

UMTRI-2002-2

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**John M. Sullivan
Michael J. Flannagan
Brandon Schoettle**

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John M. Sullivan
Michael J. Flannagan
Brandon Schoettle

The University of Michigan
Transportation Research Institute
Ann Arbor, Michigan 48109-2150
U.S.A.

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16. Abstract <p>One of the most promising proposals for an Advanced Frontlighting System (AFS) is bending light, in which light from headlamps is directed into the path of a turn. We performed a field study to investigate the appearance of bending light, implemented as a swiveling beam pattern, to other roadway users. Observers were asked to view a series of turning maneuvers performed by a vehicle equipped with bending light and were asked to comment on the maneuvers in three sets of trials. The three sets were structured to direct progressively more of the observer's attention to the vehicle's frontlighting system. Responses were classified to indicate the degree to which observers spontaneously noticed specific details about the frontlighting system. In another series of trials, observers viewed turning maneuvers in which the bending-light function was inactive on half of the trials, and were asked to distinguish whether it was active or inactive. Results suggest that observers are not very sensitive to the movement of bending light and often report lamp movement as variation in the intensity of the lamp; that is, the lamp appears to brighten and dim. Although the appearance of variation in brightness could be used as a signature for bending light, observers demonstrate a limited ability to distinguish bending light from fixed light. Overall, the results suggest that the likelihood that beam movement would either help or hinder other road users is small.</p>					
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Introduction

Innovations in vehicle frontlighting are being developed to provide forward light distributions tailored to meet the dynamic lighting needs of drivers. For example, as a driver initiates a turn, a car equipped with such a lighting system can direct light into the direction of the turn, illuminating more of the roadway and less of the shoulder than would be possible with traditional, fixed headlamp systems. Often termed *bending light* (or curve lighting) this is but one of a family of dynamic lighting distributions that have been proposed for Advanced Frontlighting Systems (AFS). Other examples include proposals to increase the range of forward illumination with increasing speed; reduce reflected pavement glare to oncoming drivers in adverse weather; optimize distribution for urban, rural, or motorway environments; or enhance overhead sign illumination.

Fixed frontlighting has always walked an uneasy line between providing sufficient seeing light for the drivers using the lamps, and imposing excessive and disabling glare on other drivers. The traditional solution to this tradeoff has been the use of systems with high and low beams. These systems implicitly recognize that the seeing light provided by low beams alone is often insufficient for safe driving. At the same time, they recognize that other road users may find the light from high beams glaring. Thus, the driver is expected to activate the high beam when needed on dark roadways, and deactivate it when it would impose on other vehicles. Drivers do not seem to faithfully follow this pattern of use (Hare & Hemion, 1968), nor is it clear that the two beam alternatives provide a complete solution to drivers' lighting needs. AFS can provide more varied lighting distributions, and can often assume the burden of deciding which distribution to select for each driving situation.

It is recognized that such dynamic changes in light distribution could be quite different from what other road users are accustomed to seeing. While drivers of AFS-equipped vehicles would presumably be aware of how well the new lighting dynamics matched their driving needs, other road users might also take notice of these new lighting dynamics. If so, the appearance of AFS might provide new cues about a vehicle's trajectory or an operator's intent to other roadway users, and benefit safety in the process. For example, a driver or pedestrian might be able to better anticipate an oncoming vehicle's left turn across an intersection by noticing that the beams are directed into the

turn, slightly ahead of the movement of the vehicle itself. However, lighting dynamics might also be seen as distracting, or potentially misleading, perhaps leading observers to mistake vehicle position in the roadway.

The purpose of the present study was to determine how other road users perceive the motion of one implementation of bending light, in which the headlamp beams swivel in the direction of a turn. We sought to determine if the beam movement was obvious to observers, how well they could detect whether a vehicle had AFS bending light activated, and how they rated the discomfort glare with and without the bending light function activated.

Method

Experimental Setup

The experiment was conducted at night, in a dimly illuminated (< 1.0 lux on the pavement surface) asphalt paved area near the UMTRI facilities. Two cars were used, a stationary observation car from which up to four subjects could observe the movements of a second experimental car equipped with swiveling AFS headlamps. Figure 1 shows an overhead view of the layout. Turns were made at two locations, one approximately 6.4 m from the observation vehicle, and another approximately 33.6 m away, simulating an intersection just beyond a crosswalk and a more distant intersection, respectively.

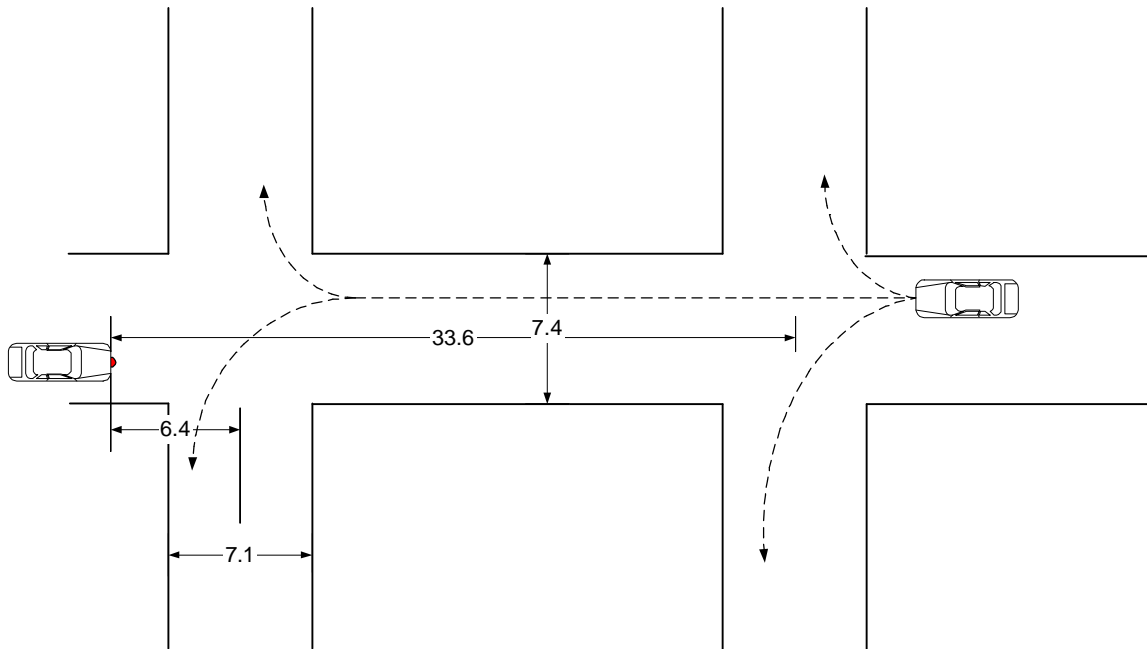


Figure 1. Layout of vehicle maneuvers. The vehicle at right approached the stationary observation vehicle on the left at low speed (about 24 kph). The approaching vehicle was equipped with swiveling headlamps that could be either active or inactive. All measurements are given in meters.

The AFS capability of the experimental car could be switched on and off by the experimenter who drove the vehicle. The maximum swivel extent of the lamp was 17 deg, and there was a dead zone of 0.1 deg before which the lamps would turn. The vehicle was an AFS prototype under active development by a supplier and, as such, not necessarily representative of a final product. Indeed, the swiveling motion of the lamps

did not appear entirely smooth. A lack of subtlety in the swiveling motion was preferred in this study in order to increase the likelihood that observers would detect and comment on the motion.

The vehicle was equipped with forward cornering lamps, which were active during signaled turns, but those lamps were masked so that they would not complicate the appearance of the vehicle's front lighting. However, just prior to the turning maneuvers, conventional flashing amber turn signals were activated and were visible to observers.

Subjects

Twenty-three paid subjects participated in the experiment. There were 12 younger subjects (ranging in age from 19 to 23 years old, with a mean of 21.1), and 11 older subjects (ranging in age from 61 to 76 years old, with a mean of 68.3). The younger group was composed of six females and six males; the older group included five females and six males. All subjects were licensed drivers with normal or corrected to normal vision.

Procedure

Subjects were asked to observe the turning maneuvers of an approaching vehicle in five blocks of experimental trials over the course of a 45-minute experimental session. Subjects were run in groups of one to four persons at a time. In the first three blocks, subjective-report blocks, subjects were asked to provide brief, unstructured, written comments about their observations for each turning maneuver. Over the three subjective-report blocks, they were given progressively more specific instructions about what to comment on. In the first block, subjects were asked to comment if they noticed "anything unusual about the vehicle." In the second block, subjects were asked to comment if they noticed "anything unusual about the *headlamps*" of the vehicles. In the third block, subjects were asked to comment if they noticed "anything about the *movement* of the car's headlamps." Thus the three stages of inquiry called progressively more of the subject's attention to the movement of the headlamps. Subjects were requested to refrain from sharing their comments with others, and they were monitored for compliance with this request.

Within each of the subjective-report blocks, a trial began when the subjects indicated that they were ready, and a start command was given to the experimenter in the approaching vehicle to begin the maneuver. The AFS bending light function was active in all subjective-report blocks. In these trials, the approaching vehicle executed either a left- or right-hand turn at either the near or far distance from the observation car, for a total of four trials per block. The order of the four maneuvers was randomized within each block.

In the fourth block, which we will refer to as the detection block, subjects were advised that the approaching vehicle was equipped with a special headlight system that moved the headlamp beams to follow the turning movements of the vehicle. They were also told that the system could be turned on and off, and asked to identify whether the bending light function was active or inactive on the approaching vehicle for each observed turning maneuver. There were eight trials in the detection block: two turn directions (left, right), by two distances (near, far), by two AFS bending light conditions (active, inactive). The order of the eight maneuvers was randomized within the block.

In the fifth block, which we will refer to as the glare ratings block, subjects were asked to assign glare values to the headlamps, using the de Boer scale after watching turning maneuvers. In this block, subjects observed turn maneuvers exclusively at the far distance (33.6 m). Each maneuver was performed twice, for a total of eight maneuvers: two turn directions (left, right), by two AFS conditions (active, inactive), by two repetitions. The order of the eight maneuvers was randomized within the block.

Light rainfall occurred during two experimental blocks involving six of the subjects. The rain was sufficient to substantially raise the level of specular reflection of the headlamps from the roadway surface. Consequently, these observations were excluded from the analysis of glare ratings.

Results

Subjective-report blocks. Two independent coders categorized transcripts of the written comments that observers recorded during the subjective-report blocks. For the first block, in which observers were prompted to comment on the vehicle without their attention having been called to headlamps, comments that included explicit mention of the headlamps were counted. Rating agreement between coders was 96%. In the second block, for which observers' attention was directed to the headlamps, comments that included explicit mention of *movement* of the lamps were counted. Rating agreement between coders was 92%. In the third block, for which observers' attention was directed to headlamp movement, comments that included explicit mention of *movement characteristics* (such as direction of movement or speed) were counted. Rating agreement between coders was 89%. Thus, as observers' attention was progressively drawn to details of the vehicle's frontlighting system, the criteria for evaluating the comments became more specific (see Table 1). Since there was strong overlap between the coder ratings, the following analyses are based on one set of ratings.

Table 1

As comment prompts became more specific, the criteria for scoring content became more specific.

Block	Comment Prompts	Scoring Criteria
1	Broad and non-specific	Headlamp mention
2	Headlamp	Movement mention
3	Movement	Movement detail mention

Results of the comment tabulations across observers for the first three blocks are given in Table 2, Table 3, and Table 4. While most of the observers' attention seems to be drawn to the headlamps of the approaching vehicle, based on the frequent mention of headlamps (71% in Block 1), it appears that few comments take specific notice of the presence of headlamp movement (8%, in Block 2 with headlamp instructions), or headlamp movement characteristics (17%, in Block 3 with headlamp movement instructions), despite prompts.

Comments about headlamps, headlamp movements, and specific headlamp movement characteristics appear to occur slightly more often when the approaching car executes a left turn at a far distance; however, a logistic regression failed to find a reliable effect of turn direction on the frequency of these comments. Perhaps some observers are more sensitive than others to the sweep of a beam pattern “hot spot” across their viewing position as the oncoming car executes a left turn.

Table 2
Percent responses in Block 1 in which mention of the vehicle’s headlamps was made.

	Left Turn	Right Turn	Total
Far	78%	70%	74%
Near	70%	65%	67%
Total	74%	67%	71%

Table 3
Percent comments in Block 2 in which mention of headlamp movement was made.

	Left Turn	Right Turn	Total
Far	9%	4%	7%
Near	13%	4%	9%
Total	11%	4%	8%

Table 4
Percent comments in Block 3 in which a specific movement characteristic was mentioned.

	Left Turn	Right Turn	Total
Far	30%	9%	20%
Near	13%	17%	15%
Total	22%	13%	17%

All observer comments were also evaluated for how often any change in the light of the approaching vehicle was noted, whether or not the comment was about headlamp or beam movement. Rating agreement between coders was 83%. Comments related to flicker, beam movement, color change, or variation in the apparent luminance of the oncoming headlamps were counted. Unlike the strict movement criteria applied to the comments made in the subjective-report blocks, in which there had been prompting for headlamp or headlamp movement (Blocks 2 and 3), this criterion was less restrictive.

The percent of comments noting some dynamic characteristic in the headlamps of the approaching vehicle is shown in Figure 2. When prompted to focus their attention on the headlamps, observers are more disposed to notice the dynamics. A logistic regression found an effect of prompt type on likelihood of mention of appearance dynamics (p of Log LR < .01, $df = 2$).

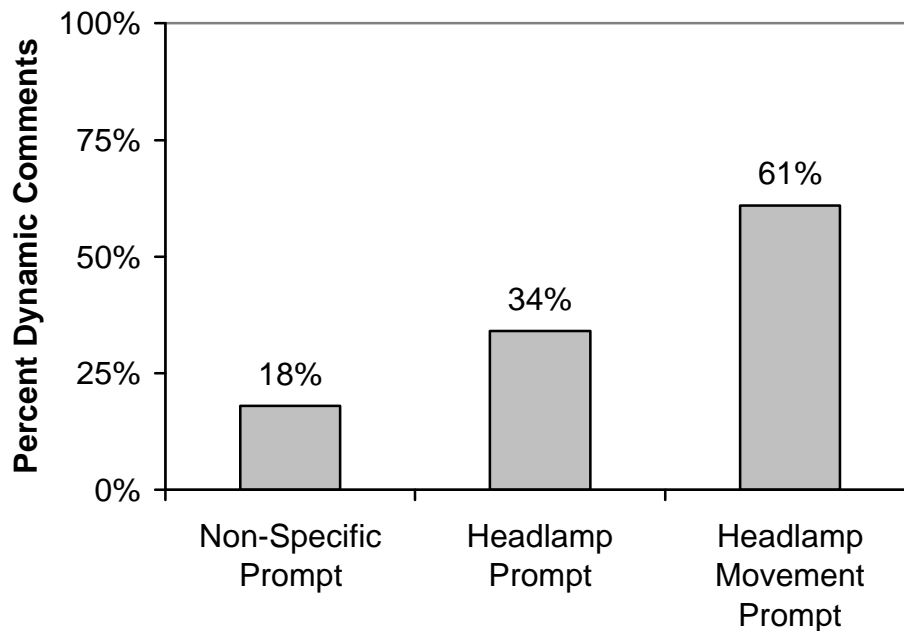


Figure 2. Percent of observer comments referring to dynamic changes in headlamp appearance from the approaching car. Percentages are grouped and labeled by the different kinds of prompts given in each block.

Similarly, all observer comments were evaluated to count how often beam *movement* was mentioned. Rating agreement between coders was 95%. A logistic regression again found an effect of prompt type on likelihood of a mentioning movement (p of Log LR < .01, $df = 2$). The percent movement comments for each of the successive blocks are given in Figure 3. Overall, observers are less likely to report beam movement than light dynamics. It is remarkable that even when explicitly prompted to report anything unusual about the headlamp movement, only 23% of the comments mentioned movement. Perhaps observers are less likely to report seeing movement because they do not easily interpret the observed headlamp dynamics as movement.

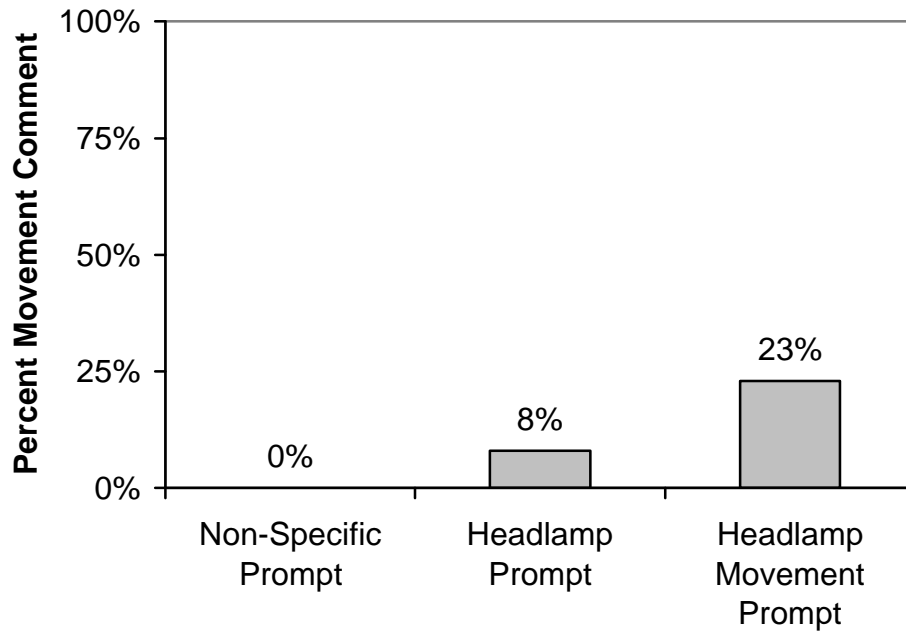


Figure 3. Percent of observer comments referring to headlamp movement on the approaching car. Percentages are grouped and labeled by the different kinds of prompts given in each block.

Detection Blocks. Detection responses made by each observer were pooled and are summarized in Table 5. No systematic influence of sex, age, turn direction, or viewing distance on judgment accuracy was observed. As a group, subjects were as likely to report active bending light when it was inactive (27%), as to report inactive bending light when it was active (30%). It is noteworthy that, during this block, observers were not only aware that the oncoming vehicle might have active swiveling headlamps, but they also had a degree of observational experience from the prior subjective-report blocks. It is also noteworthy that the detection task merely required discrimination between the active and inactive bending light conditions, rather than any specific knowledge about the lamp movement. Despite this, detection accuracy was about 71%, only moderately higher than 50% chance performance.

Table 5
Observer bending light detection reports compared to the actual state of the bending light function in the approaching vehicle.

		Observer Response	
		“On”	“Off”
Bending Light State	On	70%	30%
	Off	27%	73%

Discomfort Glare Blocks. Data from six subjects were excluded from the analysis because of wet roadway conditions (as noted previously). Glare ratings from the remaining 17 observers were pooled in a repeated-measures analysis of variance that examined the within-subject effects of turn direction and bending light activation, and between-subject effects of sex and age. The effect of bending light activation on discomfort glare was significant, $F(1,13) = 13.57, p < .01$. As Figure 4 shows, observers found the bending light to be more glaring (lower de Boer ratings) than the fixed headlamp beams.

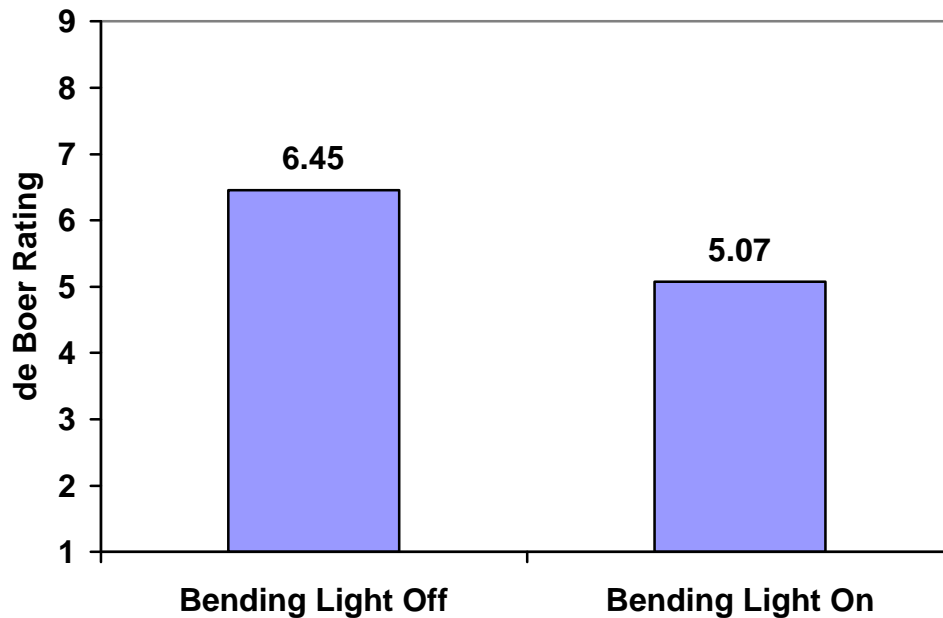


Figure 4. Glare ratings reported by observers as they viewed turn maneuvers made by vehicles with AFS bending light active and inactive.

No main effect of turn direction was observed in these data. In particular, we had expected that observers would find left turns made by the approaching vehicle to be more glaring than right turns. Because the most intense light from a low beam is directed slightly to the right, in a left turn the most intense light should pass near the observers' line of sight. In a right turn, the most intense light from the approaching vehicle is already slightly rightward, away from the observers, and continues farther rightward with the turn. Despite these likely differences, the mean de Boer ratings for left (5.73) and right (5.79) were virtually the same.

There was a significant interaction between bending light and turn direction, $F(1,13) = 5.95, p < .05$. Left turns were rated as more glaring than right turns with bending light active, but the ratings were reversed with bending light inactive (see Figure 5).

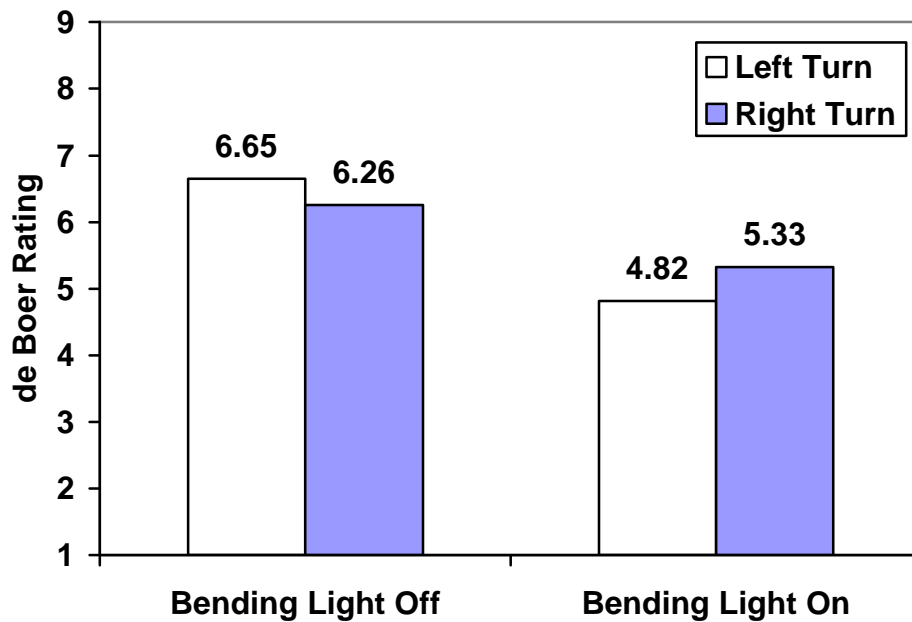


Figure 5. Interaction effect of turn direction and bending light state.

Finally, there was a significant interaction between direction and age, $F(1,13) = 4.99$, $p < .05$. Left turns were rated as more glaring than right turns by younger observers, while older observers found right turns more glaring (see Figure 6). None of the other main effects or interactions were statistically significant.

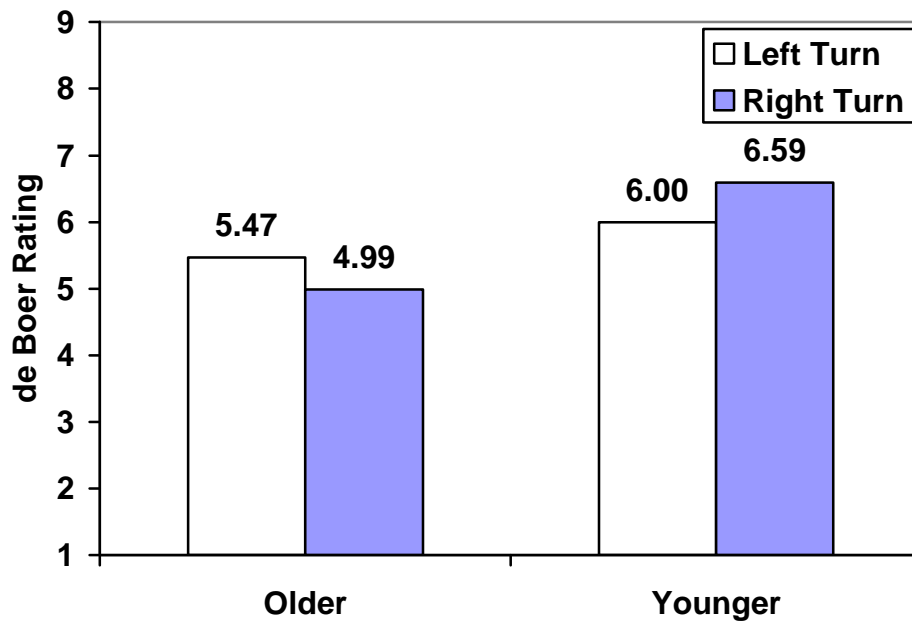


Figure 6. Interaction effect between turn direction and observer age. Older observers found right turns more glaring (lower de Boer ratings) than left turns; younger observers found left turns more glaring than right turns.

Discussion and Conclusion

The main result of the subjective-report blocks is that observers do not readily report the bending light from an approaching vehicle as *moving*. Nor are observers particularly able to distinguish between an active swiveling lamp and a non-swiveling lamp. This suggests that any benefit or detriment that knowledge of the beam's motion might impart to an observer is bound to be minimal.

In clear air, observers are sensitive to the light from an approaching headlamp beam that directly strikes their eyes. They also may notice light diffusely reflected from dry asphalt in front of the vehicle, and possibly light reflected by other objects in the path of the beam. Unless there is particulate matter in the air that would scatter light, like smoke or fog, these cues do not appear to provide sufficient information to support the perception of beam direction. If beam direction is difficult to recognize, then a change in direction (i.e., movement) is also likely to be difficult to recognize. Similarly, a lighthouse beacon is seen to rotate in foggy conditions, but flash in clear conditions.

The results from the detection block suggest that observers have a modest ability to distinguish bending light from fixed light. Based on the content of the subjective reports, this ability seems to be more a consequence of noticing dynamic changes in the illuminance reaching the eye than an appreciation of displacement of the beam.

Finally, observers rated left turns and right turns as equally glaring and they reported that bending light was more glaring than fixed headlighting. The first result is puzzling because left turns should expose observers to more intense parts of the headlamp beam than right turns, with or without bending light. The glare ratings do not appear to be closely related to an observer's exposure to beam intensity. (Unfortunately, photometric data are not available to support these informal observations.)

The second result is also puzzling, because we expected that bending light would direct more of the lamp's intense light farther away from the observers during right turns than a fixed beam, potentially reducing glare. And we expected that, during a left turn, the intense light of the bending light beam would pass across the observers' line of sight earlier in the vehicle maneuver (and at a farther distance) than it would with a fixed beam, again potentially reducing glare. Despite this, observers reported modestly more glare with the prototype bending light.

Perhaps the observers' glare ratings were not solely related to illuminance level exposure. Instead, they may have applied the de Boer rating as a one-dimensional scale to register any negative response to a salient characteristic of the observed lamp. When a static headlamp is viewed, the most salient characteristics of the headlamp are its apparent brightness and color. Ratings may reflect an observer's opinion about only these characteristics. When a headlamp moves, the beam also moves and produces illuminance variation at the observer's eye. The brightness of the light appears to vary. While such variation might be salient to observers (Yantis & Jonides, 1984, 1990), it is not clear how observers might integrate this into their assessment of glare. Perhaps large or abrupt changes in apparent brightness of an oncoming headlamp contribute to an observer's sense of discomfort and are factored into the glare rating.

There is a discrepancy between the observers' ability to discriminate when the AFS function was active, as indicated by their explicit detection judgments, versus their glare ratings. Observers apparently do not directly associate their glare rating with the presence of bending light. If they had, detection judgments would have been more accurate.

Finally, we again note that the lamps used were prototypes and did not move smoothly. Because of this, we believe that AFS bending light should have been more conspicuous to observers than would have been the case with smoothly moving lamps. The observed insensitivity to beam movement is therefore even more noteworthy. At the same time, we note that the lack of smooth headlamp movement may have been regarded negatively and perhaps influenced the glare ratings. Therefore it may not be safe to generalize these glare ratings to AFS bending light implementations in general.

These results collectively suggest that, given observers' limited sensitivity to and awareness of beam movement (even after being alerted to it), the likelihood that beam movement might either help or hinder other road users is small and does not appear to suggest cause for concern.

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Appendix

This table contains the subjective comments of observers to each of the four turn maneuvers in the first three experimental blocks of the study.

Subject	Group	Turn	Distance	Comment
1	1	Left	Far	One headlight seemed much larger and brighter than the other – the one to my right
1	1	Left	Near	N/A
1	1	Right	Far	N/A
1	1	Right	Near	I didn't notice anything else unusual about the vehicle
1	2	Left	Far	One and then the other seems predominant as the car turns
1	2	Left	Near	No differences noted
1	2	Right	Far	Same – the one to my left sometimes almost disappears
1	2	Right	Near	One headlight seemed larger and brighter than the other - the one to my right
1	3	Left	Far	Yes, I guess that's why the size and brightness seems to vary
1	3	Left	Near	He turned left and the light on the driver's side seemed to turn
1	3	Right	Far	He turned right and the headlight on the passenger side was the one that appeared smaller
1	3	Right	Near	Are they turning in the direction the car turns?
2	1	Left	Far	Left hand (driver's side) light too bright – no turn signal used when turning left (driver's side) to park
2	1	Left	Near	No left headlight (driver's side) – used left turn signal correctly
2	1	Right	Far	No right headlight – used right turn signal
2	1	Right	Near	Used right (passenger side) turn signal correctly
2	2	Left	Far	Left head light (driver's side) on bright
2	2	Left	Near	Left head light on (driver's side) – no right lamp on; left turn signal working
2	2	Right	Far	Right head light out (passenger side) and right turn signal working
2	2	Right	Near	No right head light on (passenger side)
2	3	Left	Far	Right headlight off – then came on when turning left
2	3	Left	Near	Right headlight out – turn signal ok
2	3	Right	Far	Left headlight out, only parking light on
2	3	Right	Near	Left headlight unsteady
3	1	Left	Far	The left headlamp was lighter than the right headlight. The right turn signal was on, which makes me wonder if the right headlight was brighter for this reason.
3	1	Left	Near	From afar, the headlights appear very different--left dim, right bright – but up close, both seem the same intensity.
3	1	Right	Far	The two headlamps appear very different; one seems much dimmer; the one on the left.
3	1	Right	Near	Again, the left headlight appeared different; not as bright, and the turn signal was a little strange in appearance.
3	2	Left	Far	Again, the left lamp is dimmer; the right almost seems as if the brights are on, but when the car turns, both lamps seem the same intensity.

Subject	Group	Turn	Distance	Comment
3	2	Left	Near	The right lamp is so bright that from far away, it is difficult to see that the turn signal is on. The left is dim and flickers at the turn.
3	2	Right	Far	It's easier to distinguish the turn signal on the left lamp which is again much dimmer than the right lamp. (right=driver's side) (left = passenger side)
3	2	Right	Near	The right lamp is much brighter and unchanging, whereas the left lamp seems to flicker slightly right after turning and then is noticeably dimmer than the right light.
3	3	Left	Far	Again the same phenomena as maneuver 1; right lamp is steady, left has more shifts and movements.
3	3	Left	Near	The right is steady, the left wavers slightly upon getting closer. Both seem to get smaller to the eye and flash upon turning.
3	3	Right	Far	The left bulb seems to get bigger (as in the color it gives off) as it gets closer. The right is steady.
3	3	Right	Near	Immediately when the car turns, the left bulb seems to move, as if to flicker, or in a split second go dark and then turn on. It is very noticeable to me
4	1	Left	Far	One headlight is brighter than the other (driver's side brighter). No turn signal noticed.
4	1	Left	Near	Driver came close to observers and turned using turn signal (driver's side brighter on all maneuvers)
4	1	Right	Far	Same as in #1, except driver turned farther away from observers
4	1	Right	Near	Same as #1 except turn signal indicated driver came close to observers
4	2	Left	Far	Headlamp on driver's side brighter. Driver used turn signal to turn properly. This was on bright headlight side.
4	2	Left	Near	Same as previous maneuver
4	2	Right	Far	Driver turned left using turn signal. Brighter headlight on opposite side of car. Driver turned farther from us
4	2	Right	Near	One headlight (driver-side) brighter than passenger side. Driver turned close to us using turn signal
4	3	Left	Far	No discernable difference from same previous maneuver
4	3	Left	Near	No discernable difference from previous
4	3	Right	Far	No discernable difference from previous
4	3	Right	Near	Not much. Maybe headlamp on driver side became "smaller" when he turned?
5	1	Left	Far	Everything same as (next) except left turn was made 50 feet further away.
5	1	Left	Near	Made left turn with signal on – seemed like left headlight was brighter than right.
5	1	Right	Far	Made right turn at same distance as (far) then backed up and drove towards us.
5	1	Right	Near	Made right turn same distance as number 1 (near).
5	2	Left	Far	Both headlights about the same.
5	2	Left	Near	Left headlight slightly brighter
5	2	Right	Far	Left headlight slightly brighter
5	2	Right	Near	Left headlight brighter
5	3	Left	Far	No movement of lights seen

Subject	Group	Turn	Distance	Comment
5	3	Left	Near	No movement of lights seen, left lamp appeared brighter
5	3	Right	Far	Left lamp brighter and seemed to flash a small amount at first
5	3	Right	Near	Same as 1 (3, Left, Far) with left lamp a little flash at end, not beginning.
6	1	Left	Far	Car headlight more even; used turn signal correctly
6	1	Left	Near	Car driver headlight was brighter – used proper turn signal (left)
6	1	Right	Far	Pretty much the same; parked and backed OK
6	1	Right	Near	Headlight brighter on driver side. Proper turn signal used
6	2	Left	Far	Nothing unusual
6	2	Left	Near	Headlamps varied as it came forward
6	2	Right	Far	Driver side a little brighter
6	2	Right	Near	Went from headlight – parked then used parking lights
6	3	Left	Far	Nothing unusual noticed
6	3	Left	Near	Used parking or small lamps when turning
6	3	Right	Far	After the park and back, driver light was stronger
6	3	Right	Near	After the park and back, used parking lights
7	1	Left	Far	The driver-side headlight was brighter. Then the left headlight became brighter through the turn.
7	1	Left	Near	The driver-side headlight was brighter / too bright
7	1	Right	Far	" (DS) ", the headlights seemed to fluctuate slightly (brighter, dimmer)
7	1	Right	Near	Headlights were bright, but not too bright
7	2	Left	Far	It was more difficult to see the turn signal because the headlamp was bright
7	2	Left	Near	The driver side seemed angled differently
7	2	Right	Far	No
7	2	Right	Near	No
7	3	Left	Far	As the car turned, the passenger side headlamp was extremely brighter
7	3	Left	Near	Same as maneuver 3. "As car turned, the passenger side headlamp was extremely brighter"
7	3	Right	Far	The driver's side headlamp seems blindingly bright, and continued to get brighter as it approached
7	3	Right	Near	They seemed to be aimed towards the passenger side
8	1	Left	Far	Car seemed to take turn slowly, then speed up, then slow down again quickly.
8	1	Left	Near	Seemed to start out very slowly, then speed up before turn
8	1	Right	Far	Went very steady before turn, blinker on for a long time
8	1	Right	Near	Blinker was on extra long time before turn
8	2	Left	Far	Headlamps very bright – hurt my eyes
8	2	Left	Near	Headlamps not so bright – did not hurt my eyes
8	2	Right	Far	Lights seemed bright around turn
8	2	Right	Near	Driver side headlight seemed brighter
8	3	Left	Far	Headlamps seemed to turn as vehicle turned (or even before vehicle turned)
8	3	Left	Near	Nothing

Subject	Group	Turn	Distance	Comment
8	3	Right	Far	Driver side headlamps seemed to stay too far up as passenger side headlamp went down
8	3	Right	Near	Headlamps seemed to stay the way the car was originally traveling for a second after the turn
9	1	Left	Far	Both headlamps seemed to flash brighter for a second during the turn
9	1	Left	Near	Both headlamps seemed to flash brighter for a second during the turn
9	1	Right	Far	Both headlamps seemed to flash brighter for a second during the turn
9	1	Right	Near	Both headlamps seemed to flash brighter for a second during the turn
9	2	Left	Far	They flash brighter during the turn
9	2	Left	Near	Same. They flash brighter during the turn
9	2	Right	Far	Same. They flash brighter during the turn
9	2	Right	Near	Same. They flash brighter during the turn
9	3	Left	Far	One headlamp flashes brighter and then gets dimmer just as the other headlight gets brighter
9	3	Left	Near	Same. One headlamp flashes brighter and then gets dimmer just as the other headlight gets brighter, but more pronounced when the car is closer
9	3	Right	Far	Same. One headlamp flashes brighter and then gets dimmer just as the other headlight gets brighter
9	3	Right	Near	Same. One headlamp flashes brighter and then gets dimmer just as the other headlight gets brighter
10	1	Left	Far	Made a turn at the driver side at a farther distance from us than maneuver (1, Right, Near)
10	1	Left	Near	Made a turn at the driver side at a distance roughly the same as maneuver (1, Right, Near)
10	1	Right	Far	Made a turn at the passenger side and parked at roughly the same distance from us as maneuver (1, Left, Far)
10	1	Right	Near	Made a turn at the passenger side and parked
10	2	Left	Far	No
10	2	Left	Near	No
10	2	Right	Far	Driver starts the blinking sign (turn signal?) at a farther distance
10	2	Right	Near	Driver starts the blinking sign (turn signal?) at an even farther distance
10	3	Left	Far	No
10	3	Left	Near	Same as maneuver 2. The driver starts the blinking at the same distance even though he parks closer to us
10	3	Right	Far	No
10	3	Right	Near	The driver starts the blinking at the same distance even though he parks closer to us
11	1	Left	Far	It seemed that one light (driver's side) was brighter than the other
11	1	Left	Near	I didn't notice anything remarkable
11	1	Right	Far	It seemed that the passenger side headlight was brighter than that on the driver's side
11	1	Right	Near	Again, I didn't see anything special about the car

Subject	Group	Turn	Distance	Comment
11	2	Left	Far	The driver's side headlight seemed brighter
11	2	Left	Near	The driver's side headlight appeared brighter
11	2	Right	Far	The right turn signal (the one operating) seemed brighter than the left
11	2	Right	Near	The headlight on the driver's side seemed brighter
11	3	Left	Far	I didn't see anything unusual!
11	3	Left	Near	Nothing special!
11	3	Right	Far	I didn't see anything noteworthy!!
11	3	Right	Near	I didn't see anything unusual!
12	1	Left	Far	Headlight on right side too bright – didn't have directional on until after turn was made.
12	1	Left	Near	Headlight on right side brighter – turn signal not on until several seconds after car driving straight ahead.
12	1	Right	Far	Same as (1, Right, Near) maneuver – headlight not balanced directional on after the turn completed.
12	1	Right	Near	Headlight on right still brighter than left; turn signal went on a few seconds earlier but still not as car was turning.
12	2	Left	Far	Headlights unequal intensity – wrong signal on as he made turn
12	2	Left	Near	Driver side directional went on when it should've been the opposite – headlight stronger on right
12	2	Right	Far	Headlights on right still brighter.
12	2	Right	Near	Headlights on right (driver side) stronger than left
12	3	Left	Far	Headlight on right (driver side) still flashes bright then balances with left
12	3	Left	Near	Quickly flashes on right side only
12	3	Right	Far	Same as 2. Headlight on right (driver side) still flashes bright then balances with left
12	3	Right	Near	Headlight on right (driver side) was brighter for short time, then became more balanced
13	1	Left	Far	Very bright headlights. Left turn signal on left headlight seemed brighter than right.
13	1	Left	Near	Same as in 1; but came closer to our car before turning.
13	1	Right	Far	Same as #3, but turned further away from our car than in #3
13	1	Right	Near	Bright headlights. Left parking light on. Right turn signal on.
13	2	Left	Far	Same as #2. (Both headlights started very bright, but passenger side headlight seemed to become dimmer)
13	2	Left	Near	Both headlights started very bright, but passenger side headlight seemed to become dimmer.
13	2	Right	Far	Same as #2, but passenger headlight seemed to become dimmer, then brighter, but not as bright as the driver's headlamp.
13	2	Right	Near	Very bright headlights as on part 1. Driver's side headlight seems brighter.
13	3	Left	Far	Passenger's headlight seemed to flash for a moment just after car turned into roadway. Flash seemed to come at point where the turn signal came on.
13	3	Left	Near	Driver's headlight seemed to flash for a moment just after car turned into the roadway and when it turned to complete the maneuver.

Subject	Group	Turn	Distance	Comment
13	3	Right	Far	Same as #2. Passenger's headlight seemed to flash for a moment just after car turned into roadway. Flash seemed to come at point where the turn signal came on.
13	3	Right	Near	No. But passenger headlight again becomes dimmer. It also seems to be set in a different kind of reflecting socket in the driver's headlight.
14	1	Left	Far	Right headlamp not as bright as left
14	1	Left	Near	Similar to #1: (Right headlamp not as bright as left)
14	1	Right	Far	Very similar to #3: (Hard to see headlamp right when turn signal on)
14	1	Right	Near	Hard to see headlamp right when turn signal on
14	2	Left	Far	Left headlamp slightly yellow
14	2	Left	Near	?
14	2	Right	Far	Right headlamp less bright
14	2	Right	Near	Left headlamp very bright (driver's side)
14	3	Left	Far	Couldn't detect any difference
14	3	Left	Near	Left headlamp brighter
14	3	Right	Far	Right headlamp turned to right
14	3	Right	Near	?
15	1	Left	Far	Right headlight seems to turn to the right
15	1	Left	Near	Right (driver side) headlight out
15	1	Right	Far	Right headlight seems to turn to the right and does not focus as well
15	1	Right	Near	Right headlight shows to the right and was not as bright
15	2	Left	Far	Right head light turns left light is brighter
15	2	Left	Near	Right light turns as wheel turns
15	2	Right	Far	Same as 1 (Right head light turns left light is brighter); right turn signal seems larger
15	2	Right	Near	Right lamp seems to be smaller and not as bright
15	3	Left	Far	Right same as above; left shines higher and brighter
15	3	Left	Near	Right lamp same as in 1; left lamp different shade of light
15	3	Right	Far	Right headlamp turns when car turns. Left lamp is brighter
15	3	Right	Near	Right lamp turns to right on turn and straight out as car rolls forward; left lamp is brighter
16	1	Left	Far	Car signaled left (driver's side) about 100 ft from us and turned left into the parking space, then backed out again facing us again.
16	1	Left	Near	Car signaled left (driver's side) and then turned left in front of us, about 10 ft. away.
16	1	Right	Far	Car signaled right (passenger's side) about 100 ft from us, then turned right into parking space and backed out again.
16	1	Right	Near	Car signaled right (passenger's side) at last second and then turned right into parking space a few feet away from us.
16	2	Left	Far	The left headlamp is brighter than the right one - so bright that it nearly obscures the turn signal.
16	2	Left	Near	Car came closer - headlamps were brighter when farther away as they have good focus on road.
16	2	Right	Far	Headlamps are as above. Right turn was taken so turn signal more visible than left signal.

Subject	Group	Turn	Distance	Comment
16	2	Right	Near	Again car came closer before right turn, so headlamp was less a problem in observing turn signal.
16	3	Left	Far	When the car turns right to come toward us, it looked like the right headlamp was tracking the front wheels.
16	3	Left	Near	Car turned left - I didn't notice left headlamp leaving a straight-ahead position.
16	3	Right	Far	I'm not sure. Did the right headlamp turn with the wheels like and old Tucker? Might have!
16	3	Right	Near	No - I noticed nothing unusual. The headlamps seem bright and don't dim when the car swings toward us.
17	1	Left	Far	Right headlight looks brighter than the left headlight.
17	1	Left	Near	The right light looked brighter than the left light. Also the right signal was on.
17	1	Right	Far	Right headlight is a lot "brighter" than the left headlight.
17	1	Right	Near	Right light looked "more yellowish" and stood out more than the left headlight
17	2	Left	Far	Right headlamp looked brighter than left headlamp
17	2	Left	Near	As the car came closer, the right headlamp grew brighter and left one stayed the same
17	2	Right	Far	Right headlamp had more of a yellow brightness than left headlamp.
17	2	Right	Near	The left headlamp seems to be whiter, but for some reason, the right headlamp is really intensively bright to my eyes.
17	3	Left	Far	The left light remained the same, and the right light was like a "bright spiral."
17	3	Left	Near	The right lamp had a bright glare as it came closer but the left light remained calm and stable.
17	3	Right	Far	The left headlamp seems to have no specific movement, but the right lamp seems to come closer and closer.
17	3	Right	Near	The right light was not as bright as it was in the prior trials, but still grabbed my attention more than the left light.
18	1	Left	Far	It was not entirely easy to determine the vehicle's position and speed, probably from distance and the first change in speed.
18	1	Left	Near	Nothing really unusual. Passenger side headlight seemed a bit dimmer perhaps.
18	1	Right	Far	The brightness of the headlamp disappeared quickly upon turning it off.
18	1	Right	Near	Same sort of thing – driver's side headlight seemed to glare a bit.
18	2	Left	Far	Glare increased as distance between us decreased. Driver's side light seemed brighter, glare disappeared after turned (the car turned off).
18	2	Left	Near	Glare same but it came closer. Oddly, the glare fluctuated when it got really close; it didn't glare as bad as usual.
18	2	Right	Far	Glare all acted the same, except upon turning, both lights looked the same, and glare decreased all the same too.
18	2	Right	Near	Again, glare evened out; driver's side headlamp didn't seem as bright up close as it does from a distance also.

Subject	Group	Turn	Distance	Comment
18	3	Left	Far	After the car made initial turn, it seems like the brighter-looking driver's side headlight swung around faster. After turning to its final position, though it looks like they moved with equal speed.
18	3	Left	Near	Up close, after it turned, it seems like the headlights kind of just moved away – faded during turn and kind of just turned off.
18	3	Right	Far	It seemed like the driver's side headlight was kind of approaching quicker than the other.
18	3	Right	Near	The position seemed to be equal the whole way during the entire trip; speed variation seemed nonexistent.
19	1	Left	Far	Headlamps to my right appeared more yellow in tint.
19	1	Left	Near	Headlight to my right appeared more yellow in tint in comparison to the other headlamp.
19	1	Right	Far	Both lights appeared to be the same tint.
19	1	Right	Near	Headlight to my right appeared more yellow in tint than the other headlight.
19	2	Left	Far	Headlamps were very similar in tint.
19	2	Left	Near	Headlamp to my right appeared more yellow.
19	2	Right	Far	Headlamp to my right appeared more yellow.
19	2	Right	Near	Headlamps stayed same in tint until car got closer and right light showed more yellow in tint.
19	3	Left	Far	No movement noticed
19	3	Left	Near	No movement noticed
19	3	Right	Far	No movement noticed
19	3	Right	Near	No movement noticed
20	1	Left	Far	Driver side light brighter
20	1	Left	Near	Light seemed to alternate in brightness thru turn (more to less).
20	1	Right	Far	Driver's left light brighter
20	1	Right	Near	Nothing special on turn; driver's left light more yellow.
20	2	Left	Far	Driver's side light creates more glare.
20	2	Left	Near	Driver's side light creates more glare.
20	2	Right	Far	Driver's side light creates more glare.
20	2	Right	Near	Driver's side light creates more glare.
20	3	Left	Far	Driver's side light flickers.
20	3	Left	Near	Driver's side light flickers.
20	3	Right	Far	Driver's side light flickers.
20	3	Right	Near	Driver's side light flickers.
21	1	Left	Far	Right hand turn, but earlier
21	1	Left	Near	Right hand turn
21	1	Right	Far	Left hand turn, but earlier
21	1	Right	Near	Left hand turn
21	2	Left	Far	Nothing unusual
21	2	Left	Near	Blue yellow color change, possibly headlights change position?
21	2	Right	Far	Nothing unusual
21	2	Right	Near	Blue yellow color change, possibly headlights change position?

Subject	Group	Turn	Distance	Comment
21	3	Left	Far	Headlight move left to right
21	3	Left	Near	Light moved to the right
21	3	Right	Far	Nothing odd
21	3	Right	Near	Headlight move left to right
22	1	Left	Far	As the car began its turn, the lights were very bright.
22	1	Left	Near	I didn't really notice anything weird except the turning signal kind of blended with the lights
22	1	Right	Far	Both headlights were bluish and bright but nothing seemed extremely odd.
22	1	Right	Near	The left light looked bluish.
22	2	Left	Far	The right headlight seemed brighter than the left.
22	2	Left	Near	The headlamps were fairly bright from afar, turning signal blended.
22	2	Right	Far	Bluish, nothing really
22	2	Right	Near	From afar the right still seemed brighter and more glaring, also less blue.
22	3	Left	Far	The brightness shifted from left light to right.
22	3	Left	Near	The glare seemed to be switching sides a bit. Nothing major.
22	3	Right	Far	Nothing really
22	3	Right	Near	The right one seemed a lot brighter and had more glare.
23	1	Left	Far	It appeared as though the left headlight dimmed while the right remained stable when the right blinker was engaged.
23	1	Left	Near	Again left headlamp dims, this time before right blinker engaged.
23	1	Right	Far	Again left headlamp dims, looked as though right headlamp does too as car turned to park.
23	1	Right	Near	It appeared as though the left headlight dimmed again as right remained constant when left blinker engaged.
23	2	Left	Far	Left headlamp dims.
23	2	Left	Near	Left headlight dims but then returns to same original brightness before turning right.
23	2	Right	Far	Left headlight dims while right remains constant.
23	2	Right	Near	I didn't observe any changes in either side headlight; they remained constant.
23	3	Left	Far	Left headlight dims, right blinker is on.
23	3	Left	Near	Left headlamp dims, right blinker is on.
23	3	Right	Far	Left headlamp dims, then brighter, then dims; left blinker is on.
23	3	Right	Near	Left dims, then re-brightens as left blinker is engaged.