END-USER ACCEPTANCE OF ANTI-GLARE GLASSES

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ABSTRACT

According to a survey conducted in France and Germany[1], the situation that causes the most stress to car drivers is the glare from the headlamps of oncoming vehicles. Valeo developed a solution to reduce glare, Les *Lunettes by Valeo*. The study described here aims at establishing the perceived benefits for the end-user and their acceptance of such solutions. The study combined questionnaires and a scientific evaluation to establish the benefits and acceptance of the system.

Keywords: glare, active optical shutters, discomfort, disability, automotive, night driving, active glasses

LES LUNETTES - PRODUCT DESCRIPTION

The principle of *Les Lunettes by Valeo* is to combine the wearing of glasses featuring high frequency active optical shutters with the use of special headlamps.

The lenses of the glasses are equipped with active optical shutters. The shutters switch between open mode (during maximum transmission of light) and closed mode (during minimum transmission). The LED headlamps operate on a pulsing basis, alternating between on and off at a speed that is too high to be perceived by the retina. The switching of the glasses between modes is synchronized electronically with the pulsing of the headlamps, so that the glasses are in open mode when the headlamps are lighting the road ahead, and closed when the headlamps are off.

The switching frequency is so rapid that it is imperceptible to the human eye, and wearing the glasses does not affect the driver's view of the road lit by his vehicle's own headlamps (without taking into account the effect on the glasses of reduced light transmission when in open mode). However, when the source of light comes from outside the vehicle, for instance from the headlamps of oncoming cars, the driver only sees the light when the

Advances in Display Technologies VIII, edited by Liang-Chy Chien, Tae-Hoon Yoon, Qiong-Hua Wang,
Proc. of SPIE Vol. 10556, 105560B · © 2018 SPIE · CCC code: 0277-786X/18/$18 · doi: 10.1117/12.2290461

glasses are in open mode but not when they are closed. The quantity of light received by the driver from an external source is therefore reduced on a pro rata basis according to time the glasses remain closed. If the glasses are closed for 50% of the time, the quantity of light seen by the driver is halved, if they glasses are closed for 75% of the time, it is quartered.

As the glasses must not hinder the driving, they are not physically linked to the vehicle but communicate wirelessly (e.g. via Bluetooth) and are powered by a battery with a several hours' autonomy.

EVALUATING CUSTOMER ACCEPTANCE

In 2017 Valeo conducted a qualitative study in which the optimal end-user characteristics were defined and the perceived benefits evaluated with a view to designing an anti-glare solution. Using tunable shutter settings, the objective was to determine which anti-glare level was perceived to be the most efficient and acceptable in various current driving situations.

The study aimed at evaluating extreme users perceived benefits and acceptance of the system. Therefore, as aging causes visual acuity to decline from the age of 40 onwards, thus affecting the ability to drive at night, the study focused on the senior population. The loss of clarity in the lens and cornea, while not noticeable during daytime driving, has a diffusing effect on a contrasting light source at night, such as oncoming headlamps. This means that many older drivers prefer not to drive at night, with the resulting impact on their independence in more northerly regions. Furthermore, new car buyers are on average over 50 years old, so that the most likely buyers of the glasses are seniors.

The study was co-designed with the ergonomists and optometrists Streetlab, ensuring a scientific evaluation of the system and its impact on glare-reduction. Streetlab[2] is a world-renowned certification center for products and services that prevent or limit visual impairment and a subsidiary of the Vision Institute, based at the Parisian Quinze-Vingts National Ophthalmology Hospital.

SAMPLE GROUP

The panel of 24 relatively highly educated participants from the 55 to 70 age group (average age: 64.125, SD: 5.10) was made up of 7 women and 17 men. None was an expert in the field of lighting and all were in good general health and license holders who drove a car at least once a week.

Pre-test visual examination

The participants all underwent a visual examination at the premises of Streetlab prior to the driving session. They were clinically evaluated for visual acuity (ETDRS charts), contrast sensitivity (Metrovision), glare sensitivity (Metrovision) and visual field (Octopus 900). Cognitive screening was also carried out and each participant scored over the cut-off score of 27 on the Mini Mental State Exam (MMSE)[3], indicating intact normal cognitive functioning.

To evaluate the efficiency of *Les Lunettes by Valeo* against glare, the participants were split into two groups according to their glare sensitivity based on the Metrovision glare test[4]. Classification was done according to the size of the halo for the left eye. A halo up to 120 arc minutes identified the “lower sensitivity participants” since this data is considered normal for people after 40 years old. Split was the following:

- higher sensitivity group: 11 participants
- lower sensitivity group: 13 participants

Pre-test driving habits questionnaire

All participants, as part of the recruitment process and to ensure the relevance of their participation to the test, filled in a questionnaire about their driving habits.

19 out of the 24 participants drove more than 10,000 km per year, out of which 3 declared their average driving exceeded 20,000 km per year.

20 participants were heavily using their car (13 mentioned everyday). 10 of the participants indicated driving regularly at night. However this evaluation may have been impacted by the timing of the study (end 2016/beg. 2017).

Regarding driving at night, 12 participants said they were not bothered by it, while 5 ticked the "like it" box.

7 participants said they dislike it. It is interesting to note that out of those 7 persons, 5 were identified as part of the "higher sensitivity group" mentioned earlier.

TEST METHODOLOGY AND RESULTS

The driving sessions took place on the UTAC CERAM test track in Mortefontaine, France. The 7 km-long track offers driving situations without traffic or external light on different types of road and in various glare configurations, thus guaranteeing the accuracy of the test results. They were carried out over 12 days with 2 participants per night.

The test was carried out in two phases:

1. static disability glare test
2. dynamic discomfort glare test

Four configurations were used (fig. 1)

Fig. 1. Anti-glare configurations used (© Valeo)

Disability glare test

This test measured the size in degrees of the glare halo produced by the headlamps of a vehicle traveling in the opposite direction in each of the *Les Lunettes by Valeo* configurations. The test was inspired by those developed by Metrovision on the MonPackOne vision monitor device.

A static oncoming car, positioned at 50m from a stationary car, projected illuminance of 7.8 lux toward the participant who was sitting in the driver's seat of the car. A chart of 10 horizontally arranged optotypes was placed near the oncoming car at headlamp height. The optotypes used were E of Raskin and were of identical

height and contrast. The chart was illuminated by the headlamps of the participant's car. For each test a new set of optotypes was used.
The participant underwent a five-minute adaptation to mesopic conditions and was then asked to read as many optotypes as possible with both eyes, starting at the highest eccentricity (e.g. on the right).

Disability glare test results

Significant benefits in terms of size of the glare halo were revealed for configurations 2 ($p<.01$) and 1 ($p<.001$), as seen in figure 3. Configuration 3 did not reveal any benefit compared to configuration 4, the control configuration ($p>.1$). The size of the halo produced by the glare, which was on average 3.33 degrees without the glasses, was reduced to 2.36 degrees for configuration 1 and to 2.86 degrees for configuration 2. The gain thus covered a range of 0.97 degrees to 0.47 degrees.
If the halo is considered as a disk centered on the light source, with configuration 1 *Les Lunettes by Valeo* produced a gain of 1.69m at 100m on the right-hand side and, theoretically, the same on the left-hand side (see figure 2).

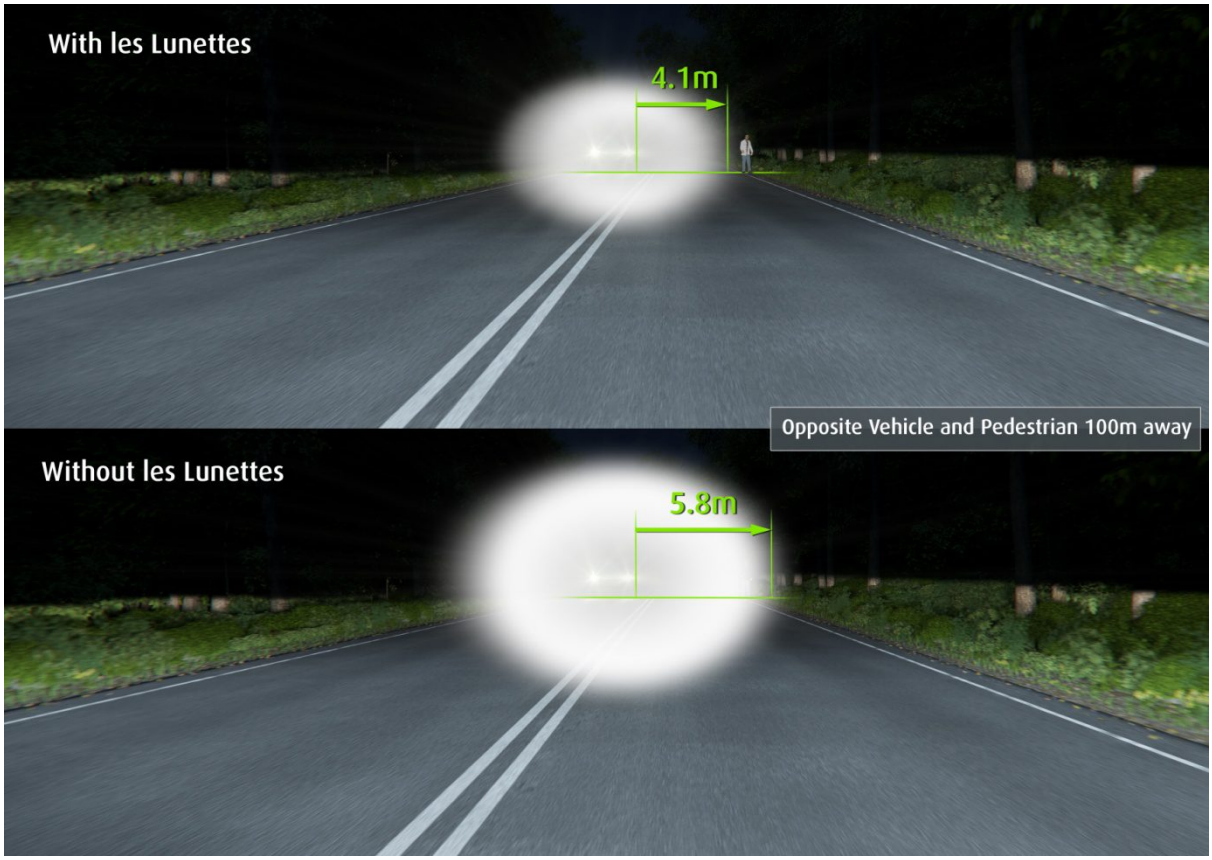

Fig. 2. Benefit of *Les Lunettes by Valeo* on size of headlamp glare halo in configuration 1 (©VALEO)

When two groups of drivers were compared, the halo size caused by the oncoming car's headlights in the control configuration (config. 4) was logically greater for the higher sensitivity drivers than for the lower sensitivity drivers ($p<.05$). However, in configurations 1 and 2, no difference was observed between the two groups, indicating that glare sensitivity had been totally eliminated by *Les Lunettes by Valeo* (see figure 3).

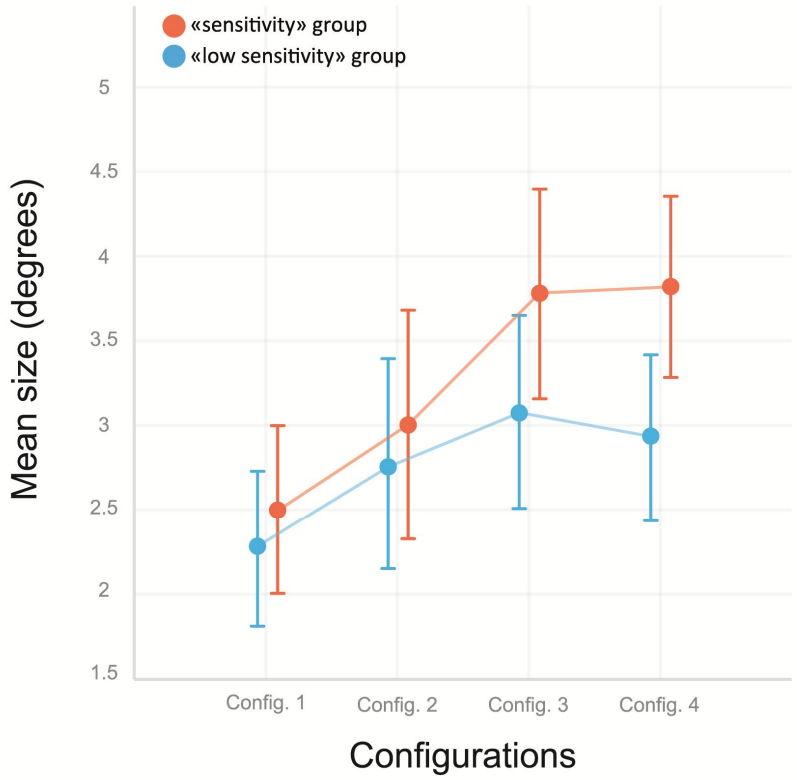

Fig. 3. Halo size averages in degrees according to sensitivity groups and configurations (© VALEO)

Discomfort glare test

Four conventional Renault Clio IVs equipped with LED headlamps were positioned at different locations on the test track. They were used as a glare source. They had headlights of varying intensity, from poorly adjusted, high beam, top of a low hill to low beam. The participants drove a premium SUV and wore *Les Lunettes by Valeo*. The person conducting the test sat next to the participant during the test. Four test runs were carried out, one using each of the three *Les Lunettes by Valeo* configurations and one in the control situation.

The participants were all subjected to four system configurations (fig. 1) and four glare situations in random order so as to avoid response bias owing to order effect.

After each exposure the drivers were asked to stop the car and quantify the glare on the de Boer rating scale[5]. The de Boer scale is a commonly accepted method for measuring discomfort glare according to a nine-point subjective scale with five anchor levels:

- 1 = unbearable
- 3 = disturbing
- 5 = just admissible
- 7 = satisfactory
- 9 = unnoticeable

Discomfort glare test results

In the situation most frequently encountered in real life, i.e. poorly adjusted oncoming headlights, the results showed that perceived discomfort decreased with increased filtering (p>.001), as seen in figure 4. The results also indicated that configurations 1 and 2 significantly reduce discomfort (higher scores on de Boer scale) compared to other configurations (p>.001). The discomfort glare test results were thus fairly consistent with the disability glare test results.

In terms of glare discomfort, the results for poorly adjusted headlights varied from lower than level 5 (just admissible) in the control configuration (without *Les Lunettes by Valeo*) to level 7 (satisfactory) in configuration 1. The same benefit patterns were observed for other taxing glare situations (high beam and top of low hill) with a gain of approximately two points on the de Boer discomfort glare scale (fig.4).

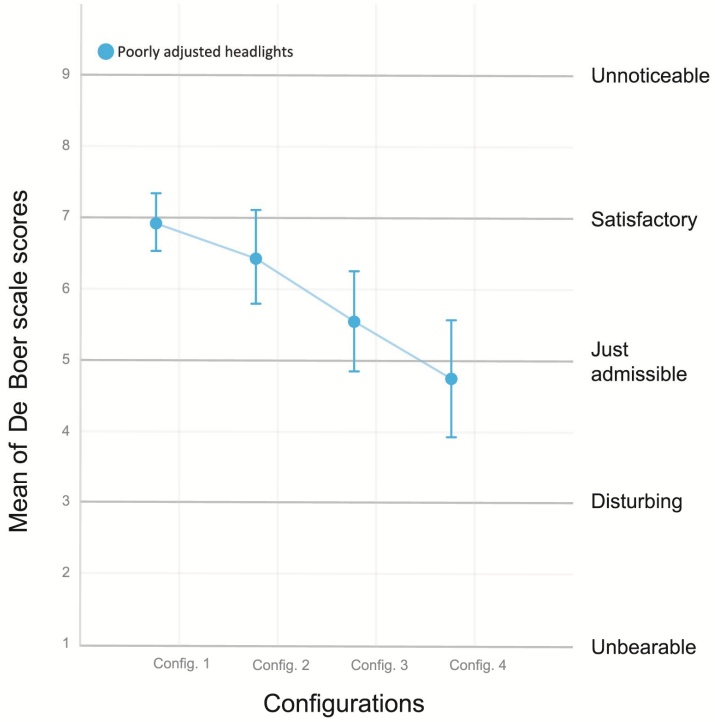

Fig. 4. Average scores on the de Boer scale in relation to system configurations and lighting situations (©VALEO)

POST-DRIVE EVALUATION

The vast majority of participants were satisfied with the anti-glare glasses: most of them found the system effective for limiting glare (22) and maintaining a good overall view of the road (21).

Les Lunettes by Valeo were considered comfortable to wear and requiring no particular effort of concentration when used. For 18 participants, driving with *Les Lunettes by Valeo* was perceived as requiring less effort than driving without them, meaning that both groups (higher sensitivity and lower sensitivity) could benefit from such an innovation. 21 participants said that they preferred driving at night with the anti-glare glasses than without.

When spontaneously discussing the system, participants mentioned comfort as a main benefit (20) but also safety (9) and the fact that they could focus more on the road (7).

All participants said they would use such system on long drive (more than a hour). However the frequency of use varies and depends on the declared “like/dislike night drive” (fig.5).

	Driving habits			
Use the system on the long drive (XX participants)	*I like night driving (5)*	*Night driving doesn't bother me (12)*	*I don't like night driving (7)*	Global (24)
Never				
Very rarely				
Rarely				
Sometimes	1			1
Frequently	2	1	1	4
Very frequently	2	11	6	19

Fig. 5. Frequency of use by night driving likes and dislikes (©VALEO)

In addition, participants find more interest in the system on country or national roads then on highway. Respectively, 22 participants and 15 say they could use this system frequently on these types of roads.
When these answers are compared to driving habits mentioned earlier, we note that people who do not like night driving are the most likely to use this system very frequently on all types of road. Indeed, 7 said they could use it very frequently in cities, 20 on country or national roads (up to 24 from frequently to very frequently) and 17 on highways (up to 20 very frequently). Furthermore, even participants who do not express a dislike for night driving are for the vast majority ready to use this system frequently and even very frequently, particularly on countries / national roads or highways (respectively 22 and 14).
Purchase intention was evaluated and almost all participants (23) would buy the system in their preferred configuration. All participants (24) were willing to recommend the sysem.
Participants were also asked to estimate average prices for such system. Assumptions made were in line with the technological content.

SUMMARY

The objective of the study was not only to evaluate the impact of glare when driving at night, but also to determine which configurations were perceived as the most efficient. The test showed highest performance with configurations 1 and 2. Evaluated both objectively and subjectively, Les *Lunettes by Valeo* were shown to provide clear benefits in most glare inducing situations. Furthermore, the results demonstrated that they were particularly suited to senior drivers who are more sensitive to glare. They not only improved vision but also reduced the glare effect to the same level as that of less sensitive drivers. The study also revealed a high end-user acceptance for *Lunettes by Valeo*.

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