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Road Safety and Vehicular Light Standardization in Nigeria Amidst Ameriacan and UN Regulation Standard (WP.29)

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Abstract

Since the first Ford's Model Ts vehicle in 1908 which has metamorphosis into the present day hybrid vehicles, yearly auto-crash leads to the death of 1.2 million people, injury and disability of another 50 million is challenging. This study assesses road users' perception and responses to red signal-lights of new/second hand vehicles imported into Nigeria and theoretical review of human vision. Questionnaires were administered to urban road users at public garages, oral interviews with the Federal Road Safety Corps (FRSC, Nigeria) and traffic cops and personal observation at intersections to assess drivers' perception of red turning signal- lights. The result reveals that 76% of the road users have low perception of red turning-signal and that poor utilization of turning-signal are responsible for 45% intra-urban road crashes. In conclusion, it is recommended that the federal government through the relevant agencies should redefine her stand on the US and World Forum for Harmonization of Vehicle Regulations, WP.29 in the furtherance of road safety crusade in the country.

Keywords: *Turning Signal-Light, Visual Perceptions, Vehicle Blinkers, Traffic Safety, and WP 29.*

1. Introduction

Science and technological advancement is not so pronounced in any sector globally as in the transportation sector. The automobile industry has metamorphoses from the wind first Ford's Model Ts vehicle in 1908 to the present day intelligent electric vehicles including the lighting systems, and automobile industries all over the world are expected to evolve series of their innovations within the global agreed standard.

Historically, early vehicles uses semaphore signals (Trafficators) which, when operated, protrude from the bodywork of a motor vehicle to indicate its intention to turn in the direction indicated by the pointing signal. Trafficators are often located at the door pillar which are in operation up till 1950s before they were replaced by the modern type of flashing signal flashing amber, red or white indicators at or near the corners of the vehicle (and often along the sides as well) as indicated in fig. 1.

Figure 1. Trafficator in the "on" position
Source: The free encyclopaedia

Historically also, early road vehicles used fuelled lamps, before the availability of electric lighting, for example, the Ford Model-T used carbide lamps for headlamps and oil lamps for tail lamps, and did not have all-electric lighting as a standard feature until several years after its introduction. Dynamos for automobile headlamps were first fitted by 1908 and became commonplace in automobiles of the 1920s. Tail lamps and brake lamps were introduced around 1915, Self-cancelling turn signals were said to have been developed in 1940 and by 1945 headlamps and signal lamps were integrated into the body styling. Halogen headlamp light sources were developed in Europe in 1960, and HID headlamps were produced in 1991, (Moore & Rumar, 1999).

Turn signals — formally called "directional indicators" or "directional signals", and informally known as "directionals", "blinkers", "indicators" or "flashers" — are blinking lamps mounted near the left and right front and rear corners of a vehicle, and sometimes on the sides, activated by the driver on one side of the vehicle at a time to advertise intent to turn or change lanes toward that side. As with all vehicle lighting and signalling devices, turn signal lights must comply with technical standards that stipulate minimum and maximum permissible intensity levels, minimum horizontal and vertical angles of visibility, and minimum illuminated surface area to ensure that they are visible at all relevant angles, do not dazzle those who view them, and are suitably conspicuous in conditions ranging from full darkness to full direct sunlight

Turn signals are required to blink on and off, or "flash", at a steady rate of between 60 and 120 blinks per minute. International UN Regulations require that all turn signals flash in simultaneous phase , (UN Regulation 48, FMVSS No. 108).

2. Turn signal colour

Until the early 1960s, most front turn signals worldwide emitted white light and most rear turn signals emitted red. Amber front turn signals were voluntarily adopted by the auto industry in the USA for most vehicles beginning in the 1963 model year, though the advent of amber signals was accompanied by legal stumbles in some states and front turn signals were still legally permitted to emit white light until Federal Motor Vehicle Safety Standard (FMVSS 108) took effect for the 1968 model year, then amber became the only permissible front turn signal colour, ("New Amber Turn Signals Causing Unexpected Turmoi).

As vehicle turn-signals developed and became standardized over the past centuries, differences arose in the European and United States standards (Moore & Rumar, 1999). One major difference is that while European standards, governed by the Economic Commission for Europe (ECE), require rear turn signals to be exclusively amber (yellow), the United States, (FMVSS) 108 allows rear turn signals to be *either* amber or red. Although ironically, the difference is said to have stems from subjective tests of amber turn signals and recommendations made in the United States by the Vehicle Lighting Committee (VLC) of the Automobile Manufacturer's Association to the European organization of lighting experts, the Group de Travail-Bruxelles (GTB), at a meeting in 1960. The GTB, in turn, recommended the exclusive use of rear amber turn signals to the Europeans, and in 1967 the ECE made it a requirement. Meanwhile, U.S. manufacturers rejected their use based on unproven cost benefits.

International proponents of amber rear signals say they are more easily discernible as turn signals, and U.S. studies in the early 1990s demonstrated improvements in the speed and accuracy of following drivers' reaction to stop lamps when the turn signals were amber rather than red. (Hitzemeyer, et al 1977; Taylor, 1981; Traube, et al, 19997; Van Iderstine 2004; D'orleans, 1997). A 2008 U.S. study by the National Highway Traffic Safety Administration (NHTSA) suggests vehicles with amber rear signals rather than red ones are up to 28% less likely to be involved in certain kinds of collisions, and a 2009 NHTSA study determined there is a significant overall safety benefit to amber rather than red rear turn signals, (Allen, Kirk, 2009).

Figure 2. Nissan Altima MY 2005, red turn signals; 2002-2004 amber turn signal

The majority of Nigerian road users, for example, might recognize amber rear-turn signals more quickly than the red because they may benefit from the redundancy in colour-coding the turn function (i.e., amber means turn, red means stop); in contrast, only young and perceptive drivers will recognize that a red signal could indicate a turning or braking vehicle and base their recognition on other signal cues (e.g., flashing lamps, asymmetric lamp illumination).

One effect of the introduction of Centre High Mounted Stop Lamps (CHMSL) in 1986 was an estimated reduction of rear-ends collisions by about 4.3 percent (Kahane & Hertz, 1998). Prior to its introduction, red rear-turn signals have been more confusable with rear-brake signals and possibly led to more rear-end collisions during turning. But after its introduction, the difference between a turning and a braking vehicle may have become clearer to following drivers. But unfortunately in Nigeria, only about one in five hundred (1: 500) vehicles has the CHMSL installed.

3. The Aim and Objectives of the study

The aim of this study is to assess the effect of the increasing red vehicular turn-signals in Nigerian cities on urban road users in the face of the present day auto crash challenges, and this is achieved through the following objectives:

i. Examine and identify the level of vehicular turn-signal colour differentiation in Minna,
ii. carry out interview on the road users to determine their perception of the red turn-signal colour differentiation,
iii. carry out a roadside personal observation of road users behaviour in response to red turn-signal colours, and
iv. examine the common vehicle models with all-red rear-end light colouration in order to proffer plausible recommendation to the policy makers.

4. Methodological approach

Studies in the past have attributed causes of road accident to human factor, environmental, and technical, but not much has been done in the area of governmental policy implementation. This study therefore focused on the effect of turn-signal colour differentiation of recently imported vehicles in Nigeria. 75 number questionnaire was administered in the five major public garage in Minna and oral interview with Federal Road Safety Corps (FRSC, Nigeria) and the traffic cops to assess drivers perception of differential turn signals (vehicle blinkers). Digital camcorder was used to monitor road user's behaviour at three intersections in responses to amber/red colour turn signal operations. Secondary data were obtained from relevant UN Highway Code literatures and conventions.

5. Review of Relevant Literatures

Studies on the road users' colour perception and reaction in relation to vehicle turn signal colour differentiation had been carried out by researchers like Post (1975) examined driver reaction time to respond to turn, brake, and hazard signals with a variety of lamp configurations. Kirk (2009) in his technical report, determine the effect of rear turn-signal colour on the likelihood of being involved in a rear-end crash. He affirm the US Federal Motor Vehicle Safety Standard No. 108 which allows rear turn signals to be either red or amber in colour, but that previous work on the subject includes laboratory experiments and analyses of crash data which suggested amber rear turn signals are beneficial. The study find out that amber signals show a 5.3% effectiveness in reducing involvement in two-vehicle crashes where a lead vehicle is rear-struck in the act of turning left, turning right, merging into traffic, changing lanes, or entering/leaving a parking space and that the advantage of amber rear turn signals is statistically significant.

In a simulated driving task, Luoma et al (1995) assessed the effect that turn signals have on recognition of brake signals. They found out that reaction time to a braking signal is shorter in the presence of amber turn signals compared to red in environment where mixtures of both colours are present. Three main effects were statistically significant – color (red turn signals had longer response times), lamp condition (reaction times were longer with the turn signal on), and age (older participants took longer to respond). Averaged across luminous intensity and signal condition, amber turn signals yielded response times about 20 percent faster compared to red turn signals. Edwards (1988) analyzed crashes in five States occurring between July 1, 1983, and June 30, 1985. He found that amber turn signals were 20.4-percent effective at reducing rear-end crashes with "total rear-end crashes" as the control group of crashes and 17.7-percent effective with "total crashes" as the control group, see table 1.

Table 1. Breakdown of crash frequencies by signal lamp colour, role in crash, and for each rear-end collision type

	Rear-end collisions while turning, merging, or changing lanes		**Rear-end collisions not involving turning, merging, or changing lanes**
Signal Lamp Colour	**Struck (Rear Impact)**	**Striking (Front Impact)**	**Struck (Rear Impact)**
Amber	4,975	4,417	58,964
Red	5,115	4,172	56,771
Total	**10,090**	**8,589**	**115735**

Similarly, Mortimer and Sturgis (1974) observed shorter reaction times were with amber turn signals in their studies. Recognizing that as a red stimulus shifts toward the visual periphery it appears less saturated and more yellow, Sivak, Flannagan, Miyokawa, and Traube (2000) questioned the general utility of signal colour coding in normal driving, where objects are presumably first detected in the periphery. They found that in daylight conditions, colour discrimination declined at viewing angles of 10 degrees or more, suggesting that the usefulness of colour might be somewhat limited in hastening detection.

Lindsay et al (2006) compared the visual detection thresholds for cone-isolating stimuli of trichromats (those with normal color vision) with those of X-linked dichromats, who lack either the long-wavelength-sensitive (L) cones (protanopes) or middle-wavelength sensitive (M) cones (deuteranopes). They discovered that at low (1 Hz) temporal frequencies, dichromats have significantly higher (twofold) thresholds for all coloured stimuli than trichromats; whereas at high (16 Hz) temporal frequencies, they perform as well or better than trichromats. Other researchers like Van Arsdel & Loop, (2004) have investigated the disadvantages of dichromats in visual detection.

6. Theories of color vision

Two complementary theories of colour vision are the trichromatic theory and the process theory. The trichromatic or Young–Helmholtz theory states that; the retina's three types of cones are preferentially sensitive to blue, green, and red. But Ewald Hering states that the visual system interprets colour in an antagonistic way: red vs. green, blue vs. yellow, black vs. white. But it has been proved that both theories are correct, describing different stages in visual physiology, Green ⟵⟶ Magenta and Blue ⟵⟶ Yellow are scales with mutually exclusive boundaries as displayed in table 2, (John, 2001)

Table 2. Cone cells in the human eye

Cone type	Name	Range	Peak wavelength
S	β	400–500 nm	420–440 nm
M	γ	450–630 nm	534–555 nm
L	ρ	500–700 nm	564–580 nm

When light strikes an object, it can be absorbed, reflected, or scattered. When the surface absorbs all wavelengths equally, we perceive it as black. When the surface reflects all wavelengths equally, we perceive it as white.

7. Colour vision in the human eye to brain

Colour processing begins at a very early level in the visual system (even within the retina) through initial colour opponent mechanisms. Visual information is then sent to the brain from retinal ganglion cells via the optic nerve to the optic chiasma: a point where the two optic nerves meet and information from the temporal (contralateral) visual field crosses to the other side of the brain (fig. 3).

Cones are one of the two types of photoreceptor cells that are in the retina of the eye which are responsible for colour vision as well as eye colour sensitivity. There are about six to seven million cones in a human eye and are most concentrated towards the macula (Nathan et al 1986; Neitz J, Jacob, 1986; Jacobs, 1996).

The human brain has the same general structure as the brains of other mammals, but is larger than any other in relation to body size. The cortex is divided into four "lobes", called the frontal lobe, parietal lobe, temporal lobe, and occipital lobe as displayed in Fig. 3. Within each lobe are numerous cortical areas, each associated with a particular function such as vision, motor control, language, etc. The occipital lobe is entirely dedicated to visual reception, visual-spatial processing, movement, and colour recognition, each of the lobes contains a variety of brain areas that have minimal functional relationship, (Loveleena Rajeev Last (2012).

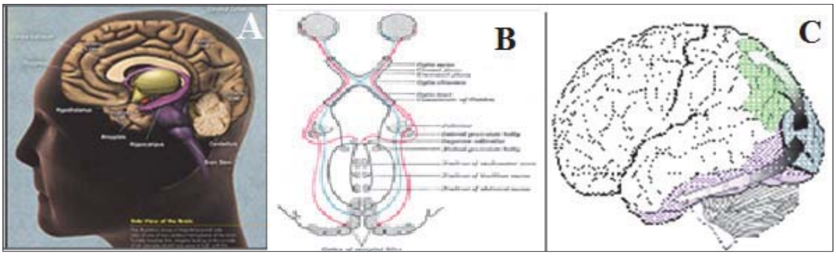

Figure 3. Visual pathways in the human brain (purple is important in colour recognition).
Source: after Loveleena Rajeev Last (2012).

8. Visual Aging

There are neural losses in aging drivers; but the major decline is due to changes in the eye's optics. First, the lens becomes yellower, making discrimination of blue colours more difficult. More importantly, less light entering the eye reaches the photoreceptors and the lens and other optical media become opaque. Also, the shrinking of the pupil allows less light to enter the eye. Table 3 shows how the pupil size shrinks with age, note that the pupil's response to dim light also decreases with age and becomes virtually nil by age 80. This means the elderly have especially large vision problems in low light environments. Human vision, perception and reaction time decline with advancing age, so the roads will be filled with sight-impaired drivers.

Table 3. Light Vision Capacity according to Age

Age (yr)	Day (mm)	Night (mm)
20	4.7	8.0
30	4.3	7.0
40	3.9	6.0
50	3.5	5.0
60	3.1	4.1
70	2.7	3.2
80	2.3	2.5

9. Harmonization of Vehicle Regulations (WP.29)".

WP.29 was established on 6 June 1952 as the Working Party on the Construction of Vehicles, a subsidiary body of the Inland Transport Committee (ITC) of the United Nations Economic Commission for Europe (UNECE). But in March 2000, it became the "World Forum for Harmonization of Vehicle Regulations". These regulations are aimed at:

- improving vehicle safety;
- protecting the environment;
- promoting energy efficiency and
- increasing anti-theft performance.

The major challenging issue is the existence of two Agreements for Harmonization of Vehicle Regulations. The United States of America and Canada is said to have follows a system of self-certification and thus, found it difficult to implement the mutual recognition of approvals, as required under the 1958 Agreement. Appreciating the need for harmonization of regulations, the partners proposed the 1998 Agreement (so-called Global Agreement) with the objective of involving countries from all parts of the world in the elaboration of Global Technical Regulations (GTRs). The title of the Agreement is:

> *"Agreement concerning the establishing of global technical regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles", done at Geneva on 25 June 1998.*

A Contracting Party can also decide to accept the products complying with a GTR without adopting the same into its own laws or regulations. (i.e. can adopt the GTR as an option to the domestic regulation). It is currently observed that it is not possible to produce a single car design that fully meets both UN and US requirements simultaneously; therefore, many manufacturers produce vehicles in three versions: North American, rest-of-world right-hand drive (RHD) and rest-of-world left-hand-drive (LHD). Nigeria presently opts for RHD but what of turn-signal-lighting system?

10. Background of the study area

Minna, the capital of Niger State derived its initial growth and importance from the development of the Lagos-Kaduna rail line and the subsequent transfer of the local government headquarter from Kuta to Minna. Geographically, the town lies between latitude $9^0\ 38'$ - $9^0\ 45'$ N and Longitude $6^0\ 33'$ - $6^0\ 39'$ East, and is about 140 km away from Abuja the Federal Capital Territory (FCT) south-west, see fig. 4. In term of built-up area, the area coverage increased from 884 hectares in 1979 to 5336 hectares in 1983 and from 7070 hectares in 1993 to about 14,568 in 2012. The phenomenal growth of Minna after the establishment of FCT is quite tremendous and later aggravated by the political upheaval in the northern neighbouring states like Kano, Kaduna and Plateau from where people migrated into the State due to its relative peace. In 1979, the population of Minna was estimated at 76 480, in 1991 census figure, it was 143,896 people but in 2012, it was estimated at 291,930 people.

Figure 3. Minna in relation to FCT

11. Data presentation

The differentiation in vehicular rear-end light colouration appear to become more common in Minna and other parts of the country from the year 2002 as expressed by the drivers interviewed. From table 4, the dominant year according to the respondents in which vehicles with complete red rear-end signal become common is in the 2010, 48% of the respondents claimed the year as the first time of seeing vehicles with that lighting system. This may be unconnected to some import policies that encourage such act.

Table 4. Year of first sighting red signal-light vehicle.

OPTION	FREQUENCY	PERCENTAGE
2007	2	2.7
2008	12	16
2009	9	12
2010	36	48
2011	4	5.3
2012	4	5.3
2013	4	5.3
TOTAL	75	100

In the area of vehicular models that carry complete red rear-end lighting system, from Fig. 5, Honda and Toyota leads the responses. In fact, Honda Odessa Space-bus tops the list.

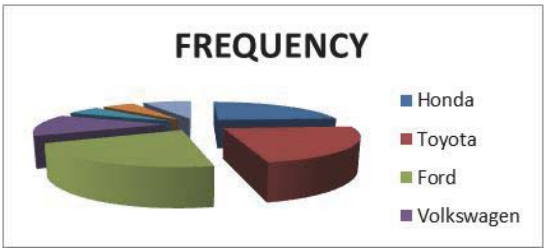

Figure 5. Vehicular models that carry complete red rear-end lighting system.

12. Drivers' perception and reactions

As vehicles approach a lane that is close to interchanges, there is usually both braking and signalling of a merge into an adjacent lane. But the drivers following behind in an adjacent lane, mistakes the forward vehicle's signal as braking instead of merging, a rear-end collision then occurs when the forward vehicle encroaches into the following driver's lane. This is mostly common around intersections without traffic signalling.

In another case, a vehicle transitions from a high speed to a lower speed, braking occur over an extended duration in order to decelerate in a smooth fashion. From the perspective of a following vehicle, in this context the forward vehicle's brake lamp does not signal an imminent deceleration. However, as a turn signal is energized, a following vehicle may well anticipate that a stronger deceleration is about to happen (in order to make a turn at a comfortable speed). But failure to detect the turn signal impeded the following driver's ability to anticipate the deceleration, resulting in a rear-end collision (shown in Figure 6).

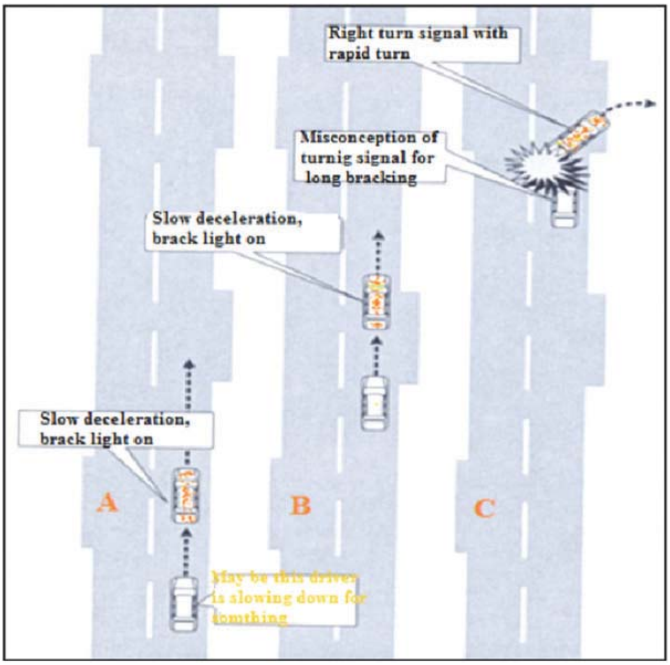

Figure 6. Crash scenario in red-turn signal and brake light (after John et al, 2008)

The analysis in Fig. 6 is in consonant with the fact that most Nigerian drivers have low comprehension of the red light vehicle signalling and that many are suffering from colour blindness. Colour vision is the ability of an organism or machine to distinguish objects based on the wavelengths (or frequencies) of the light they reflect, emit, or transmit. Sufficient differences in frequency give rise to a difference in perceived hue.

13. Conclusion

It is has been argued without any equivocal that amber turn signals are noticed earlier than red turn signals and provide drivers with more time to anticipate the movements of a forward vehicle. If a driver sees a brake signal, and mistakes it for a turn signal, it is conceivable that the driver might fail to brake and strike the forward vehicle. The federal government through the relevant agencies need to standardize the vehicular lighting system to be imported for use on the highways if road safety is a watch word in the country.

14. Recommendations

In the light of the above discussions, the following recommendations are hereby given.

While the federal government should as a matter of urgency redefine her stand in the UN Harmonization of Vehicle Regulations (WP.29, 2005)".

That if Nigeria will continue to import vehicles from both continental blocks, then certain road infrastructure and regulatory laws that calls for the adaptation of American vehicle to Nigeria UN standard codes should be put in place for the safety of the national highways.

The custom officers right from the port of entry should enforce the corrective measures on

American vehicles with; red-turn signal lights and other cosmetic none essential glaring snow, fog, run lights that are causing lots of road mishaps which the FRSC is currently battling with.

Boarder policing and readiness to shun compromise is none negotiable if sanctity to be achieved on the country's roadway.

The FRSC should redefine and expand their scope of operation in term of road users visual test and impoundment of none conforming/compatible vehicles on Nigeria roadway.

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