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DOI
10.1016/j.trf.2024.12.021

Publication date
2025

Document Version
Final published version

Published in
Transportation Research Part F: Traffic Psychology and Behaviour

Citation (APA)
de Winter, J. C. F., Onkhar, V., & Dodou, D. (2025). Cross-national differences in drivers' eye contact and traffic violations: An online survey across 20 countries. *Transportation Research Part F: Traffic Psychology and Behaviour*, *109*, 711-725. https://doi.org/10.1016/j.trf.2024.12.021

Transportation Research Part F: Psychology and Behaviour 109 (2025) 711–725

Contents lists available at ScienceDirect

Transportation Research Part F: Psychology and Behaviour

journal homepage: www.elsevier.com/locate/trf

Cross-national differences in drivers' eye contact and traffic violations: An online survey across 20 countries

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ARTICLE INFO

Keywords:
Online study
Crowdsourcing
Aggressive driving
Eye contact
Communication
Cultural differences

ABSTRACT

The advent of self-driving cars has sparked discussions about eye contact in traffic, particularly due to challenges that automated vehicles face in non-verbal communication with human road users. In his 1992 book, *Turn Signals Are The Facial Expressions Of Automobiles*, Don Norman describes how drivers in Mexico City deliberately avoid eye contact when entering a roundabout to create uncertainty in the minds of other drivers, leading the latter to yield right of way. Norman argued that such manipulative or aggressive behavior would not be tolerated in the United States. In the present study, we tested these claims through an online survey involving 3,857 respondents from 20 countries. The results confirmed that Mexican drivers reported a higher frequency of non-speeding 'aggressive' violations compared to those from most other countries. Regarding eye contact in the roundabout scenario presented in the survey, national differences were found not so much in the frequency of eye contact but in the reasons behind its use. Mexican drivers tended to avoid eye contact to reduce tension or avoid conflict with other drivers. However, they also frequently reported making eye contact to assert or subtly enforce their right of way. In higher-income countries like the United States, driver-driver eye contact is often deemed unnecessary. In conclusion, our findings partially correspond with Norman's anecdote based on his experiences in 1950s Mexico City. These results may have implications for understanding the stability of traffic cultures and the challenges related to eye contact and non-verbal communication faced by developers of automated vehicles.

1. Introduction

In the last decade, there has been some scientific debate about the importance of eye contact in traffic. This has been fueled by concerns that automated vehicles cannot engage in social interaction or non-verbal communication (of which eye contact is one example) and therefore may struggle to navigate complex traffic situations involving human road users (e.g., Dey et al., 2022; Rasouli & Tsotsos, 2020; Rouchitsas & Alm, 2019; Sahaï et al., 2022). Additionally, there is the belief among traffic researchers that sizable national and cultural differences exist in these behaviors (e.g., Üzümcüoğlu et al., 2018), adding an additional layer of complexity that automated vehicle developers may need to consider.

The current study was conducted with the hypothesis that there are significant cross-national differences in making or avoiding eye contact by drivers. The direct inspiration for this paper is the following passage from the book, *Turn Signals Are The Facial Expressions Of Automobiles*, by the designer and researcher Prof. Don Norman:

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https://doi.org/10.1016/j.trf.2024.12.021
Received 24 August 2024; Received in revised form 9 November 2024; Accepted 15 December 2024
Available online 8 January 2025

"*Imagine doing this in traffic: signaling a left turn, hoping that this will open up a hole in traffic that will let you dart to the right. I once got a driver's license in Mexico City, where aggression was the rule. But even there, intentions had to be signaled honestly. Above all, it was essential to avoid eye contact with other drivers. In the traffic circles of the city, the trick was to avoid letting the other drivers see that you had seen them. Once the other drivers knew that you knew they were there, they would proceed at high speed around the circle, completely ignoring your presence, because they knew that you knew that they were there, so they expected you to stop or slow down. And you had to, or be killed. On the other hand, if you could manage to avoid letting them see you see them, you could proceed with impunity, because now it was their responsibility to avoid you. If you collided, it couldn't have been your fault, because after all, you hadn't seen them.*

Most places in the United States don't let you get away with such games. In my community in southern California, for example, fault and blame are mechanically assigned according to strict orders of precedence. The rules of the road determine whose responsibility it is to avoid accidents." (Norman, 1992, p. 130).[1]

Norman suggests here that as a driver in Mexico, it might be useful to *not* make eye contact with other drivers. This strategy has been noted before, not only regarding Mexico (Lomnitz, 2001, p. 60; Vanderbilt, 2008, p. 32), but also beyond, as a general strategy to obtain right of way (Portouli, Nathanael, Gkikas, Amditis, & Psarakis, 2019; Rubin, Steinberg, & Gerrein, 1974; Youssef, Plant, & Waterson, 2024). However, to the best of our knowledge, this has not yet been empirically substantiated.

Building on previous cross-national research (Bazilinskyy, Kyriakidis, Dodou, & De Winter, 2019; De Winter & Dodou, 2016; De Winter, Kyriakidis, Dodou, & Happee, 2015; Üzümcüoğlu, Özkan, & Lajunen, 2018), we conducted an online survey across 20 countries using the platform Prolific. Respondents were asked about their eye contact behavior in a hypothetical traffic scenario similar to one described by Norman. In addition to assessing the frequency of traffic violations across these countries, we examined whether drivers in Mexico and the United States differ in terms of self-reported eye contact behavior. Additionally, we analyzed correlations between country means of eye contact behaviors, self-reported traffic violations, and other factors that might influence eye contact and interactions in traffic, such as social anxiety. The cross-national analysis also incorporated public statistics, which may serve as indicators of the level of traffic complexity in different countries.

2. Methods

2.1. Participant recruitment

This study recruited participants through the online research platform Prolific (Douglas et al., 2023; Peer et al., 2021). We first assessed, per country, the number of potentially available respondents on Prolific. Next, we launched 20 identical surveys, each targeting 200 participants from the 20 most represented countries. These countries were Australia, Canada, Chile, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Mexico, the Netherlands, New Zealand, Poland, Portugal, South Africa, Spain, Sweden, the United Kingdom, and the United States. Only participants who previously indicated in the Prolific database that they had a valid driving license or learner's/driver's permit were eligible to participate.

The surveys were made public on Friday, August 9, 2024, and Monday, August 12, 2024, at 4:00 PM local time for each participating country. This scheduling approach was introduced to reduce variance across countries due to differences in response times (daytime vs. nighttime). The survey ended when 200 participants from that country had taken part. We kept the survey open for 1 week (i.e., until August 16, 2024) for Chile and Japan, two countries where the target of 200 participants was not reached. All respondents received a recommended payment of £9.00 per hour, equivalent to £0.75 for the estimated 5-minute completion time of the survey.

The research was approved by the TU Delft Human Research Ethics Committee (Reference Number 4182). Respondents provided informed consent via a dedicated questionnaire item.

2.2. Survey questions

Participants accessed the study via Prolific, where they were provided with a hyperlink to the survey platform Qualtrics to complete our survey titled 'Eye contact in traffic'. The survey started with an informed consent item. This was followed by an image of a busy roundabout created by the generative AI model, DALL-E3 (Betker et al., 2023) (see Fig. 1), together with three multiple-choice questions with five response options each:

E1) "*You are entering a chaotic roundabout in your country, such as in the image above. How likely are you to make eye contact with other drivers?*" (1: Highly unlikely, 5: Highly likely).

E2) "*I would normally **avoid eye contact** with approaching drivers at the roundabout to increase my chances of entering the roundabout.*" (1: Strongly disagree, 5: Strongly agree).

E3) "*I would normally **make eye contact** with approaching drivers at the roundabout to increase my chances of entering the roundabout.*" (1: Strongly disagree, 5: Strongly agree).

[1] Norman added in a footnote: "*Please note that I do not wish to imply that the driving habits of cultures carry over to other behaviors. Mexicans are certainly not more aggressive a people than the British. If anything, they have been much more the victims of aggression. But the differences in driving behavior are striking.*" (p. 191).

Fig. 1. Image of a busy roundabout created using generative AI, as shown to participants during the survey.

These were followed by the open-ended question (E4) "*Explain your answers to the above three questions*." A response of at least 20 characters was required here.

Next, the survey included questions about gender (D1), age (D2), household income (D3), age when a driving license was first obtained (D4), number of accidents in the last 3 years (D5), driving frequency in the last 12 months (D6), and mileage in the last 12 months (D7).

It further included a 7-item violations scale from the Driver Behavior Questionnaire (DBQ; De Winter, 2013), coded from 1 (*0 times per month*) to 5 (*10 or more times per month*). The survey also included a 5-item version of the Social Interaction Anxiety Scale (SIAS; Fergus et al., 2012), supplemented with one item from the long SIAS regarding difficulty in making eye contact with others (Mattick & Clarke, 1998), on a scale of 1 (*Not at all*) to 5 (*Extremely*). The SIAS items were included to investigate whether social anxiety is a contributing factor in eye contact during traffic interactions.

The last item concerned delay discounting. Participants were asked: "*Would you prefer*", with the response options being "*50 USD today*" or "*100 USD in one month*". Based on previous research on national differences in temporal discounting (Wang et al., 2016), we expected that choosing the more impulsive option of "*50 USD today*" might predict aggressive driving behaviors.

Twelve out of the 22 multiple-choice questions (more specifically, the demographic questions and the DBQ items) included an "*I prefer not to respond*" option. The full questionnaire is available in the data repository.

2.3. Cross-national differences in non-speeding 'aggressive' violations

First, the seven DBQ violations items were classified using principal component analysis (PCA) into 'non-speeding violations', 'speeding violations', or 'other violations' (see Table A1 in the Appendix A). Violations that loaded strongly on both components were labeled as 'other violations'. The obtained non-speeding violations have also been described as 'aggressive violations' (see Lawton et al., 1997).

Next, we calculated a non-speeding violations score for each respondent by summing the scores across three items:

- Item 1: "*Becoming angered by a particular type of driver, and indicating your hostility by whatever means you can.*"
- Item 5: "*Racing away from traffic lights with the intention of beating the driver next to you.*"
- Item 6: "*Sounding your horn to indicate your annoyance with another road user.*"

For participants who selected "*I prefer not to respond*" for one or more DBQ items, we imputed values for these 'missing' responses with the corresponding value from the nearest-neighbor column, identified using the nearest-neighbor interpolation method based on Euclidean distance.

We then calculated the country means and corresponding 95% confidence intervals for the non-speeding violations score to determine whether Mexico had a higher score compared to the United States and the other 18 countries. Additionally, we conducted independent samples *t*-tests on the non-imputed scores of the individual DBQ violation items to assess whether respondents from Mexico reported more non-speeding violations than those from the United States.

2.4. Cross-national differences in making and avoiding eye contact

We calculated national averages and 95% confidence intervals for questions E2 and E3, and plotted them to assess whether making or avoiding eye contact in traffic was a more common strategy in Mexico than in the United States. As an additional analysis, we also

conducted a comparison between Mexico and the Netherlands. Independent samples *t*-tests were used for the country comparisons.

2.5. Cross-national differences in the reasons for making and avoiding eye contact – Manual analysis

Each respondent provided a statement in question E4 explaining their responses to the previous three questions (E1–E3), i.e., regarding why they would or would not make eye contact in the scenario shown in Fig. 1. The responses from all participants in Mexico and the United States, following Norman's (1992) assertion, were manually categorized, with responses from the Netherlands included as an additional group.

Specifically, one author performed a content analysis of an Excel file containing 600 question E4 responses (199 from Mexico, 200 from the United States, and 201 from the Netherlands) sorted alphabetically, and without having any information on the individual respondents' countries of residence. The author was given the following guidance: "*Please define a number of categories (columns) and mark whether each comment belongs to the respective category(ies). For example, one category could be 'avoids eye contact to focus on the road/minimize distractions*'.". In other words, the annotator remained blind to each respondent's country, and a response from a respondent could potentially be placed in more than one category.

After completing the coding, we present the percentage of respondents in each category and use Fisher's exact test to determine a *p*-value for the difference between Mexico and the United States for each of the 15 identified categories. We considered a *p*-value less than 0.05 as a tendency, and a *p*-value less than 0.0033 (0.05 / 15, adjusted with a Bonferroni correction) as statistically significant.

2.6. Cross-national differences in the reasons for making and avoiding eye contact – Automated analysis

As a follow-up to the manual coding described above, we employed an automated annotation of all responses to question E4. For this purpose, we used OpenAI's *o1-preview* (model: *o1-preview-2024–09-12*; OpenAI, 2024). Details on how all responses were categorized into 15 categories can be found in Appendix B.

OpenAI's *o1-preview* is a novel AI model that not only completes prompts in an autoregressive manner but also performs reasoning steps, which improves its capabilities in complex systemization tasks (De Winter et al., 2024). Our subjective assessment indicates that *o1-preview* excels in annotation, possibly surpassing the accuracy of a human annotator. Given the impracticality of manually categorizing all 3,857 comments, we opted to use *o1-preview* for automatic annotation in our national analysis (in addition to the manual annotation for Mexico, the United States, and the Netherlands).

2.7. National predictors of eye contact behavior

Finally, we examined whether country means of three eye contact variables ([1] an eye contact score, calculated by summing the scores of E1, reverse-coded E2, and E3; [2] based on the *o1-preview*-based annotations of E4, whether the respondent avoids eye contact to gain priority, and [3] avoids eye contact because it is deemed unnecessary) correlated with the country means of the SIAS score, the non-speeding violations score, respondent age, and delay discounting. This correlation analysis also included some indicators that we

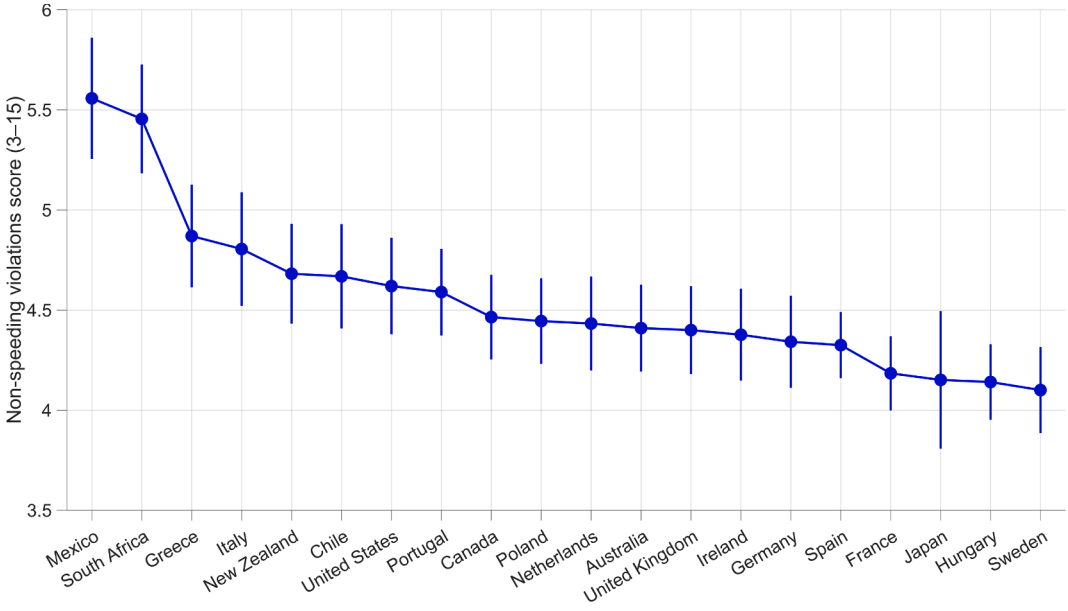

Fig. 2. Country means for the DBQ non-speeding violations score. The items were scored from 1 (0 times per month) to 5 (10 or more times per month). The results are sorted in descending order of the means. The vertical lines represent 95% confidence intervals of the means.

Table 1
Means, standard deviations (*SD*), and results of a *t*-test between Mexico and the United States, for the seven individual DBQ violations items ($n = 20$ countries).

DBQ violations item How often do you do the following?: …	Type of violation	Mexico Mean (*SD*)	United States Mean (*SD*)	Independent-samples *t*-test
1. Becoming angered by a particular type of driver, and indicating your hostility by whatever means you can	Non-speeding	2.18 (1.10)	1.75 (0.96)	$t(392) = 4.11$, $p < 0.001$
2. Disregarding the speed limit on a motorway	Speeding	1.93 (1.07)	2.27 (1.34)	$t(390) = -2.75$, $p = 0.006$
3. Disregarding the speed limit on a residential road	Speeding	1.62 (1.01)	1.79 (1.14)	$t(394) = -1.58$, $p = 0.114$
4. Driving so close to the car in front that it would be difficult to stop in an emergency	Other	1.48 (0.88)	1.23 (0.55)	$t(396) = 3.35$, $p < 0.001$
5. Racing away from traffic lights with the intention of beating the driver next to you	Non-speeding	1.44 (0.86)	1.23 (0.55)	$t(396) = 2.92$, $p = 0.004$
6. Sounding your horn to indicate your annoyance with another road user	Non-speeding	1.93 (0.99)	1.63 (0.76)	$t(396) = 3.46$, $p < 0.001$
7. Using a mobile phone without a hands free kit	Other	1.91 (1.18)	1.79 (1.06)	$t(395) = 1.04$, $p = 0.301$

Note. Responses for all seven items were coded as: (1): 0 times per month, (2): 1 to 3 times per month, (3): 4 to 6 times per month, (4): 7 to 9 times per month, (5): 10 or more times per month.

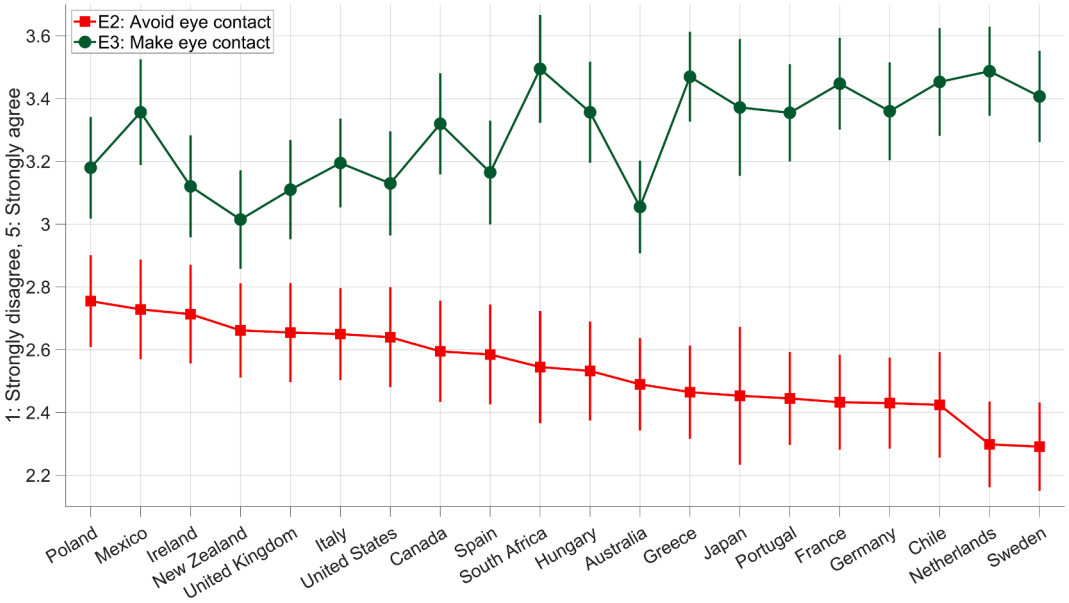

Fig. 3. Country means for question E2: "*I would normally **avoid eye contact** with approaching drivers at the roundabout to increase my chances of entering the roundabout*" (red) and question E3: "*I would normally **make eye contact** with approaching drivers at the roundabout to increase my chances of entering the roundabout*" (green). The results are sorted in descending order of the means of E2. The vertical lines represent 95% confidence intervals of the means.

thought could have predictive value for driving behavior in a given country (based on Bazilinskyy et al., 2019; De Winter & Dodou, 2016), namely GNI per capita as of 2023 (downloaded from World Bank, 2024a), life expectancy at birth as of 2022 (World Bank, 2024b), and number of traffic fatalities per 100,000 population as of 2021 (World Bank, 2024c; World Health Organization, 2024).

3. Results

3.1. Survey completion information

We excluded respondents who did not fully complete the survey (including those who failed to enter the payment code) and those whose country of residence was not available in the Prolific database.

A total of 3,857 respondents completed the survey and were included in the analysis. Out of the 20 countries, 18 countries had 199 to 201 respondents, while Chile had 172 respondents and Japan had 86 respondents due to insufficient participants from these countries to reach the anticipated 200. The occurrence of 199 or 201 respondents instead of the expected 200 in some countries was due to a technical glitch in Prolific or the above-mentioned exclusions.

321 out of the 3,857 respondents selected the "*I prefer not to respond*" option for the household income question (D3). The question about mileage (D7) was answered with "*I prefer not to respond*" in 128 cases, while the remaining questions had 42 or fewer "*I prefer not to respond*" selections. The median time to complete the survey was 5.25 min.

The overall mean age of the respondents was 34.3 years ($SD = 11.0$, $n = 3{,}857$). The sample consisted of 1,754 females (45.5%), 2,078 males (53.9%), and 25 respondents (0.6%) who ticked "*I prefer not to respond*".

3.2. Cross-national differences in non-speeding 'aggressive' violations

Based on the country means and 95% confidence intervals of the non-speeding violations scores in Fig. 2, it is clear that Mexico scores high. The United States ranked 7th, the Netherlands 11th, while Sweden ranked the lowest in terms of non-speeding violations.

In Table 1, we present the results per DBQ item of the comparison between Mexico and the United States. The non-speeding violations (Items 1, 5, 6) were more frequent in Mexico, while speeding violations (Items 2 and 3) were more frequent in the United States. Thus, the findings provide support for Norman's (1992) claim that aggression is higher in Mexican traffic compared to traffic in the United States.

3.3. Cross-national differences in making and avoiding eye contact

Fig. 3 shows the means per country for questions E2 and E3, with corresponding 95% confidence intervals. The results are sorted in descending order based on E2 ('avoid eye contact'), represented by red markers. It can be seen that respondents were more likely to

Table 2
Categories in which the 600 responses to the question "*Explain your answers to the previous three questions*" (E4) were annotated.

	Category	Abbreviation
1	Avoids eye contact in order to focus on the road / minimize distractions / out of safety considerations *Example: "Eye contact can be a distraction and can cause accidents."*	Avoids – focus
2	Avoids eye contact because it is stressful / uncomfortable / not liking eye contact in general Example: "*eye contact on its own is stressful…eye contact in a high stress environment like the described scenario, would drive me mad.*"	Avoids – stress
3	Avoids eye contact to prevent yielding right of way / increase chance to enter Example: "*if you focus on your car and their car and don't make eye contact they are more likely to let you in*"	Avoids – obtain
4	Avoids eye contact to prevent irritating the other driver / getting intimidated Example: "*other drivers might be aggressive so I definitely avoid eye contact at any moment while driving.*"	Avoids – prevent
5	Does not use eye contact because is not needed; kinematics / blinkers / rules give the necessary information / it is safer to rely on objective information *Example: "I don't really make eye contact with other drivers in those situations. I just look at car's positions and make decisions based on that."*	Avoids – not needed
6	Does not make eye contact as it is not physically possible because of e.g., distance, speed, or window glare Example: "*Some vehicles also have darker tint than others, or drivers may be wearing sunglasses, so I might not be able to make eye contact.*"	Avoids – impossible
7	Makes eye contact to achieve mutual awareness / out of politeness / reciprocation Example: "*I find more success on the road when I make eye contact with drivers to convey understanding and to be polite and considerate.*"	Makes – politeness
8	Makes eye contact to indicate intentions / make oneself noticeable / indicate to the other drivers they have been noticed Example: "*I feel that making eye contact ensures the other driver sees you and know you are there*"	Makes – noticeable
9	Makes eye contact to receive information about the other driver's intentions or state / to see if the other driver has noticed them Example: "*might make eye contact to see what the other driver would do*"	Makes – receive
10	Makes eye contact to increase the chance to get right of way / ask permission Example: "*giving eye contact in my opinion increases your chance of getting into the roundabout because other drivers can see that you're trying to enter.*"	Makes – ask
11	Makes eye contact for safety reasons Example: "*Eye contact is a good way to avoid an accident*"	Makes – safety
12	Makes eye contact to thank or criticize an action already taken Example: "*I don't like to make eye contact I just do it when they do something wrong*"	Makes – feedback
13	Eye contact might not have an effect / can happen accidentally / not on purpose Example: "*I don't feel that eyecontact should change the flow of traffic*"	No effect
14	Makes or avoids eye contact depending on the situation or culture Example: "*Everything depends on the way the roundabout works and the place you are driving*"	It depends
15	Non-specific / unclear / other Example: "*Eye contact is very important when you drive*"	Other

indicate making eye contact (E3) than not making eye contact (E2).

Regarding the mean scores for E2, Mexico is high up (2nd highest from the 20 countries) compared to the United States in 7th place, which is in line with Norman (1992). However, the former's 95% confidence intervals still overlap with those of many other countries, including the United States. The difference between Mexico ($M = 2.73$, $SD = 1.14$) and the United States ($M = 2.64$, $SD = 1.14$) was not significant, $t(397) = 0.78$, $p = 0.437$.

Furthermore, Mexico was located in the middle in terms of making eye contact (E3) (9th and 10th highest from the 20 countries; *ex aequo* with Hungary). Again, the difference between Mexico ($M = 3.36$, $SD = 1.21$) and the United States ($M = 3.13$, $SD = 1.19$) was not significant, $t(397) = 1.89$, $p = 0.060$.

In summary, while there were statistically significant differences between countries (see non-overlapping confidence intervals in Fig. 3), no statistically significant support was found for Norman's (1992) claim that the eye contact behavior of drivers in Mexico and the United States is different. However, responses to our multiple-choice questions do not reveal the reasons *why* drivers make or avoid eye contact. For this, the answers to the free-response question (E4) need to be considered.

3.4. Cross-national differences in the reasons for making and avoiding eye contact – Manual analysis

The human annotator identified a total of 15 thematic categories, as shown in Table 2. The 600 responses to question E4 from participants in Mexico, the United States, and the Netherlands were manually categorized into these 15 categories, with a response being allowed to fall into more than one category. Respondents indicated a variety of reasons for avoiding or making eye contact.

Avoiding eye contact was reported by participants because: they preferred to focus on the traffic itself (1), they generally felt uncomfortable with eye contact (2), eye contact was not considered useful compared to more objective information (5), or because eye contact was impossible, e.g., due to windshield glare (6). Avoiding eye contact was also reported as a deliberate strategy to gain right of way, as described by Norman (1992) (3), or to avoid conflicts (4).

On the other hand, *making* eye contact was reported by participants because: it was a polite gesture (7), a way to make themselves known to other drivers (8), or a way to confirm or ensure that other drivers had noticed them (9). Eye contact was also reported as a means to ask for right of way or to subtly enforce it (10), made primarily for safety reasons (11), or as a 'thank you' to or criticism of other drivers for an action they took (12).

Table 3 presents the percentage of respondents per category for all countries (based on *o1-preview*) and for the three countries annotated by the human annotator.

Several observations can be made based on the human annotator's results:

- There is some support for Norman's (1992) statement that not making eye contact to gain right of way (3. Avoids – obtain) is more common in Mexico (6%) compared to the United States (3%). However, the difference was not significant ($p = 0.135$).
- In Mexico, it is relatively common for respondents to avoid eye contact due to anxiety, discomfort, or a general aversion to direct gaze (2. Avoids – stress) ($p = 0.022$ for Mexico vs. the United States).
- Respondents from Mexico tend to avoid eye contact to prevent potential conflict or aggression (4. Avoids – prevent) ($p = 0.037$ for Mexico vs. the United States).

Table 3
Percentage of respondents across the 15 response categories for the question, "*Explain your answers to the previous three questions*" (E4). A distinction is made between annotation by *o1-preview* and by the human annotator.

	o1-preview																				Human annotator			
	AUS	CAN	CHL	FRA	DEU	GRC	HUN	IRL	ITA	JPN	MEX	NLD	NZL	POL	PRT	ZAF	ESP	SWE	GBR	USA	NLD	MEX	USA	*p*
1 Avoids – focus	20	18	12	12	13	12	11	20	19	13	12	12	26	22	13	20	17	12	23	19	11	10	15	0.127
2 Avoids – stress	5	7	6	4	7	5	3	3	6	5	13	3	3	10	6	3	7	3	7	7	2	12	6	0.022
3 Avoids – obtain	2	0	2	3	2	3	1	1	2	2	4	0	1	1	2	3	2	2	2	2	1	6	3	0.135
4 Avoids – prevent	2	3	3	2	3	3	3	2	2	5	5	2	2	4	1	3	5	0	6	2	1	4	1	0.037
5 Avoids – not needed	31	27	17	15	21	13	24	30	22	17	11	21	38	20	18	12	23	24	23	22	21	9	23	< 0.001
6 Avoids – impossible	6	4	3	3	4	1	4	3	2	2	3	6	8	2	4	1	3	12	7	5	6	2	3	0.724
7 Makes – politeness	11	8	9	10	10	6	10	9	4	9	7	9	7	6	11	15	9	8	10	9	9	7	9	0.570
8 Makes – noticeable	8	17	18	12	14	9	13	9	10	22	17	16	9	8	16	18	12	9	10	15	13	8	11	0.300
9 Makes – receive	25	22	17	30	20	26	27	13	32	24	13	26	20	18	30	26	22	24	15	21	18	8	14	0.106
10 Makes – ask	9	17	34	22	20	25	13	24	15	20	35	17	13	20	26	16	19	10	23	17	14	33	17	< 0.001
11 Makes – safety	16	19	9	14	12	15	14	3	10	16	9	11	10	9	8	25	11	16	6	15	10	9	14	0.150
12 Makes – feedback	2	1	1	1	0	2	1	1	2	2	3	1	1	1	2	1	2	1	0	2	1	2	2	1.000
13 No effect	10	6	4	8	9	6	5	8	10	9	6	7	9	6	9	1	7	3	8	7	5	3	7	0.106
14 It depends	12	8	8	10	17	9	13	13	11	14	12	16	17	8	10	5	8	19	13	14	16	12	17	0.201
15 Other	4	5	2	5	6	8	9	5	3	5	5	7	1	6	5	11	9	12	4	6	10	9	9	1.000

Note. The *p*-values are the results of Fisher's exact tests between Mexico and the United States. Color gradient is applied linearly from the lowest value (0%; blue: RGB 90,138,198) to the 50th percentile (8.5%; white) to the highest value (38%; red: RGB 248,106,106).

Table 4
Pearson's product-moment correlation matrix among all country means and national variables ($n = 20$ countries).

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	S	Eye contact score (3–15)															
2	S	*o1-preview.* Avoids − obtain (%)	0.12														
3	S	*o1-preview.* Avoids − not needed (%)	−0.58	−0.61													
4	S	Percentage males (%)	0.38	0.01	−0.28												
5	S	Age (years)	−0.48	−0.11	0.45	−0.45											
6	S	Household income (1–9)	−0.26	−0.52	0.67	−0.42	0.49										
7	S	Age driver's license (years)	0.36	0.06	−0.33	−0.03	0.03	−0.29									
8	S	Driving frequency (1–6)	−0.45	0.14	0.04	−0.59	0.24	−0.07	−0.06								
9	S	Mileage (1–10)	−0.44	−0.05	0.15	−0.62	0.14	0.05	−0.08	0.90							
10	S	No. of accidents (0–6)	0.11	0.59	−0.53	−0.08	−0.59	−0.60	0.02	0.42	0.34						
11	S	Delay discounting (% USD 100)	0.01	−0.24	0.32	0.52	0.16	0.36	−0.18	−0.52	−0.43	−0.59					
12	S	SIAS score (6–30)	−0.24	0.22	−0.12	−0.05	−0.44	−0.19	−0.24	−0.02	0.06	0.45	−0.16				
13	S	Non-speeding violations score (3–15)	−0.07	0.51	−0.44	−0.29	−0.24	−0.52	0.00	0.68	0.52	0.83	−0.69	0.28			
14	P	Fatal accidents/100,000 population	0.10	0.39	−0.43	−0.43	−0.42	−0.43	0.07	0.50	0.45	0.75	−0.86	0.35	0.76		
15	P	GNI per capita (USD)	−0.30	−0.42	0.61	−0.40	0.59	0.95	−0.33	0.02	0.08	−0.62	0.41	−0.29	−0.50	−0.46	
16	P	Life expectancy (years)	−0.19	−0.29	0.48	0.36	0.49	0.48	−0.20	−0.35	−0.40	−0.70	0.83	−0.27	−0.67	−0.91	0.53

Note. S: Based on responses from the current survey, P: Based on publicly available national statistics. Color gradient is applied linearly from −1 (red: RGB 248,106,106) to 0 (white) to 1 (blue: RGB 90,138,198).

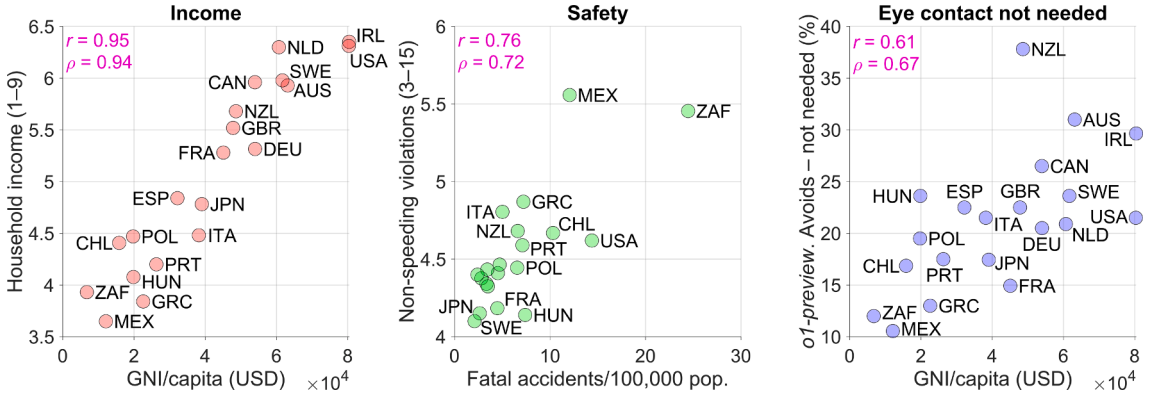

Fig. 4. Country means obtained from the current online survey (*y*-axis) vs. national statistics (*x*-axis). Each circular marker represents an individual country. *r* stands for Pearson's product-moment correlation coefficient, and ρ stands for Spearman's rank-order correlation coefficient.

- In the United States and the Netherlands, avoiding eye contact is common because drivers believe eye contact serves no direct purpose, for example because explicit cues (like turn indicators) provide the needed information (5. Avoids − not needed) ($p < 0.001$ for Mexico vs. the United States).
- Interestingly, *making* eye contact to request right of way (10. Makes − ask) is also common in Mexico ($p < 0.001$ for Mexico vs. the United States).

In summary, it appears that drivers in Mexico experience a more social dynamic while driving, where, on the one hand, eye contact is avoided to prevent stress or conflict (Categories 2 and 4), and on the other hand, eye contact is made to engage more assertively in confrontation (Category 10); in comparison, in the United States and the Netherlands, eye contact between drivers in a roundabout scenario is not always deemed essential and may therefore not be made (Category 5). The latter would be consistent with Norman (1992, "*The rules of the road determine whose responsibility it is to avoid accidents*", p. 130).

3.5. National predictors of eye contact behavior

Table 4 presents correlations between national variables, specifically eye contact variables, country averages for demographics, the social interaction anxiety scale (SIAS) score, and the non-speeding violations score (also shown in Fig. 2), supplemented with national statistics (the number of fatal accidents per 100,000 population, gross national income per capita, and life expectancy).

First, it is noticeable that some correlations are strong. For example, self-reported household income very strongly correlates with GNI per capita ($r = 0.95$; see Fig. 4; left), and the non-speeding violations score moderately correlates with self-reported driving frequency ($r = 0.68$) and with the number of fatal accidents per 100,000 population ($r = 0.76$; see Fig. 4; middle).

Regarding selected eye contact scores (Columns 1 to 3), the correlations with the other variables are less strong. However, results

show that self-reported eye contact while entering a roundabout (Variable 1) is less common in higher-income countries ($r = -0.26$ for self-reported household income, $r = -0.30$ for GNI per capita). Furthermore, the percentage of respondents in the '*Avoids – not needed*' category (Variable 3) positively correlates with national income ($r = 0.67$ for self-reported household income, $r = 0.61$ with GNI per capita; see Fig. 4, right). This supports our above suggestion that drivers in wealthier countries consider eye contact to be less necessary.

4. Discussion

4.1. Main findings

This study was inspired by a claim by Norman (1992), namely that there are major cross-national differences in drivers' eye contact, explained by different levels of aggression in traffic. In line with earlier literature (Bazilinskyy et al., 2019; Özkan et al., 2006; Wallén Warner et al., 2011), we found there are indeed statistically significant country differences in traffic violations of an aggressive nature by drivers. In particular, a non-speeding violation sum score (consisting of 'getting angry at other drivers', 'racing away from traffic lights', and 'honking to express irritation with other road users') was found to be higher in countries with higher accident rates, lower income per capita, and lower life expectancy. Furthermore, in line with Norman, traffic aggression was substantially higher in Mexico than in the United States, with Mexico having the highest non-speeding violations score among the 20 countries polled.

Our specific research question, based on Norman (1992), was whether drivers from Mexico usually *avoid* eye contact in order to merge into a gap, while drivers from the United States do not. Although we found support for these country differences, with 6% of Mexicans, 3% of Americans, and 1% of Dutch drivers reporting such behavior, this behavior was overall rare. What we mainly discovered is that eye contact avoidance by drivers is part of a broader pattern, where drivers (and Mexican drivers in particular) also tend to avoid eye contact because they find it uncomfortable or stressful, or to avoid conflict, while they often *make* eye contact in order to request access to a gap or to subtly exert influence to merge into said gap. In short, our findings indicate that, compared to the United States, driving in Mexico is dynamic, with greater reliance on non-verbal communication, as suggested by Norman (1992).

Although all respondents viewed the same image of a roundabout (see Fig. 1), drivers in wealthier countries found eye contact to be less necessary. The reason for this pattern is unclear, but it is possible that drivers in wealthier countries are more accustomed to structure, partly due to better infrastructure, including traffic lights, road markings, and road designs in general. We found that in the United States and the Netherlands, eye contact is used more to communicate one's presence or to extract additional information or as a precaution. The latter would align with literature which suggests that eye contact by road users can provide clarity in otherwise ambiguous situations (Nathanael et al., 2019; Onkhar et al., 2022; Uttley et al., 2020).

Furthermore, we found that a sizable portion of respondents mentioned avoiding eye contact to better concentrate on the kinematics of the traffic itself. This corresponds with literature that suggests vehicle kinematics (also called implicit communication) often play a more critical role in communication between road users and the decision they make than eye contact or other forms of non-verbal communication (Domeyer, Lee, & Toyoda, 2020; Onkhar, Bazilinskyy, Dodou, & De Winter, 2022; Moore et al., 2019).

Having identified national differences in reported aggressive traffic violations and eye contact, the question arises as to how these differences can be explained. One hypothesis is that aggressive driving behaviors are due to situational factors, consistent with Shinar's model of aggressive driving (Shinar, 1998). According to this model, stressful traffic situations, such as congestion, can trigger emotions such as frustration, leading drivers to act more aggressively. Further, as suggested above, in lower-income countries, drivers may show greater disregard for traffic rules due to less developed road infrastructure and weaker regulatory and enforcement mechanisms (e.g., Nævestad et al., 2019). However, it is worth noting that patterns of traffic aggression might not exist in isolation but rather be connected to other societal issues as well. For example, the two countries that ranked highest in our study for aggressive traffic violations also ranked highly in terms of fatal accident rates (see Fig. 4, middle), as well as in terms of homicide rates (South Africa: 43.7; Mexico: 25.9 per 100,000 population in 2022; United Nations Office on Drugs and Crime, 2024), much higher than the homicide rates in countries with the lowest traffic violation scores (Sweden: 1.11; Hungary: 0.97; Japan: 0.23 per 100,000 population in 2022). This raises deeper questions about the connections between income levels, crime rates, culture, national institutions and organizations, safety statistics, and individual differences in aggression.

Regardless of the attempt to find root causes of national differences in aggressive driving and eye contact, the impression arises that national traffic cultures are stable over time and may be difficult to change. Norman's book was published in 1992, but his anecdote about the strategic avoidance of eye contact dates back to his experiences from around 1956, approximately 36 years prior and 68 years ago (D. A. Norman, personal communication, August 15, 2024).

4.2. Limitations

A limitation of this study is its reliance on survey responses rather than direct measurements. Nevertheless, there is evidence suggesting that the present self-reports are reliable. For example, the self-reported household income showed a strong correlation with the income statistics of participants from the same country ($r = 0.95$; see Fig. 4, left). We also found a strong correlation between the self-reported age of participants in the current survey and their previously provided age in the Prolific database ($r = 0.99$). These correlations indicate that participants did not complete the survey in a random or arbitrary manner. However, it still remains uncertain whether participants could accurately assess their own eye contact behavior in the hypothetical traffic situation shown in Fig. 1.

Although this idea is still somewhat futuristic, we see potential in fully automating the measurement of gaze direction or detecting eye contact. For example, it could theoretically be possible to use driver monitoring systems already available in some cars, in

combination with computer vision or vehicle-to-vehicle communication, to determine if a driver is looking toward another driver. However, this type of experimental setup would require significant innovation and resources, which is why we believe that the current crowdsourcing-based study is, for now, the most sensible approach to gain insight into national differences in traffic gaze behavior. Our current results should be viewed as hypothesis-generating for further research.

It is also possible that the phrasing of our questions may have influenced their responses (cf. Loftus & Zanni, 1975). Language barriers can be a complicating factor here, with respondents from non-English-speaking countries ($n = 2{,}657$) on average having taken more time to complete the survey (median: 336 s) than those from the English-speaking countries (median: 276 s, for Australia, Canada, Ireland, New Zealand, United Kingdom, United States, $n = 1{,}200$).

Another limitation of our study is that participants signed up voluntarily, perhaps motivated by monetary incentives or simply for leisure (Abbas & Gadiraju, 2022; Muldoon & Apostolidis, 2023), and that we had no control over who participated, except that participants should have a driver's license and live in the selected country. For example, in terms of age, the means varied between 28.9 years (Poland) and 42.1 years (United Kingdom), with Mexico (32.2 years) and the United States (36.5 years) in between. The gender distribution of participants ranged from 28.6% male in South Africa to 66.5% male in both Poland and Spain, with 57.9% male in Mexico and 34.8% male in the United States. It is well known that age and gender are correlated with aggressive traffic violations (e.g., Özkan & Lajunen, 2005; Parker et al., 1995; Shinar, 1998), which means the current results should not be taken as absolute truths. For example, it is possible that South Africa would have shown an even higher score for non-speeding violations than what is presented in Fig. 2 if more men had participated. Similarly, it is conceivable that the United States would be closer to Mexico in terms of non-speeding violations if the proportion of males in the United States population were higher. These age and gender differences could be statistically corrected for in future analyses, although we expect that this will not change our overall findings much. For example, in Mexico, the mean non-speeding violations score was 5.46 for women and 5.66 for men, whereas in the United States, it was 4.51 for women and 4.86 for men. Thus, the national differences in this case were larger than the gender differences.

Similarly, we found that our mean SIAS score for the United States was around the average of all 20 countries, despite previous research showing that the United States scores high in terms of social anxiety (Jefferies & Ungar, 2020) and social anxiety disorder (Stein et al., 2017). This discrepancy raises questions about the representativeness of our samples across different countries and the generalizability of previous studies.

A final limitation is that Norman's (1992) book specifically mentioned Mexico City, whereas our survey evaluated Mexico as a whole. Based on the IP addresses, we determined that 46 out of the 199 participants (23%) from Mexico were located in the metropolitan area of Mexico City at the time of completing the survey, which corresponds well with national statistics, according to which 17% of Mexicans live in this area (Gobierno de México, 2024).

5. Conclusion and Recommendations

This study was directly inspired by a claim made by Norman (1992) that in countries with aggressive driving behavior, such as Mexico, eye contact is avoided as a strategy to gain right of way, whereas in wealthier countries like the USA, the formal rules of the road usually prevail.

The results of our study are generally consistent with Norman's claim. We found significant national differences in aggressive driving behavior, with Mexico scoring high, as well as differences in the reasons for making eye contact. Avoiding eye contact to gain the right of way in an aggressive manner was observed, as was making eye contact to assert the right of way. Thus, our research shows that both making and avoiding eye contact are tools for navigating unregulated traffic situations.

For the development of automated vehicles, one implication could be that these vehicles should behave assertively (or 'aggressively', as it is described in this paper), or that a human who *appears* to be manually driving and making or avoiding eye contact should be present in the driver's seat, thereby 'assisting' the automation system. Another option could be an external display on the automated vehicle, also known as external human–machine interfaces (eHMIs), for (not) communicating intent (Avsar et al., 2021; Colley et al., 2022; De Winter & Dodou, 2022). However, a point of concern is that few automated vehicles currently being developed make use of such eHMIs. The general view among current automated vehicle developers seems to be that existing indicators, such as turn signals and possibly flashing high beams, should be sufficient for communication in traffic. Time will tell whether these existing communication channels will be adequate in challenging traffic situations, such as the one shown in Fig. 1, where both automated and manually driven vehicles coexist. Additional measures or traffic adjustments may be needed to improve flow, or other road users may need to adapt to automated vehicles that sometimes behave surprisingly assertively without being able to facilitate eye contact.

CRediT authorship contribution statement

J.C.F. de Winter: Writing - Original draft, Writing - Review & Editing, Conceptualization, Methodology, Software, Validation, Formal analysis, Data curation, Visualization. **V. Onkhar:** Writing – review & editing, Methodology, Conceptualization. **D. Dodou:** Writing – review & editing, Software, Methodology, Investigation.

Appendix A. Principal component loadings of the Driver Behaviour Questionnaire (DBQ)

Table A1 shows component loadings as obtained through principal component analysis (PCA) on a 7 × 7 correlation matrix among country means, as in De Winter and Dodou (2016), i.e., the sample size was 20.

Table A1
Varimax-rotated principal component loadings for the DBQ violations items (n = 20 countries).

Item	Non-speeding violations, loading	Speeding violations, loading
1. Becoming angered by a particular type of driver, and indicating your hostility by whatever means you can	**0.85**	0.22
2. Disregarding the speed limit on a motorway	0.10	**0.87**
3. Disregarding the speed limit on a residential road	−0.01	**0.84**
4. Driving so close to the car in front that it would be difficult to stop in an emergency	**0.64**	**0.36**
5. Racing away from traffic lights with the intention of beating the driver next to you	**0.63**	−0.16
6. Sounding your horn to indicate your annoyance with another road user	**0.86**	−0.01
7. Using a mobile phone without a hands free kit	**0.69**	**0.56**

Note. Loadings greater than 0.30 are listed in boldface.

Appendix B. Cross-national differences in the reasons for making and avoiding eye contact – Automated analysis

We used *o1-preview* to automatically code, per prompt, 10 selected responses to question E4 from all 3,857 responses into the 15 categories. This process was repeated until each response to E4 was reviewed a total of 12 times. The use of more than one, but specifically 12 repetitions, is based on the consensus method, where repeated prompting yields a statistically more reliable result (De Winter et al., 2024). This resulted in a 12 repetitions × 3,857 participants × 15 categories matrix, consisting of 595,600 zeros, 72,470 ones, and 26,910 NaNs. These NaNs were caused by cases where the output of *o1-preview* was not machine-readable.

We then counted whether a comment was predominantly (i.e., 6 or more times) in the category, resulting in a 3,857 x 15 matrix with 51,975 zeros and 5,880 ones.

An example prompt for 10 randomly selected responses is[2]:

```
Consider the following 15 categories:
1 Avoids eye contact in order to focus on the road / minimize distractions / out of safety considerations. Example: "Eye contact can be a distraction and can cause accidents."
2 Avoids eye contact because it is stressful / uncomfortable / not liking eye contact in general. Example: "eye contact on its own is stressful...eye contact in a high stress environment like the described scenario, would drive me mad."
3 Avoids eye contact to prevent yielding right of way / increase chance to enter. Example: "if you focus on your car and their car and don't make eye contact they are more likely to let you in"
4 Avoids eye contact to prevent irritating the other driver / getting intimidated. Example: "other drivers might be aggressive so I definitely avoid eye contact at any moment while driving."
5 Does not use eye contact because is not needed; kinematics / blinkers / rules give the necessary information / it is safer to rely on objective information. Example: "I don't really make eye contact with other drivers in those situations. I just look at car's positions and make decisions based on that."
6 Does not make eye contact as it is not physically possible because of e.g., distance, speed, or window glare. Example: "Some vehicles also have darker tint than others, or drivers may be wearing sunglasses, so I might not be able to make eye contact."
7 Makes eye contact to achieve mutual awareness / out of politeness / reciprocation. Example: "I find more success on the road when I make eye contact with drivers to convey understanding and to be polite and considerate."
8 Makes eye contact to indicate intentions / make oneself noticeable / indicate to the other drivers they have been noticed. Example: "I feel that making eye contact ensures the other driver sees you and know you are there"
```

[2] The prompting was repeated 12 times. In 7 out of the 12 repetitions, the prompt was executed with a slight variation of Category 9, namely: "*Makes eye contact to receive information about the other driver's intentions or state / see if the driver has been noticed. Example: "might make eye contact to see what the other driver would do*"". For 6 out of the 12 repetitions, 10 random responses were selected without replacement from the 3,857 available comments each time. In the remaining 6 repetitions, the same sets of 10 responses were used as in the first 6 repetitions. The total cost of all 12 repetitions was approximately 4.9 million input tokens and 25.9 million output tokens (including reasoning tokens), with an estimated expense of USD 1,626.

```
9 Makes eye contact to receive information about the other driver's intentions or state / to see if the other driver has noticed them. Example: "might make eye contact to see what the other driver would do"
10 Makes eye contact to increase the chance to get right of way / ask permission. Example: "giving eye contact in my opinion increases your chance of getting into the roundabout because other drivers can see that you're trying to enter."
11 Makes eye contact for safety reasons. Example: "Eye contact is a good way to avoid an accident"
12 Makes eye contact to thank or criticize an action already taken. Example: "I don't like to make eye contact I just do it when they do something wrong"
13 Eye contact might not have an effect / can happen accidentally / not on purpose. Example: "I don't feel that eyecontact should change the flow of traffic"
14 Makes or avoids eye contact depending on the situation or culture. Example: "Everything depends on the way the roundabout works and the place you are driving"
15 Non-specific / unclear / other. Example: "Eye contact is very important when you drive"
Categorize the following 10 comments into the above 15 categories. A comment can be placed in more than one category, but be conservative. Produce a comma-seperated 10 x 15 matrix consisting of 0s and 1s, nothing else:
1 I would make an eye contact to enter to the roundabout faster because looking straight to them increase this, they might see that i'm desperated or sth
2 I feel like people tend to help more in situation like that when i make eye contact with them, as they seem eager to make way to the roundabout
3 If I make eye contact with approaching drivers, there is a possibility that they let me in
4 Eye contact is a also a form of communication that we can use on the road as drivers because we can use sign language so need your eyes to see that
5 I usually wait for a sign to pass
6 I don't make any eye contact whatsoever, I think it would increase the danger of entering into a busy round about
7 It kind of depends. Whatever is safer option for driving I will choose that!
8 I'm paying attention to the cars not eye contact
9 It is not about making eye contact. It is about being aware of total surroundings. Focusing on one person eye contact results in tunnel vision
10 I feel embarrassed. I don't like to have eye contact with strangers
```

The corresponding output of *o1-preview* is given below:

```
0,0,0,0,0,0,0,1,0,1,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0
0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1
1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0,0,0,0,0,0,0,0,1,0
1,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0
1,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0
0,1,0,0,0,0,0,0,0,0,0,0,0,0,0
```

Table B1 provides a comparison between the *o1-preview* annotation and the annotation by the human annotator. It shows that the percentage of false positives ranges from 0% to 9%, while the percentage of true positives ranges from 49% to 100%. The largest discrepancy between *o1-preview* and the human annotator concerns Categories 7, 8, and 9. Closer inspection revealed that this discrepancy was not so much due to *o1-preview*, but rather that these categories were somewhat fuzzily defined. For example, the human annotator tended to classify a quote like *"I usually try to make eye contact at roundabouts so that if the other driver goes or signals me to go I will see. But it's not about trying to gain a chance to go ahead of them. I just want to be a safe driver*" under Category 7. Makes – politeness (reciprocity), whereas *o1-preview* categorized it as Category 9. Makes – receive. We considered these discrepancies acceptable for our research purposes, viewing them as simply a different perspective on the data.

Table B1
Comparison between human annotation and annotation using *o1-preview*. A total of 585 out of 600 comments were compared. The 15 comments used as examples in the prompt were excluded to prevent unfair contamination. The numbers in parentheses represent the false positive rate and true positive rate.

	Number of true negatives *o1-preview*: 0 Human: 0	Number of false positives *o1-preview*: 1 Human: 0	Number of false negatives *o1-preview*: 0 Human: 1	Number of true positives *o1-preview*: 1 Human: 1
1. Avoids – focus	497	17 (3%)	4	67 (94%)
2. Avoids – stress	540	7 (1%)	3	35 (92%)
3. Avoids – obtain	568	0 (0%)	5	12 (71%)
4. Avoids – prevent	569	6 (1%)	1	9 (90%)
5. Avoids – not needed	468	17 (4%)	13	87 (87%)
6. Avoids – impossible	558	7 (1%)	0	20 (100%)
7. Makes – politeness	517	21 (4%)	20	27 (57%)
8. Makes – noticeable	477	45 (9%)	14	49 (78%)
9. Makes – receive	461	46 (9%)	6	72 (92%)
10. Makes – ask	438	21 (5%)	9	117 (93%)
11. Makes – safety	512	10 (2%)	4	59 (94%)
12. Makes – feedback	574	2 (0%)	0	9 (100%)
13. No effect	542	14 (3%)	4	25 (86%)
14. It depends	476	19 (4%)	26	64 (71%)
15. Other	525	7 (1%)	27	26 (49%)

Data availability

Data and scripts that reproduce the figures and tables presented in the paper are available at: https://doi.org/10.4121/94ddb48b-3a57-453e-861a-fab2da9f947b.

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