

## **DEVELOPMENT OF ATTENTIONAL WORKLOAD METRICS TO ASSESS DRIVER DISTRACTION**

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## TOPICS

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- Nature of attentional workload metrics
- Driving simulator experiments
- Objective and subjective measures
- Example workload estimate (WE) metrics
- Application of metrics

## **ATTRIBUTES OF A GOOD ATTENTIONAL WORKLOAD METRIC**

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- Applies to dual task conditions
- Objective, quantifiable
- Reflects driver behavior in
  - Primary task, and
  - Secondary task
- Sensitive to changes in secondary task attentional demand
- Uses variables that can be measured in driving simulator or actual vehicle
- Consistent with
  - Human factors principles
  - Known driver behavior characteristics

## **“COMPOSITE” OBJECTIVE MEASURES OF ATTENTIONAL WORKLOAD**

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- Several objective measures weighted and combined to obtain a single metric (WE)
- Measure primary plus secondary task attentional demand
- For visual-manual secondary tasks
- Based on correlation with subjective ratings of task difficulty and mental workload
- Several resulting metrics, depending on available objective measures
- Can be used to:
  - Assess or compare secondary task or HMIs
  - Monitor driver attention and performance while driving (in real time)

## DRIVING SIMULATOR EXPERIMENTS

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- Primary task
  - Straight 4 lane highway
  - Directional disturbance (crosswind gusts)
  - Constant speed with speed disturbance
- Secondary tasks
  - Navigation destination entry, touch screen
  - Simple word entry, touch screen
  - Critical tracking task (CTT)
  - Radio tuning (Alliance guidelines)



## **EXPERIMENTAL PROCEDURES**

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- Baseline (primary task only), or
- Dual task condition
- 60 second runs (plus warmup and end periods)
- 4 repeats per participant for each dual task condition
- 35 runs in two 2 hour sessions with rest breaks
- Subjective ratings after each run

## **INSTRUCTIONS FOR DUAL TASK CONDITIONS**

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- Do both tasks
- Primary task is to
  - Drive safely
  - Maintain car in center of lane
  - Maintain specified speed
- Secondary task is less important

## **DRIVER PARTICIPANTS**

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- Typical, experienced drivers
- Various occupations
- Average age: 41
- Trained in secondary tasks
- Familiar with rating procedures



## SUBJECTIVE RATING FORMS

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Ease of Performing  
the Driving Task (EOD)

Effortless
Easy
Fairly Easy
Moderately Difficult
Difficult
Very Difficult
Impossible

Overall Mental Workload (OMW)

None
Very Low
Low
Moderate
High
Very High
Impossible, cannot do it

- Equal interval numerical scale used in data analysis

## **OBJECTIVE RESPONSE AND PERFORMANCE MEASURES**

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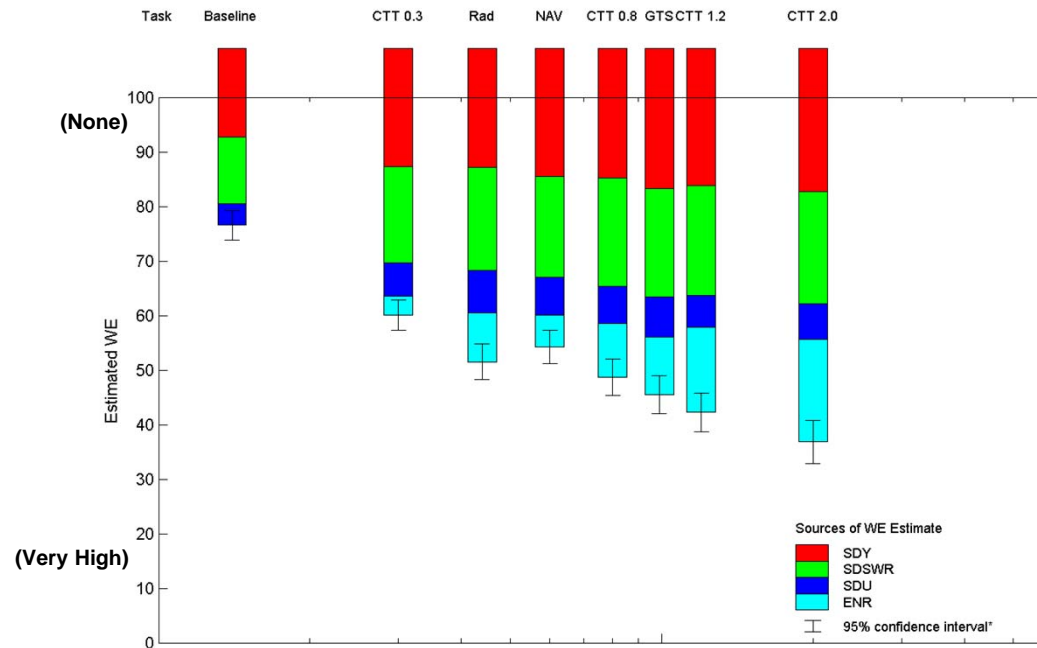
- Primary task measures for directional control:
  - Standard deviation of steering wheel angle (SDSW)
  - Standard deviation of steering wheel angle rate (SDSWR)
  - Kurtosis of steering wheel angle (KSW)
  - Kurtosis of steering wheel angle rate (KSWR)
  - Standard deviation of yaw rate (SDR)
  - Standard deviation of lateral lane position (SDY)
- Primary task measures for speed control:
  - Standard deviation of accelerator pedal position (SDAP)
  - Standard deviation of forward speed (SDU)
- Secondary task measures:
  - Entry rate (ENR)
  - Error rate (ERR)

## **ATTENTIONAL METRIC (WE) SEARCH PROCESS**

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- Correlate objective measures and subjective ratings (EOD)
- Use goodness of fit statistic, RPRED
- Results in candidate Workload Estimates (WE)
  - Sum of objective terms
- Can have various WE metrics, based on candidate terms considered

## WE METRIC, EQ (1)

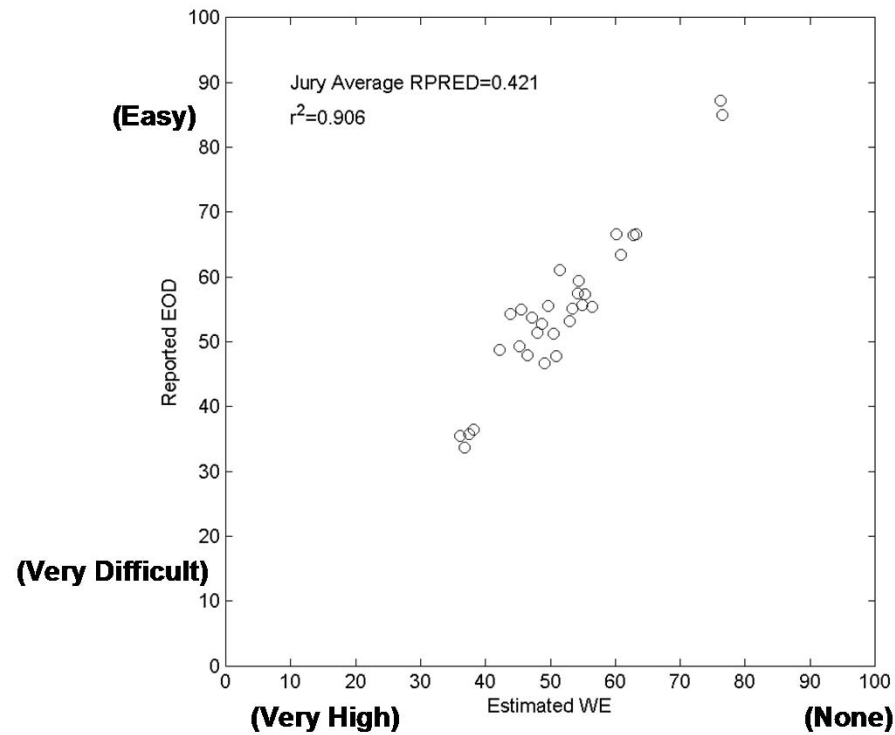


WE=109 -1.3 SDSWR -55 SDY – 2.0 SDU -.24 ENR

- Steering wheel angle rate (SWR)
- Lateral lane position (Y)
- Forward speed (U)
- Entry rate (ENR)
- RPRED: .42

## CORRELATION OF ESTIMATED AND REPORTED ATTENTIONAL WORKLOAD FOR EQ (1)

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## OTHER EXAMPLE METRIC RESULTS

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WE=88 -54 SDY -.30 ENR (2)

- Lateral lane position (Y)
- Entry rate (ENR)
- RPRED: .34

WE=118 -30 SDR -.29 ENR (3)

- Yaw rate (R)
- Entry rate (ENR)
- RPRED: .36

WE=119 -27 SDR -1.5 SDU -.27 ENR (4)

- Yaw rate (R)
- Forward speed (U)
- Entry rate (ENR):
- RPRED: .37

## **DISCUSSION OF WE METRIC SEARCH RESULTS**

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- Lane position (SDY) is usually selected
- Yaw rate (SDR) is an alternative to SDY
- Forward speed (SDU) is usually selected
- Entry rate (ENR) is always selected
- Steering wheel angle rate (SDSWR) is a useful “quality of control” measure, and may indicate change in behavior (lag, intermittency)
- Steering kurtosis terms are not useful
- Preferred metrics are “orthogonal,” reflecting
  - Lateral and longitudinal performance
  - Primary and secondary task activity

## **POSSIBLE USES OF WE METRICS**

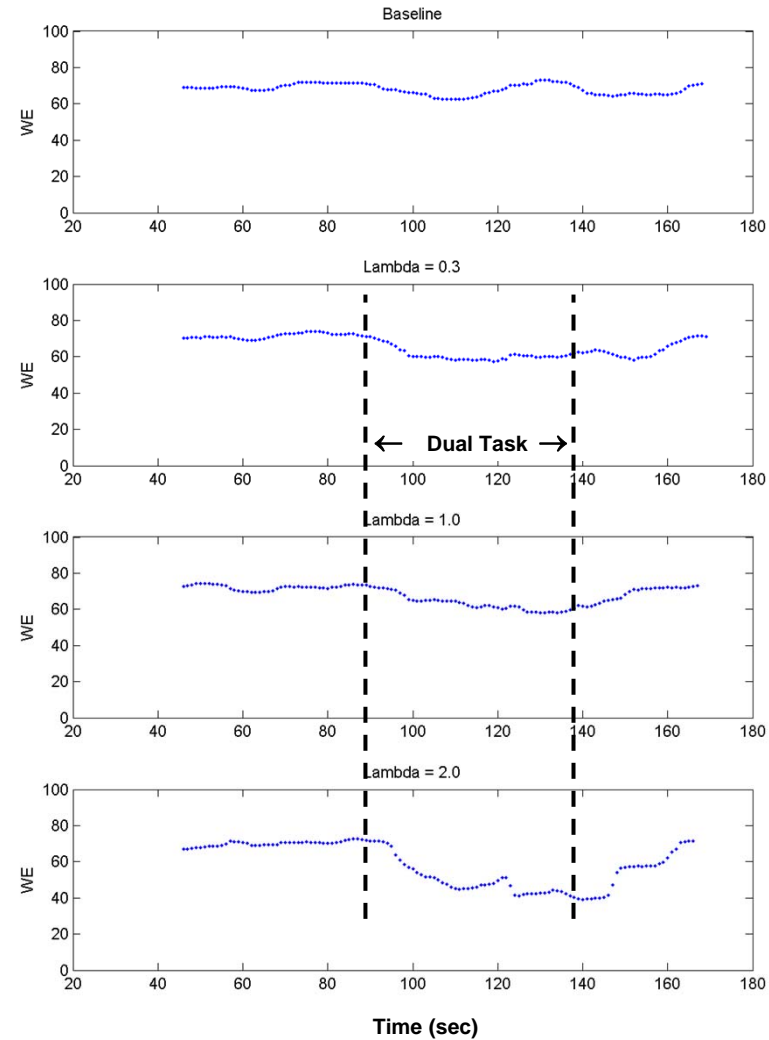
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- Evaluate an HMI against a reference
- Compare several HMIs
- Continuous calculation and monitoring of attentional workload
  - In real time
  - While driving



## TIME VARYING WE METRIC APPLICATION (EXAMPLE)

- Eq (1): SWR, Y, U, ENR
- Averaging window: 24 sec
- Baseline: 72 sec
- Dual task (CTT): 48 sec
- Baseline: 24 sec



## SUMMARY

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- Composite workload metrics have been developed
- Examples shown for typical objective measures
- Additional confirming experiments have been done in driving simulator and actual vehicle
- Other versions of WE metrics can be (and have been) developed for other objective response and performance measures