

Perception Response Issues

by Gregory Gravesen

1

Goals of Presentation

- Review the human eye and define some terms used in this field.
- Review some human factor studies commonly used as source documentation for perception response scenarios.
- Discuss the components of perception-response.
- Improve your ability to evaluate your case scenario and select the appropriate perception response time.

2

Topics of Discussion

- The Human Eye
- Definitions
- Perception-Response studies
- Case specific considerations

3



The Human Eye

- In a pure mechanical sense, the eye is an instrument that gathers light rays and focuses them into an image registered on its rear surface.
- Retina – light sensitive part of the eye packed with two types of light receptor cells:
 - Cones (Red and Green – Central Vision, 2-3 degrees)
 - Rods (Black and White - Periphery)

4



Background - Vision

- Daytime or Photopic Viewing
- Cone receptor cells are used.
- Colors can be seen.
- Images are sharper.
- Object contrast is not as important because different visual cues (depth perception, color, etc.).
- Sufficient contrast with its background is still required.

5



Background – Vision cont'd

- Nighttime or Mesopic to Scotopic Viewing
 - Mesopic Viewing uses a combination of rod and cone receptor cells.
 - Some color may be seen.
 - Driver's ability to see is greatly reduced.

6

Background – Vision cont'd

- Scotopic Viewing.
 - Only rod receptor cells are used.
 - One can only see shades of gray and white.
 - Images are fuzzy and indistinct.
 - Object/background contrast very important.
 - Contrast and depth perception is reduced.

7

Definitions

- **Perception – Reaction** time is the time that expires from the moment a stimulus is first perceived until the moment the observer first moves in response to that stimulus.

8

Definitions

- **Perception – Response** time is the time that expires from the moment the stimulus is first perceived until the vehicle begins to respond. It is the perception-reaction time PLUS the transition time or the perception-reaction time PLUS the movement time and mechanical latency.

9



Definitions – cont'd

- **Conspicuity** - the capacity of an object to stand out in relation to its background and be readily discovered by the eye.
- **Contrast** - Defined as the difference of contrast reflectivity of the stimulus against its background relative to the contrast reflectivity of the background.

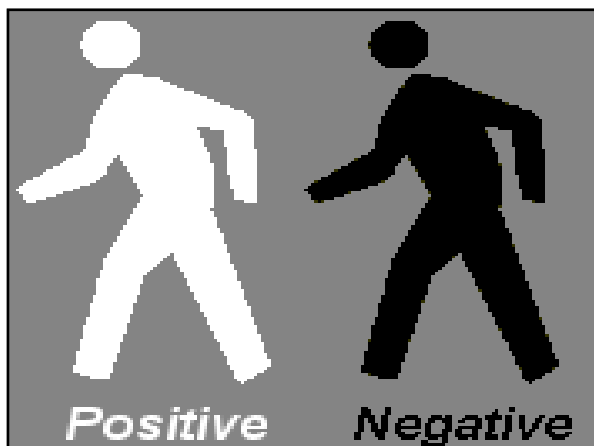
10



Contrast

- Negative Contrast - occurs when a dark object lies on a bright background (i.e. the prevailing light comes from behind).
- Positive Contrast - occurs when a bright object lies on a dark background.
- ***Assists in pattern recognition.

11



Review the next slide
and count how many
birds did you see.

13



How many?

15



Perception-Response Studies

- All studies are not alike.
- Manner in which the study is conducted can be a significant influence on the results.
- Specific variables must be considered.

17

Specific Variables

- Transition time
- Anticipation
- Experiment type (lab, simulator, road)
- Engaged in driving task?
- Direction from which the stimulus emerged
- Stimulus type (pedestrian, horn, light, car, etc.)

18

OLSON and SIVAK

- SAE Paper 890731 "Perception-Response Time to Unexpected Roadway Hazards"

19

SAE 890731 Overview

- A 95th percentile perception-reaction time of 1.6 seconds was found for both young and older age groups
- 1986 study was two part
 - Participants had to detect and respond to a yellow foam mattress in their lane after they crested a hill.
 - Participants responded to a light on the hood and were told to brake when they saw the light.

20

SAE 890731 Continued

- The older age group had 15 participants compared to 49 participants in the younger age group.
- Has broken down the perception response phase into 4 intervals.

21

PHASES OF PERCEPTION-RESPONSE

- Detection Interval
- Identification Interval
- Decision Interval
- Response Interval

22

Four Phases

- DETECTION INTERVAL – starts when an object or condition enters the individuals' field of view. It ends when the driver becomes consciously aware that something is present which could be or become a hazard.
- IDENTIFICATION INTERVAL – begins when the driver starts acquiring enough information to decide what to do. For example, speed trajectory, etc.

23

Four Phases – cont'd

- DECISION INTERVAL – begins when the detection and identification intervals have been completed.
- RESPONSE INTERVAL – begins as the brain tissues orders to the muscles to set the decided response into motion. This entire perception-response ends when the foot contacts the brake pedal and/or the hands begin to turn the steering wheel.

24

Olson Study Considerations

- Difficult to assess if the strength of the stimulus was greater or less than what drivers in real world situations face.
- Is yellow foam hazardous?

25

Considerations cont'd

- Contrast – yellow foam is clearly discernible from the darker colored asphalt
- Foam was not in the driver's path.
 - No decision time for path interpretation.
 - No considerations for avoidance options were necessary.

26

Considerations cont'd

- Olson states the research conducted suggests a reasonable upper-bound estimate of perception-response time of 1.6 seconds for a relatively straightforward situation.
- What is a "relatively straightforward situation.?"
- Is this study similar to your case facts?

27

Johansson & Rumar

- Johansson, G., & Rumar, K. (1971).
Driver's Brake Reaction Times

28

Study Overview

- The most cited study regarding the detection-response of drivers.
- Based upon tests with random drivers, a "klaxon horn" was placed in a mailbox.
- The perception-response time was measured from the time the horn sounded until the driver applied their brakes.
- It was determined that the 85% percentile driver reacts within 1.6 seconds.

29

Study Evaluation

- Subjects were alerted to the study and were random drivers without known hearing capabilities, physiological abilities, experience or age.
- A klaxon horn is not a typical stimulus that a driver must react to; no conditioned response for such a stimulus.
- Driving is predominately a visual task, so an audible stimulus will not likely measure a driver's ability to respond to a visual stimulus.
- "Slow" responses were NOT INCLUDED in the data sets!

30

Mortimer Study

- Mortimer, R. G. (1993). Human Factors in Highway-Railroad Grade Crossing Accidents, *Accident Reconstruction Journal*, 5(2), 26-35.

31

Study Overview

- Deals with a person's ability to judge distance and approaching train.
- Humans estimate the speed of objects based upon the rate of change of the relationship of the object to its background.

32

Conclusions

- If the observer is not sure of the size of the object being viewed, estimating its distance becomes more difficult.
- Lighting, contrast, expectation and weather conditions can all be significant factors in the ability of a person to judge this distance.

33

Muttart Prediction Equations

- SAE 2003-01-0885 "Development and Evaluation of Driver Response Time Predictors Based upon Meta Analysis" by Jeffrey W. Muttart

34

Muttart cont'd

- Developed mathematical equations that would estimate the response times of drivers in various situations.
- It's the first study involved the development of a series of equations that predict driver response times.

35

Muttart cont'd

- These prediction equations were then compared to measured real world responses collected from video cameras.
- Involved frame by frame analysis of video and audio recordings of real crashes.

36

Accident Maneuver



- **Specific components:**
 - Detection Interval
 - Perception-Reaction Time
 - Movement Time
 - Vehicle Latency
 - Vehicle Response

37

DETECTION INTERVAL

- Represents the time period between sensation and detection from when the object is first visible to when it's true character is known.
- Generally, this represents the difference between "visible" and "perceived."

38

Visible vs. Perceived

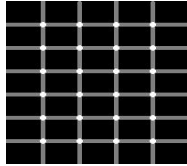


39



Visible vs. Perceived

Count the number of black dots in this picture



40



CONSIDERATIONS

- Contrast
- Anticipation
- Strength of the Stimuli
- Eccentricity

41



CONTRAST

- Positive / Negative Contrast
- Glare? May create an uneven lighting situation and may reduce the contrast.
- Rain increases glare.
- We are concerned with disability glare, not discomfort glare.
- Recovery time?

42

ANTICIPATION

- Defined as whether or not the stimulus and/or the appropriate response were known to the driver.
- Driver may have expected one thing, and encountered something totally different.

43

STRENGTH OF STIMULUS

- Number of stimuli
- Intensity
- Movement
- Pattern recognition
- Visual noise
- Time of exposure
- Consideration of these variables may illustrate how the object may provide a weak stimulus for the driver to detect.

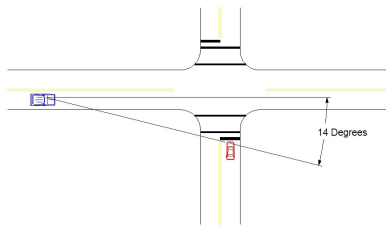
44

ECCENTRICITY

- Defined as the degrees (angle) to which the stimulus was presented to the subject relative to the direction the subject was looking.
- Research has shown drivers require additional time to react for every 10-degrees of eccentricity.

45

ECCENTRICITY



Eccentricity is the number of degrees from straight ahead

46

PERCEPTION-REACTION TIME

- Represents the time covers the time when the driver knows the true character of the object until the driver's first motor response.
- This is the cognitive part of the avoidance maneuver.


47

PERCEPTION-REACTION TIME

- Complex responses occur driver has to evaluate the number of alternatives available to them.
- Conditional responses.
 - i.e. ball rolling into the roadway


48

YELLOW BLUE
ORANGE
BLACK RED GREEN
PURPLE YELLOW
RED
ORANGE GREEN
BLACK
BLUE RED PURPLE
GREEN BLUE
ORANGE

 **MOVEMENT TIME**

- Movement time is the period of time involved to implement a chosen response.
- This is the time from first movement to response implementation (i.e. accelerator to brake pedal).

50

 **VEHICLE LATENCY**

- This component represents the time from steering and/or brake application to the point where the vehicle begins to respond.
- In other words, the time from when pressure is applied to the brake pedal to the point where the brakes are actually retarding the tire's motion.

51



VEHICLE RESPONSE

- This represents the distance actually traveled, the distance necessary to avoid an object, or the distance required to stop the vehicle.

52



Summary

- Perception response times are not "one size fits all."
- One should review the facts of their case and how they relate to the conditions present during a particular study.
- Caution should be used when the test data does not fit the case scenario.

53



Nighttime Events

- Pattern Recognition is extremely important
 - We tend to recognize shapes and want to make a pattern out of things
 - If we cannot make a pattern out of things, there will not be a driver response
- Visible does NOT equal Detection
- As glare increases, contrast is

54

Nighttime Events

- Pedestrians wearing black at night have a reflective index at 5 to 7%
- A study by Weber indicates most observers may not ever detect a dark object against a dark background
- Requires an reflective index of >8% for detection

55

Nighttime Events

- Traffic vests, athletic clothing, wrist/ankle bands, etc.
- Previous studies showed reflective vest can be seen from a long ways away, but drivers did not respond until they recognized the pattern/outline of the pedestrian.

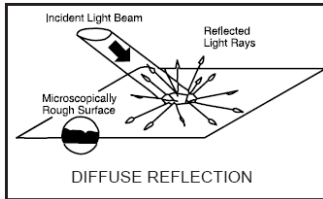
56

Reflective vs. Retroreflective

- Reflective material will generally work up to 15 degrees
- Retroreflective material reflects light backwards towards the light source
- Retroreflective material standard is 30 degrees, but will work at 45 degrees

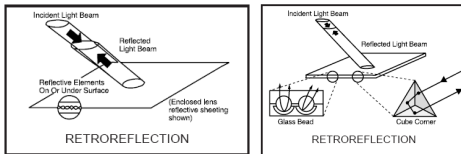
57

Reflective Materials



58

Retroreflective Materials

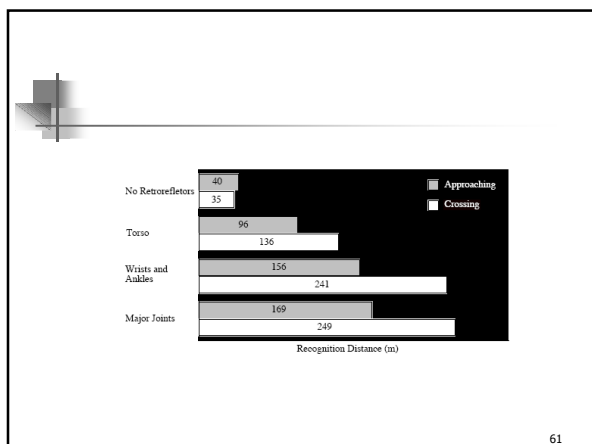


59

Nighttime Events

- Traffic vests, athletic clothing, wrist/ankle bands, etc.
- Biological motion with retroreflective allows drivers to discern pedestrians earlier.

60



Headlight Patterns

- Headlight pattern is shaped like a chili pepper
- Headlight height and aim effect the light distribution
- Pedestrians often enter the headlight pattern from the sides, not from the peak.
- Pedestrians often believe they are more visible than what they actually are

Questions

- Contact Information:
 - Sgt. Greg Gravesen
 - St. Paul Police Department
 - greg.gravesen@ci.stpaul.mn.us
