confrontation, would be to confront participants with their recordings *without* the speed displayed, and investigate their memory and recollection of their behaviour. The use of ADAS (specifically adaptive cruise control) and its influence on awareness could also then be investigated.

5. Conclusion

Regular drivers generally have a high level of latent self-awareness concerning their speed and easily rationalise their behaviour, which limits the use and potential of informative feedback. Speeding seems considered normal and safe (on average, up to 10 % above the limit), highlighting a more systemic phenomenon of normalisation of this violation, and calling for a systemic answer. It seems therefore unlikely that merely providing individuals with informative speed feedback will have a positive effect on their speed behaviour. Several alternative recommendations for prevention strategies have been formulated.

While this study indicates that speeding would be better addressed through a more global prevention campaign, aiming to change norms and shared beliefs about its normality, other risky and/or deviant behaviours on the roads may still benefit from informative feedback. It is important to first assess whether drivers are aware of their behaviours to determine whether informative feedback would be effective. Also, as discussed in the limitations, this normalisation of speeding may not occur in countries with different safety cultures, and it is therefore important to first assess how risky behaviours are perceived in order to better prevent them.

Finally, this study revealed that most drivers rely on specific justifications and personal safety assessments to determine their speed, rather than simply following the rules. This may constitute valuable information in itself, because normative safety (i.e., safety relying on rules alone) may not be sufficient to completely ensure safety and needs to be complemented by adaptive safety (i.e., human expertise and adaptability) (Cuvelier & Falzon, 2011; Nascimento et al., 2013). Behavioural variability and deviations from the rules may provide valuable insights into the limitations of normative safety. For example, these deviations can indicate discrepancies between road design and speed limits. Therefore, monitoring driver behaviour could help identify safety–critical road sections rather than focusing solely on identifying safety–critical drivers.

CRediT authorship contribution statement

Angèle Picco: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Data curation, Conceptualization. **Arjan Stuiver:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Joost De Winter:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization. **Dick De Waard:** Writing – review & editing, Supervision, Project administration, Methodology, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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