基于人机工程学的行车环境安全性评价

The Safety Evaluation of Driving Environment Based on Ergonomics

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一. 研究背景

1.意 义

诱导交通事故发生的因素是多方面的，受行车速度、道路条件、车辆状况、驾驶员行为、驾驶员的文化素质和社会背景、道路交通与自然环境等因素的综合影响。其中道路交通环境的宜人性程度不仅关系到驾驶环境的舒适性，更关系到驾驶的安全性。

Ⅰ． Research Background

1. purport

Many factors induce traffic accident，such as the driving speed, road conditions, vehicle state, driver's behaviors, driver's culture trait and social background, road traffic environment and natural environment, etc. Among them, the amenity level of the road traffic environment not only concerns the comfortableness of the driving environment, but also concerns the driving safety.

一. 研究背景

2. 现代交通的要求

在人、车、路（环境）的交通体系中，人和环境不可分离，传统的理念是驾驶员的行为应力求适应外界环境的变化。但是人的适应能力是有一定界限的。现代交通的要求是，道路工程环境、交通设施环境等在工程设计上必须满足驾驶宜人性的需要。

本研究从人机工程学的角度，通过医学与工学相结合的实验研究方法，提高和改善道路线形环境和交通环境的行车安全性和驾驶宜人性。

Ⅰ.Research Background

2.The Request of Modern Traffic

Among the traffic system consisted of human, vehicle, road (environment), human and environment can't be separated. Traditional idea is that the driver's behaviors should make every effort to adapt to the external environmental change. But human adaptive capacity has certain limit, modern traffic require road engineering environment, traffic facility environment, etc, must meet the need of the driving amenity in engineering design.

This research tries to enhance and improve driving safety and amenity of road alignment and traffic environment by experiment research approach that combing engineering with medical science from ergonomics aspect.

一. 研究背景

3. 研究的主要内容

1）基于驾驶员心率血压变动的道路线形安全性评价

2）基于驾驶员动视点的行车安全应用研究

3）脑电波在道路交通环境评价中应用的可能性

Ⅰ.Research Background

3. Main Content Of The Research

1） The Safety Evaluation of Road Alignment Based on the Fluctuation of Driver's Blood Pressure and Heart Rhythm

2） Driving Safety Application Research Based on Driver’s Dynamical Focus Point

3） The Possibility of The Brain Wave’s Application In Road and Traffic Environment Evaluation

EMR-8B主机输入端
EMR-8B Main Machine Input

二．基于驾驶员心率血压变动的研究

Ⅱ．The Traffic Environment Safety Evaluation Based on Driver’s Dynamical Focus Point

1．心率与血压变动评价指标

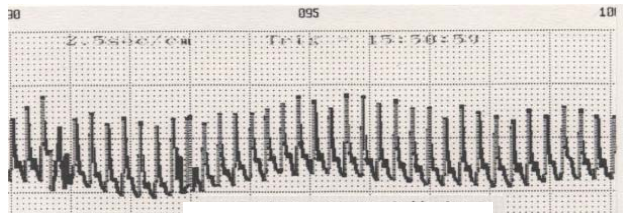
1. The Evaluation Index of the Fluctuation of Driver's Blood Pressure and Heart Rhythm

➢实验与研究证明：

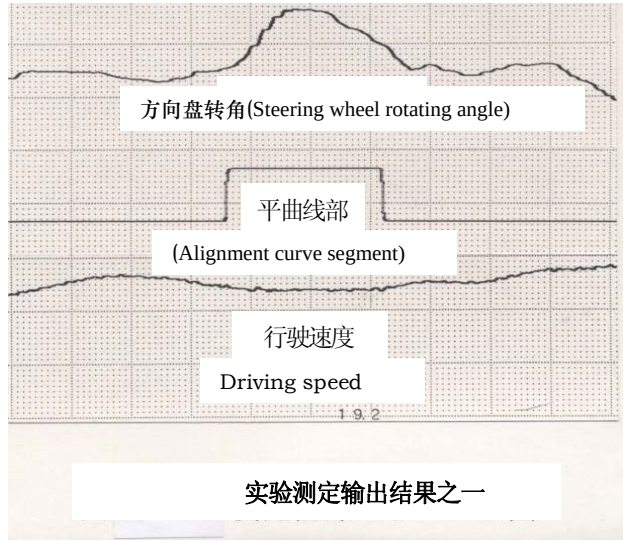
在机动车驾驶这种既有肉体上的刺激，又有精神上压力的作业劳动中，可把心率和血压的变动，作为评价驾驶员作业时负担程度的指标，衡量驾驶员因紧张、不安、危险或疲劳，产生的心理上的压力和生理上的负担程度。为道路交通环境的改善和设计提供科学依据。

The experiment and research proves:

In the labor of vehicle driving with body incitement and mental pressure, the fluctuation of the heart rate and blood pressures can be ascertained as the evaluation index of working burden level, to evaluate the driving burden level coming from strain, discomfort, danger or fatigues, psychological pressure and physiological burden level.



心率和血压的变动波形 (The wave forms’ fluctuation of rhythm of the heart and blood pressure)



One of the results of experiment testing output

二．基于驾驶员心率血压变动的研究

Ⅱ．The Traffic Environment Safety Evaluation Based on Driver’s Dynamical Focus Point

2. 心率·血压的实验设备

Finapres 2300型24小时连续自动血压测定装置

2. The experiment equipments of the heart rate and blood pressure

The continuously automatic blood pressure measurement of 2300 type, 24 hours of Finapres equip

二．基于驾驶员心率血压变动的研究

3. 实验用车

实验用机动车使用日产（NISSAN）8人乘的面包车（车长436cm，车宽169cm，轴距235cm）

Ⅱ．The Traffic Environment Safety Evaluation Based on Driver’s Dynamical Focus Point

3. The experiment vehicle

The experiment uses the minibus which 8 people took of Nissan (NISSAN) with the motor vehicle (vehicle commander 436 cms, the car is 169 cms wide, 235 cms of wheelbase)

二．基于驾驶员心率血压变动的研究

Ⅱ．The Traffic Environment Safety Evaluation Based on Driver’s Dynamical Focus Point

4.实验驾驶员

4.Experiment Drivers

驾驶员	性别	年龄	驾龄	职业
Y	男	62	37	教师
G	男	42	23	教师
S	男	31	6	教师
H	男	22	2	学生

Driver	Gender	Age	Driving Years	Career
Y	Male	62	37	Teacher
G	Male	42	23	Teacher
S	Male	31	6	Teacher
H	Male	22	2	Student

二．基于驾驶员心率血压变动的研究

5.实验道路

以山岭重丘区的道路为实验道路。线形弯曲程度由简单（包括一段未开通的高速道路）到复杂，区间长分别为800m左右的14个区间为实验道路。

线形简单弯曲程度的路段平均IP间距离为55.5m、平均交角54度、纵坡度3-5%。

复杂区间包括回头曲线存在、平均IP间距离为31.5m、平均交角120.5度、纵坡度6-9%。

Ⅱ．The Traffic Environment Safety Evaluation Based on Driver’s Dynamical Focus Point

5．Experiment Road

Choose the heavy highland road of the mountain range as experiment, the alignment flectional degree varies from simple (includes the expressway not run) to complicated, sums to 14 zones which the distance is 800ms or so.

An average IP distance of the alignment road with simple flectional degree is 55.5ms, the average connected angle is 54 degree, the vertical slope is 3-5% equally.

An average IP of road of complicated zones including return curves is 31.5ms, the average connected angle is 120.5 degree, the vertical slope is 6-9% equally.

三．基于驾驶员血压变动的研究成果介绍之一

1. 平面线形评价指标

回归分析了如图所示的9种道路平面线形评价指标。结果显示⑨视距率的标准偏差系数明显最高，其次为⑧单位曲线长2和③单位交角率。

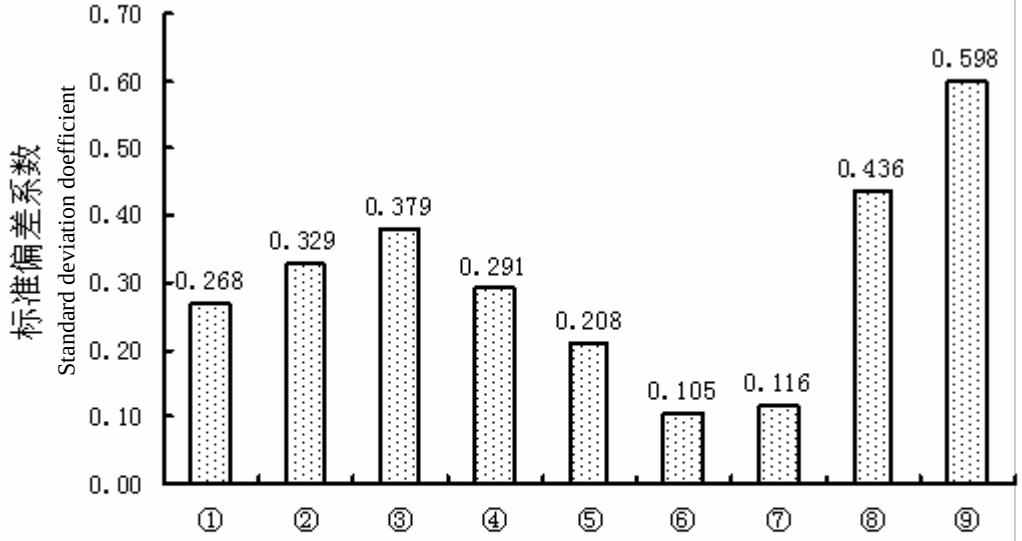
视距率与行车中驾驶员的心理生理负担有较显著的相关性，可作为评价山区道路平面线形合理性的评价指标。

Ⅲ. The First of the Research Results Is Introduced Based on Fluctuation of Blood Pressure

1. The evaluation index of horizon alignment

Regression analyzes 9 kinds of roads horizon alignment form evaluation index sign that is shown as diagram. The result indicates standard deviation coefficient of ⑨ (sight distance ratio)is obviously tallest, the next in order is ⑧(unit curve distance 2) and ③ hand over the Cape rate with unit of ③ .

The sight distance ratio has distinct relativity with driver's psychological and physiological burden of driving state, and can be ascertained as an effective evaluation index of to road horizon alignment's rationality in the mountain area.



道路平面线形评价指标

The Evaluation Index of road horizon alignment

注：设区间长为L、曲线半径为R、曲线长为CL、曲线交角为θ。

①=单位曲线率$_1$(ΣCL/L)；　②=单位曲率(Σ(1/R)/L)；

③=单位交角率(Σθ/L)；　④=平均曲率(Σ(1/R)/曲线个数)；

⑤=平均交角(Σθ/IP个数)；　⑥=平均曲线长(ΣCL/曲线个数)；

⑦=单位交角数(IP个数/L)；　⑧=单位曲线长率$_2$(ΣCL/ΣIP$_{to}$IP)；

⑨=视距率（实测累计视距／L）。

图　基于最高血压变动的道路线形评价指标

Fig　The Evaluation Index of Road Alignment Based on the Fluctuation of Driver's Upper Blood Pressure

三．基于驾驶员血压变动的研究成果介绍之二

2. 视距率的评价

从生理学的角度，最高血压增加数应控制在30mmHg以下，也就是为了减轻驾驶员的心理生理负担和保证行车安全，山区道路平面线形的视距率应该满足60％以上

驾驶员所承受的心理压力和生理负担，下坡行驶时明显高于上坡行驶。因此，在有关行车安全性研究中，应加大力度对下坡行驶环境的研究。

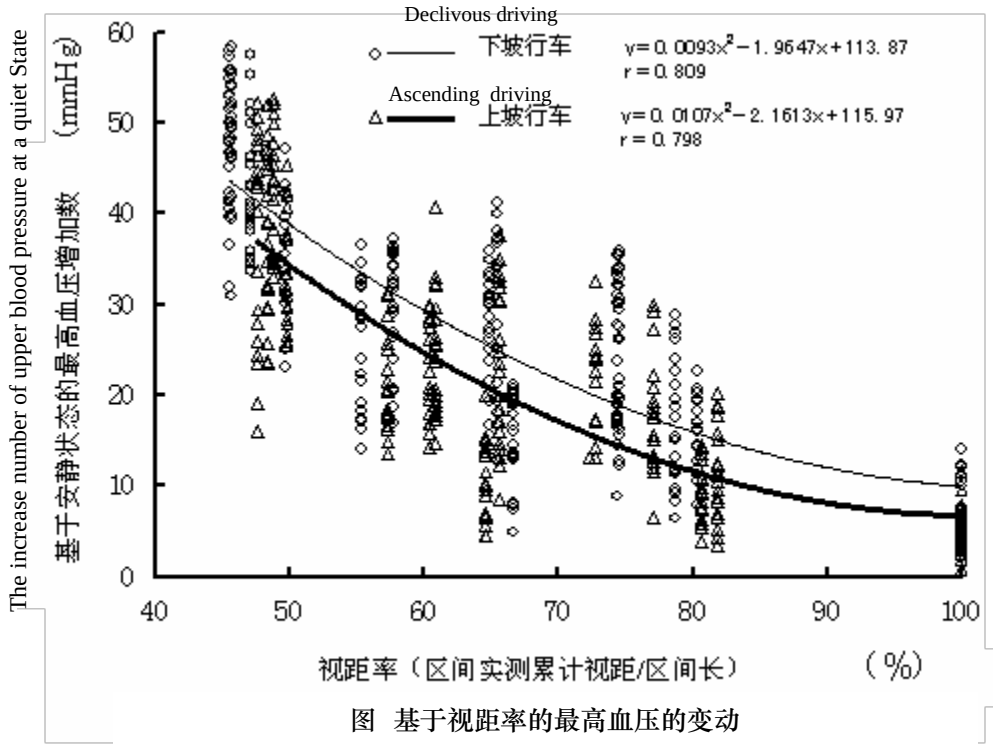


图 基于视距率的最高血压的变动

Fig The Fluctuation of Driver's Upper Blood Pressure Based On Sight Distance Ratio

Ⅲ. The Second of the Research Results Is Introduced Based on Fluctuation of Blood Pressure

2.The evaluation of sight distance ratio

From the physiological aspect, most the increase value of the upper blood pressure should control below the 30 mmHg, also to lighten the psychological and physiological burden of the driver, and guarantee the traffic safety, the sight distance ratio of the mountain road horizon alignment should be above 60%.

The psychological stress and physiological burden of the driver, the declivous path' burden is beyond the ascending path obviously. Therefore, in a driving safety research, should enlarge strength to the research of the declivous driving environment.

四．基于驾驶员动视点的行车安全应用研究

驾驶员注视点对于行车安全意义重大，交通信息大多是由眼睛获得的。如在交通管理上交通标志通过色彩，形状等引起驾驶员的足够注意，起警戒提示作用。

另一方面，如果让驾驶员过多的关注驾驶行为以外的内容，则会给行车安全带来隐患。

Ⅳ. Driving Safety Application Research Based on Driver’s Dynamical Focus Point

Driver’ focus point is vital importance to driving safety. Traffic information mostly collected by the eye, so we can absorb the driver’s enough attention by setting various colors and figures of traffic signs to operate as hints and precaution in traffic management.

On the other hand, if let a driver pay excessive attention on the matter which has nothing with the driver’s behaviors, then will bring hidden trouble to driving safety.

四．基于驾驶员动视点的行车安全应用研究

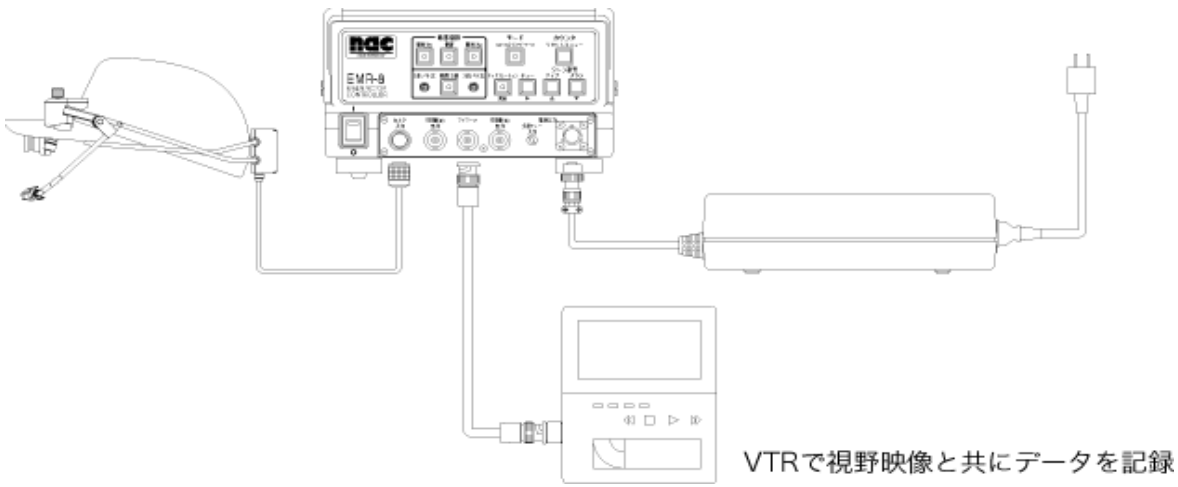
1.驾驶员动视点测试系统

实验仪器为眼动仪EMR-8B（Eye Mark Recorder-8B），是把眼球运动重叠在视野影象上的一种测试系统。该仪器（见下图）是由EMR主机、控制器、场景摄像机以及数据分析软件等部分组成。

Ⅳ、Driving Safety Application Research Based on Driver’s Dynamical Focus Point

1. The driver’s testing system of **dynamical** focus point

Experiment apparatus is EyeMark Movement Recorder-8B, a testing system that can superpose eyeball’ movement on the image of visual field. The apparatus (see the figure 1)consists of EMR main machine, controller, scene vidicon and data analysis software etc.



四．基于驾驶员动视点的行车安全应用研究

2. 动视点测试系统应用领域

1）人机工程学
2）道路交通环境工程
3）心理学
4）体育学
5）商业系统

Ⅳ. Driving Safety Application Research Based on Driver’s Dynamical Focus Point

2. Application field of the testing system of **dynamical** focus point

1) Ergonomics
2) Road and Traffic Environment Engineering
3) Psychology
4) Physical Culture
5) Business System

实验时的状态
The experiment state

四．基于驾驶员动视点的行车安全应用研究

3. 实验研究结果之一

实验道路：城市隧道；
目　　的：检验隧道内行车管理速度的合理性；
驾 驶 员：不同驾龄的4人；
结果1：研究结果表明，城市道路中隧道部分行车速度的设计和交通管理，应该从驾驶员速度感适应性的角度出发，采用同隧道前过渡段相同的设计速度和管理速度，满足驾驶习性的要求，提高行车的安全性。

Ⅳ、Driving Safety Application Research Based on Driver’s Dynamical Focus Point

3. The first of the experiment results

Experiment road: Urban tunnel;
Purpose: Examine the rationality of the driving speed’s management in the tunnel;
Drivers: Four drives of different driving years.

Result 1:Research result indicates, the driving speed’s design and traffic management in the tunnel part of urban road, should that the design and management speed at inner part of urban tunnel should be same as part in front of it, from the aspect of driver's speed consciousness adaptability to satisfy the need of driver’s characteristics and to improve driving safety.

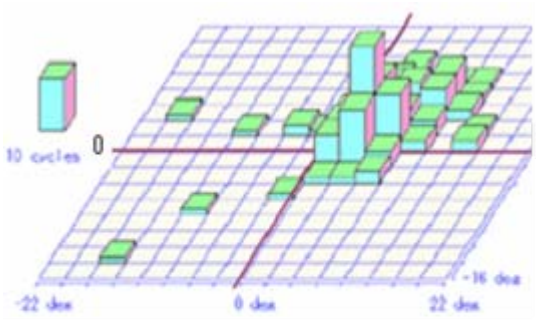


图　一般路段视野范围视点停留分布

Fig The dynamical focus point’s stay and distribution of vision field’s width In the general road.

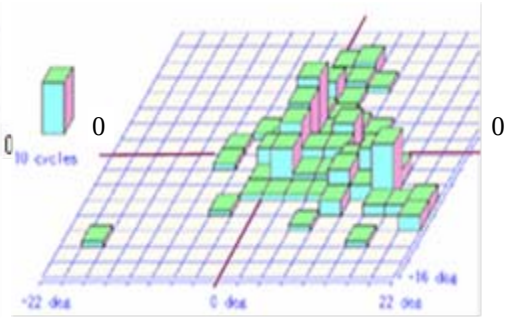


图 隧道路段视野范围视点停留分布

Fig The dynamical focus point’s stay and distribution of vision field’s width in the tunnel road.

图　驾驶员观看速度表时的视点示例

Fig The Example Of the Driver’s Focus Point When Looking At the Speedometer

四．基于驾驶员动视点的行车安全应用研究

4. 实验研究结果之二

瞳孔的变化规律：
❖隧道前一般路段瞳孔直径2.1mm。
❖隧道内瞳孔直径5.5mm。
❖瞳孔变化过渡区间：应加大照明亮度的研究力度

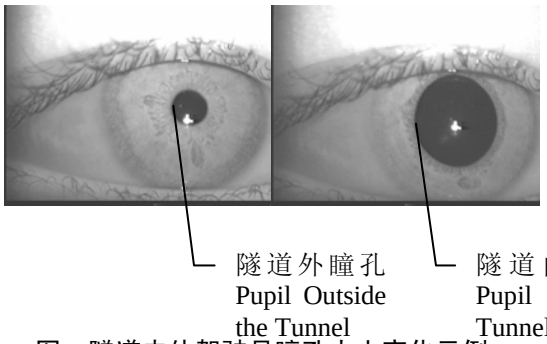


图　隧道内外驾驶员瞳孔大小变化示例
Fig　The Demonstration Changing Of Internal and External Driver's Pupil Diameter

Ⅳ、Driving Safety Application Research Based on Driver's Dynamical Focus Point

4. The second of the experiment results

The variety regulation of the eye pupil:
❖general pupil's diameter is 2.1 mms on road in front of tunnel.
❖Pupil's diameter 5.5 mms inside the tunnel.
❖The Pupil's variety transitional zone: Should intensify the research strength of lighting luminance

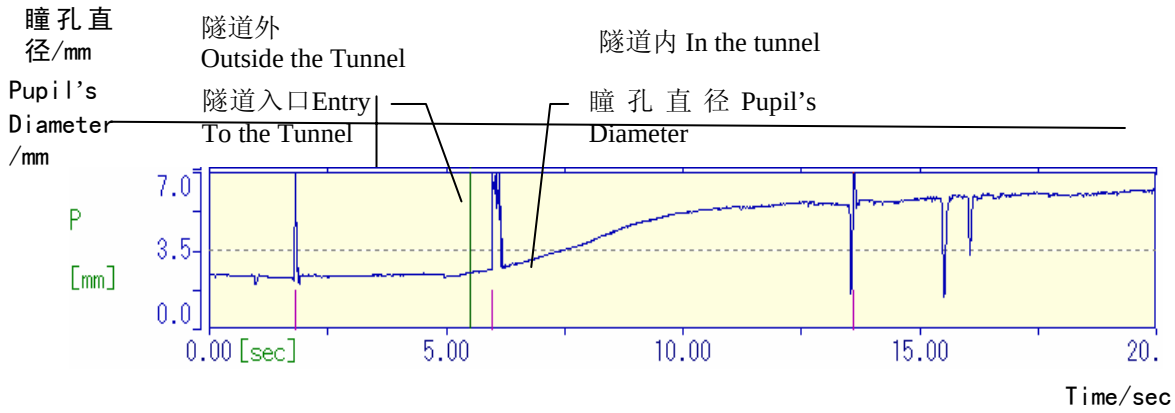


图　瞳孔直径变化趋势图
Fig　Variation Tendency Of the Pupil's Diameter

五．脑电波在道路交通环境评价中应用的可能性

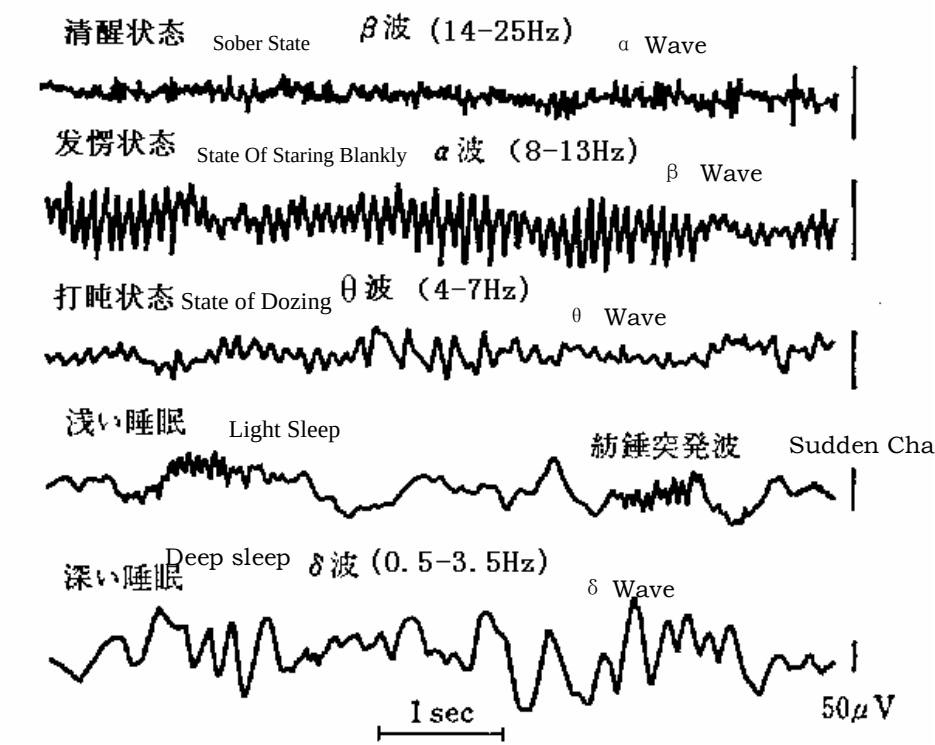
Ⅴ.The Possibility of The Brain Wave's Application In Road and Traffic Environment Evaluation

1．脑电图（脑波，EEG）

脑电图（脑波，**electroencephalogram**，ＥＥＧ），与心电、肌电一样也是生物体电现象之一。在生理学上把大脑意识状态分为五个阶段。并把它与人为错误发生的潜在危险性相联系。

1. Electroencephalogram(ＥＥＧ)

Electroencephalogram(ＥＥＧ), electrocardiogram, electromyography are electrical phenomena of living creature body. Brain conscious state is divided into five stages to the brain on the physiology and it is contacted with the hidden danger's happen of human mistakes.



脑电波成分

The component of brain wave

五．脑电波在道路交通环境评价中应用的可能性

2、道路交通环境对乘客舒适性的影响研究

在人机工程学研究领域，一般是利用脑电波的频率和幅度的变化来评价大脑的觉醒状态，如噪声、室温、床类用具的尺度及质地等对睡眠深度的影响。

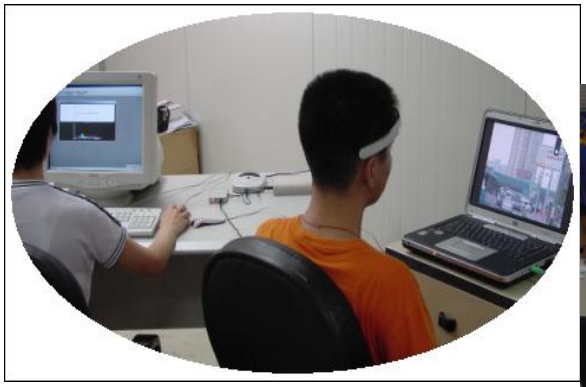
通过对乘客脑电波的测试，探讨利用脑电波的变动规律，评价道路交通环境对乘客舒适性影响研究的可行性。

Ⅴ.The Possibility of The Brain Wave's Application In Road and Traffic Environment Evaluation

2、The influence research of the road traffic environment to passenger's comfortableness

In the research field of ergonomics, usually make use of the frequency and the fluctuation of the brain wave's range to evaluate the awakening state of the brain, for instance the impacts on depth of sleep, such as noise, room temperature, and yardstick and quality of bed, etc.

Through the test of the brain wave of passenger, the feasibility of evaluation the impact of road traffic environment on passenger's comfortableness by using the fluctuation law of the brain wave is discussed.



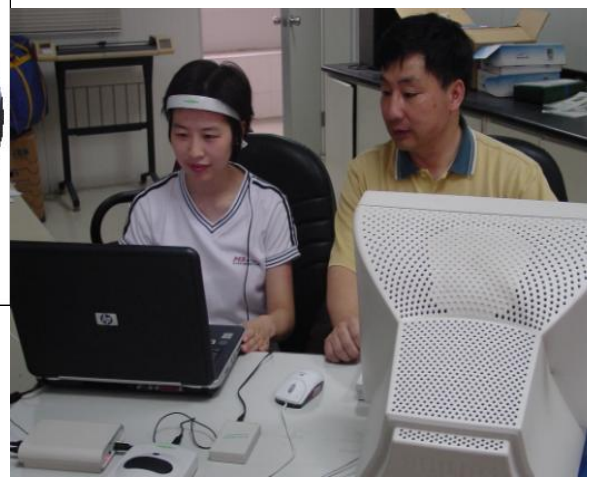


图　室内研究状态

Fig　The indoor research state

基于人机工程学的行车环境安全性评价

基于人机工程学的道路交通环境宜人性的研究，是投入大、牵涉面广、复杂而又周期长的研究，也是很有应用前景的研究。

谢 ！ 谢！

同济大学

潘 晓 东

The Safety Evaluation of Driving Environment Based on Ergonomics

The research on road traffic environment's amenity based on ergonomics, is high input, concerns wide, complicated and long-cycle research, but has great applicable prospect.

Thank You!

Tonji University

Pan Xiao-dong