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# The influence of text rotation, font and distance on legibility in VR

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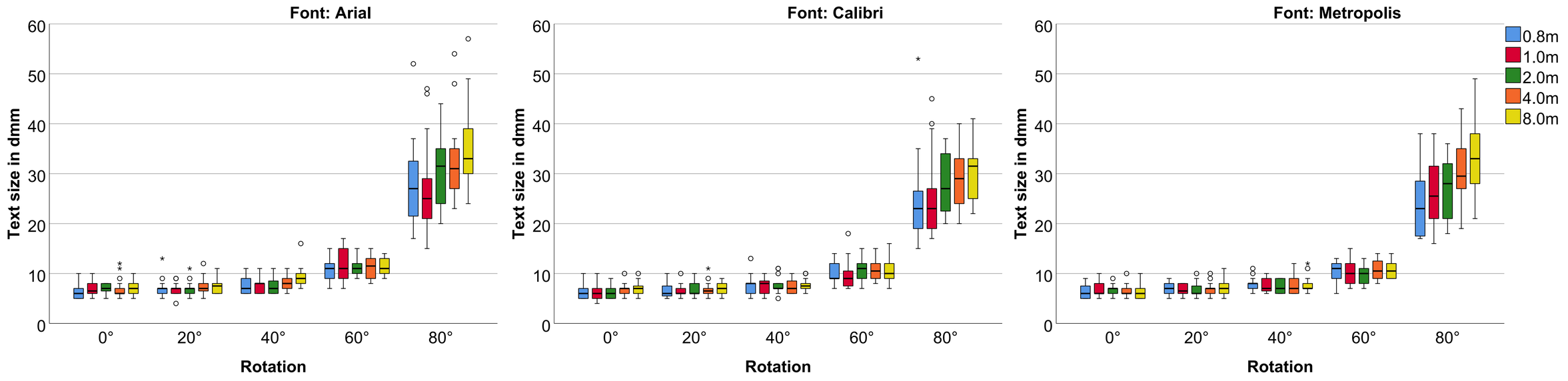
## Results Overview




## Introduction

The representation of text is necessary and important for many applications of VR. In many real-world environments text is presented in different viewing positions. Thus, when designing VEs where legibility and readability of text is necessary, it is important to estimate the required text parameters before implementing the system to avoid dissatisfying results and unnecessary costs (cf. [Bolder, Grünvogel, and Angelescu 2018]).
We present a study on the influence of rotation, distance to the user and font on the legibility of text presented in a VE.

## Related Work

- Searching for optimal text parameters by measuring user performance [Burmistrov et al. 2016; Jankowski et al. 2010].
- The influence of text size and left or right rotation on a 3D-display [Larson et al. 2000].
- Displaying text in object space has benefits for a bigger field of view [Polys, Kim, and Bowman 2007].
- First guideline for the parameters font, font size, convergence distance, and text box size for UIs in a VE with HMDs [Dingler, Kunze, and Outram 2018].

## Study Design

- Split-Plot Design ($2 \times 3 \times 5 \times 5$ )
- Dependent variable: Text size in dmm
- Between Group variable: Rotation direction (left, right)
- Within Group variables:
  - Font: Arial, Calibri, Metropolis
  - Distance: 0.8 m, 1.0 m, 2.0 m, 4.0 m, 8.0 m
  - Rotation angle: 0°, 20°, 40°, 60°, 80°

## Technical Setup

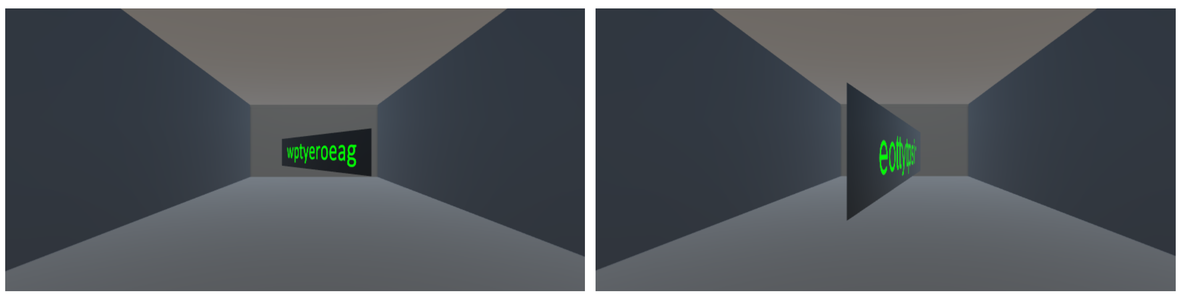



Figure 1: Scenario examples. Left: Font Calibri, Distance 8.0 m, Rotation 60°. Right: Font Metropolis, Distance 4.0 m, Rotation 80°.

- Equipment:
  - HTC Vive Pro
  - HTC Vive Controller 2.0
  - Unity 3D
- Virtual environment:
  - Simple, grey room
  - Viewer located in the center of the room at a height of 1.5 m
  - Green text on a black rectangle
- Text rendering: Signed distance field (SDF) fonts

## Experimental Task

- 75 conditions per test participant in randomized order
- Procedure for every condition:
  1. Ten random characters are displayed in a non-legible size
  2. Participant increases text size until the characters are legible
  3. When all characters can be recognized, the characters are replaced
  4. Verification of legibility

## Results

- The study was conducted with 19 test participants (4 f, 15 m), aged 20-54 ($MV = 27.6$, $SD = 7.2$).
- **Rotation angle:** A Friedman Test shows a significant difference for all cases ($31.148 < X^2(4) < 64.190$, $p < 0.001$).
- **Distance:** A Friedman Test shows no significant difference for twelve of fifteen cases ($1.812 < X^2(4) < 8.374$, $0.079 < p < 0.770$). In three cases there is a significant difference ($13.386 < X^2(4) < 15.447$, $0.004 < p < 0.010$).
- **Font:** A Friedman Test shows no significant difference in nineteen of twenty five cases ($0.259 < X^2(2) < 6.000$, $0.052 < p < 0.910$). In six cases there is a significant difference ($6.043 < X^2(2) < 8.943$, $0.010 < p < 0.047$).
- **Rotation direction:** A Kruskal-Wallis Test shows no significant difference for all cases ($X^2(1) < 3.403$, $p > 0.064$).

## Discussion

- Additional human factors, e.g. age and vision, need to be considered.
- Different text and background colors should be tested.
- Displays with different resolutions and pixel architectures should be compared.
- The light caused unexpected Fresnel artifacts that may have distorted the results.
- Text rotation may only be relevant for specific use cases, e.g. VR simulators for entertainment systems in cars.

## Conclusion

The results of our study show that rotation angles greater than 60° have a significant impact on the minimal legible text size, in contrast to the tested fonts and distances. However, further research is needed to produce reliable recommendations that take all relevant factors into account.

## References

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