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## **Perceptual quality of video on simulated low temperatures in LCD vehicle displays**

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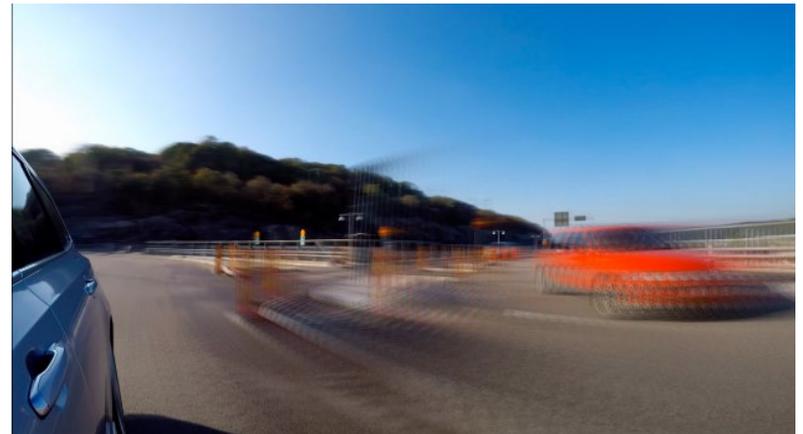
# Introduction

- More and more displays are used in cars e.g. back cameras or digital mirrors
- Response time will be longer for LCD displays at low temperatures
  - The viscosity of the liquid crystal will increase with lower temperatures
- For the vehicles industry displays should be useable down to  $-30^{\circ}\text{C}$  and below.
- Motion will be blurred in low temperatures



# Introduction

- Our aim was to find and quantify the acceptable ranges of displayed images in traffic.
- Challenges in setting up experiment with showing video on displays in low temperatures
  - Set-up experiment in a cooling chamber
  - Showing through a window in a cooling chamber
  - Filter the video consistent with long response time



# Method

- Video processed with RC-filter as a Finite Impulse Response (FIR) filter:
  - Time constants: 0, 32, 50, 100, 200, 316 and 500 ms
  - Approximation: same processing for all grey levels
- Four different source videos seen from a digital rear view mirror



Video in original presentation



Video in original presentation



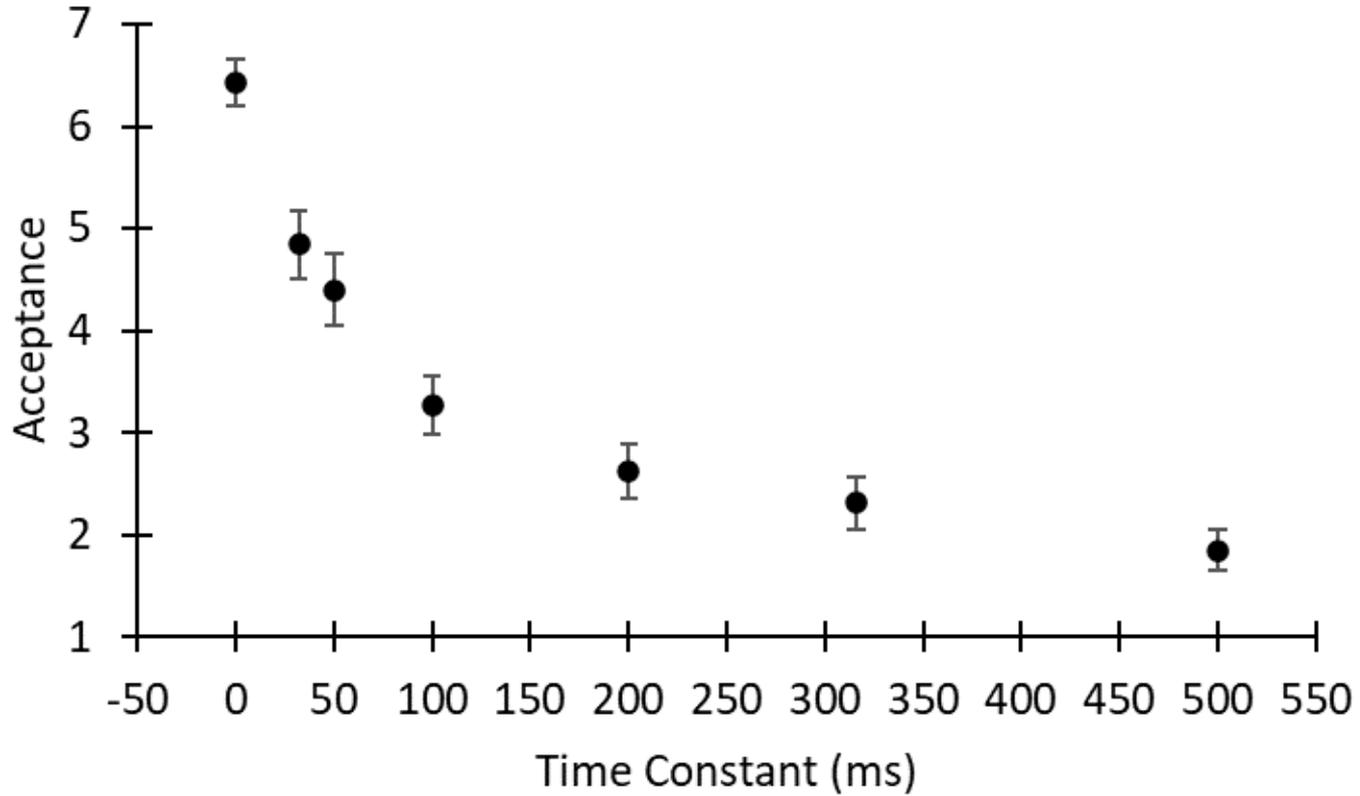
# Method

- Test conducted in lab ITU-T Rec P.913
  - Rather bright
  - Vehicle display
- Test person rated acceptability on a 7 point scale
- 20 test persons
  - 23 – 57 years
  - Mean age: 35



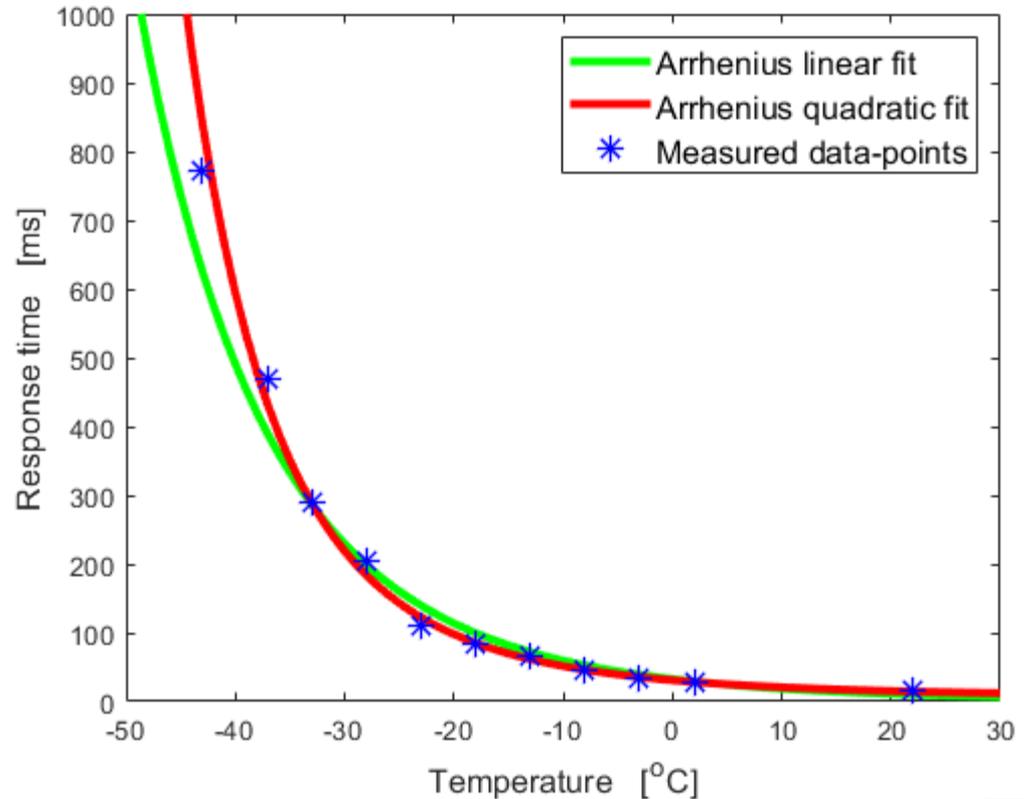
7	Very Acceptable
6	Acceptable
5	Slightly Acceptable
4	Neutral
3	Slightly Unacceptable
2	Unacceptable
1	Very Unacceptable

# Results



# Results

- Time constant to response time conversion:
  - Response time =  $2.2 * \text{time constant} (\ln 9)$
- Time constant -> Response time
  - 50 - 100 -> 110 - 220
- Temperatures:
  - -20 - -30 °C



# Summary

- A perceptual range for acceptable video distortions on vehicle LCD-displays in low temperature has been identified
- A practical methodology for investigating video low temperatures distortions was tested
- Temperature behavior of the display following a modified Arrhenius law behavior was measured and analyzed.

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