

DIPLOPIA AND DRIVING

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Abstract

The effects of diplopia on driving skills are described, based on the responses of subjects in two groups. Group 1 (12 subjects) had artificially produced diplopia. Group 2 (three subjects) had diplopia associated with a medical condition. Results showed that diplopia reduces the accuracy and judgement skills of drivers regardless of the cause of the diplopia.

Key words: *Diplopia, driving skills.*

INTRODUCTION

Diplopia is described by Duke Elder¹ as having an affect that is "usually so disturbing that the simultaneous activities of the eyes cannot be tolerated". In the complex activity of driving where sensory and motor functions are required to work in harmony and at a high level, diplopia must affect driving ability.

Little has been recorded about the effects that diplopia has on the driving skill. Currently the presence of diplopia does not preclude a driver from holding a driver's licence.

METHOD

In order to investigate the effects that diplopia has on driving skills the responses of two groups

are reported. The first had diplopia artificially created with the use of press-on prisms on plano glasses (normal group) and their driving skills in the presence of the diplopia was evaluated. The second group comprised three subjects who were being evaluated for their ability to drive and who had diplopia caused by a medical condition or injury.

ARTIFICIAL DIPLOPIA (Normal Group)

Diplopia was artificially produced in 12 subjects who had normal binocular single vision and then each persons' driving skill was tested over a set driving route.

The 12 subjects in the study were six males and six females between the ages of 18 and 30 years.

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All subjects were physically fit, had held a licence for at least one year and had driven regularly. Each subject was given an eight dioptre fresnel prism placed base in on both the left and right lens of a pair of plano glasses. These prisms caused artificial horizontal diplopia which could not be fused.

Each subject drove over two courses which had been selected for their similarity. Each course had three right corners, three left corners, straight stretches of road, the need to pass parked as well as moving vehicles and a laned section of road. All subjects commenced with course one. Half the subjects drove course one with diplopia created by the prisms and then course two without the prisms so that they had binocular single vision. The other half of the subjects drove course one with binocular single vision and course two with diplopia.

All subjects were assessed under the same conditions which included driving in a car that was unfamiliar to them; in lighting conditions that were constant, i.e. full sunlight; and on quiet back streets of a Sydney suburb. To ensure the safety of each subject the test was carried out in a car which had dual controls and in the presence of a fully qualified driving instructor whose role was to take over control of the car in the likelihood of any danger, collision or loss of control. All subjects were informed that they had the right to terminate the testing procedure at any time.

The test procedure involved each subject driving the test route whilst using binocular single vision. This took five minutes and enabled them to become familiar with the car. They were then directed by the driving instructor to follow the test route and to maintain a constant speed. Two responses were observed:

1. *Driving Speed*

Three speed levels were recorded during each of the following activities, right hand turns, left hand turns, driving on a straight stretch of road, driving past parked vehicles and driving past moving vehicles. The speed levels for each activity were averaged in order to compare each driver's response in the diplopic and single vision state. If the subject closed

one eye, stopped when it was unnecessary or refused to continue with the course they were given a speed score of zero.

2. *Driving Accuracy*

This was recorded in two situations. The first situation was along 500 metres of a two lane road whilst maintaining a constant speed of 50 km/h. Each time the driver deviated from the lane one point was deducted from a total score of 10. This score was changed into a percentage and the response compared between the diplopic and binocular single vision state.

The second situation examined the ability of the driver to weave the car around six witches hats. The hats were placed in a straight line with a gap between each hat. The driver had to maintain a constant speed of between 15-20 km/h and make no errors. A point score system was used. One point was deducted from a total of six, when either a hat was hit or the driver failed to successfully drive around a hat.

If at any stage the subject shut one eye to overcome the diplopia their score was recorded as zero.

RESULTS (Normal Group)

The speed at which all the subjects drove for each assessed activity was averaged and the results of speed with diplopia was compared to the average speed with binocular single vision. Table 1 and Figure 1 show the results. In all situations the speed at which the driver travelled when diplopia was present was less than the speed at which the same driver travelled when binocular single vision was present. In each situation the difference was statistically significant with the *t* test showing the *p* value to be 0.00001.

TABLE 1
Comparison of speed with and without diplopia

	Corners	Straight ahead	Parked vehicles	Moving vehicles
Speed with single vision km/h	22.06	60.05	52.22	50.84
Speed with diplopia km/h	10.53	31.87	15.87	16.72

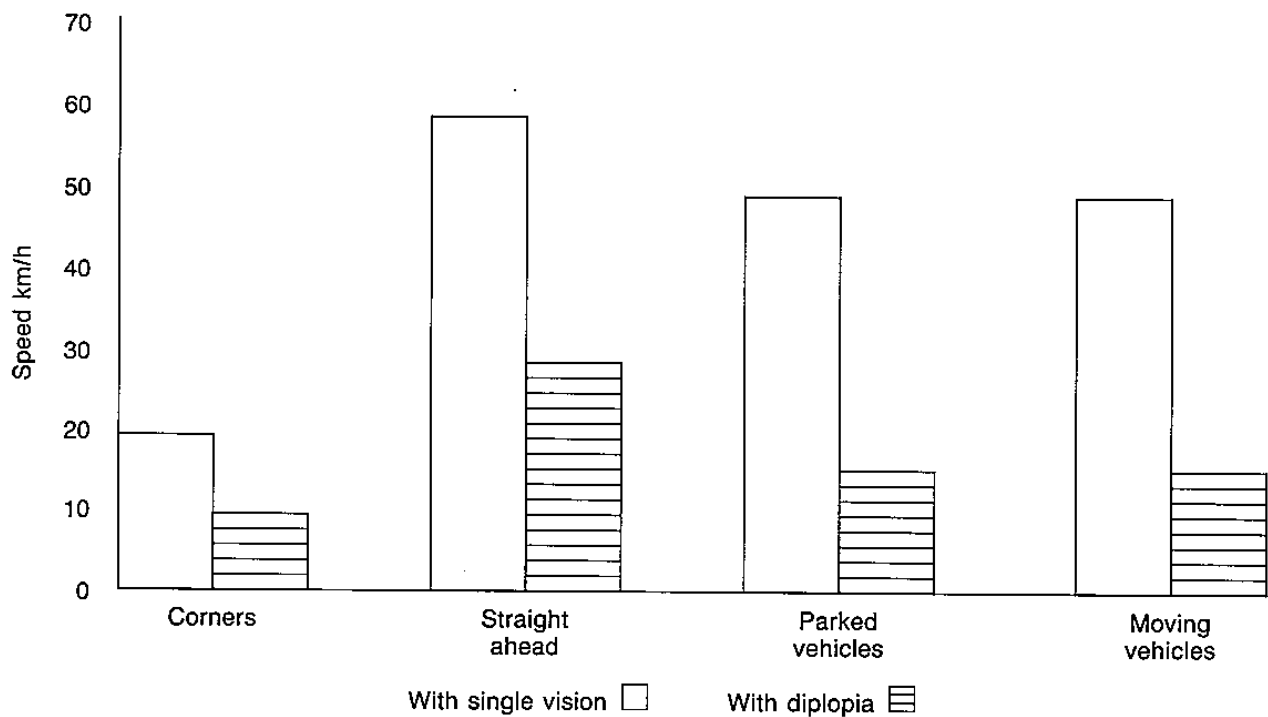


Figure 1: Comparison of speed with and without diplopia.

Accuracy was determined by the ability to perform each of two tasks without error. In the first task of weaving around the witches hats, each driver gained six out of six possible points when they were using binocular single vision. An average score of five out of six possible points was scored when the subjects performed the task in the presence of diplopia. The difference was shown by the *t* test to have a *p* value of 0.0069.

In the second task the ability to remain within marked lanes over a 500 metre straight stretch of road was tested. Each driver gained 10 points out of a possible score of 10, when they used binocular single vision. In the presence of diplopia the average score dropped to 4.5. By the *t* test the *p* value was 0.00001.

DIPLOPIA IN DRIVER REHABILITATION

It is fully recognised that the experimental situation does not represent the circumstances that occurs in clinical practice for patients with diplopia caused by ocular motor nerve or extra ocular muscle damage. For instance in the experimental situation prisms were used to produce the diplopia and these produced a reduction in vision to approximately 6/9. Additionally

the diplopia was not associated with any illness or injury so did not have any accompanying disorientation related to reduced bodily function. It is also unusual for a person with diplopia which has just occurred to immediately drive. Normally some adaptation time would occur. Therefore these factors raised doubt about the true effect that diplopia will have in the driving situation as well as the need to test drivers' abilities in the presence of diplopia.

Three subjects presented to the Driver Rehabilitation Centre at Cumberland College as part of the regular assessment programme for drivers with physical handicap. Each one had diplopia. The results of their on-road tests are proposed as evidence of how diplopia may affect driving skills.

SUMMARY OF THE OCULAR CONDITIONS OF THE SUBJECTS WITH DIPLOPIA

Subject 1

Aged 23 years, had a medical history of removal of an astrocytoma from the right side of the cerebellum.

- Visual acuity • right 6/12, left 6/9, binocularly 6/9
- Visual fields • normal
- Ocular condition • major muscle underaction of left superior oblique; nystagmus, left beating in the primary position and elevation, rotary on right and left gaze, less on extreme depression; saccades hypometric and "zig-zag" on elevation
- Symptoms • DIPLOPIA constant for eight months, maximal in the field of the left superior oblique.

Subject 2

Aged 16 years, had a medical history of head injury.

- Visual acuity • right 6/4, left 6/5, binocularly 6/4
- Visual fields • normal
- Ocular condition • left esotropia and left hypotropia; nystagmus on elevation, right beating to the right and left beating to the left; saccades, "zig-zag" movement on elevation
- Symptoms • DIPLOPIA in all positions of gaze for 12 months.

Subject 3

Aged 71 years, medical history of cerebrovascular accident and cardiac problems.

- Visual acuity • right 6/9, left 6/6, binocularly 6/6
- Visual fields • normal
- Ocular condition • major muscle underaction, right superior rectus compensated with head posture to right shoulder
- Symptoms • DIPLOPIA, present on right gaze for at least 12 months; difficulty looking at the dashboard; problems with "changes in the level of the road surface".

During the on-road assessment overall speed levels were noted, for instance if the client constantly exceeded or travelled well below the limit. Averaged responses for specific activities were not recorded and therefore speed patterns in these clients could not be directly compared to the patterns reported in the normal group.

Accuracy in driving performance was routinely noted in each client during the on-road assess-

ment, particularly with reference to judgement and positioning.

Judgement was noted in relation to:

- timing, when braking at corners and at intersections, which was either too early or too late
- timing accuracy for lane change.

Positioning was noted in relation to:

- the car being kept to the left of the centre of the road
- staying within marked lanes
- placement of the car when turning corners
- placement of the car at intersections.

RESULTS

Table 2 summarises the problems experienced by each subject.

Judgement errors included braking too late when turning into corners, braking for no reason, premature changing of position to avoid a parked car, merging too late and, braking too early or too late at intersections.

Positioning problems included turning on the wrong side of a silent cop, driving too close to the gutter, losing position on lane change and steering into the gutter after turning corners and at curves.

Other problems encountered included failure to check the blind spot on the side of the diplopia and failure to identify a sign on the side of the diplopia.

The problems experienced when driving were eliminated when the diplopia was corrected by

TABLE 2
Driving problems in the presence of diplopia

Driving problems	Case 1	Case 2	Case 3
Judgement errors	At corners Premature lane change	Intersection	Right merge late
Positioning errors	Wrong side silent cop Lost position on lane change	At corners and curves	
Other			Could not check: — Blind spot to right — Signs on right