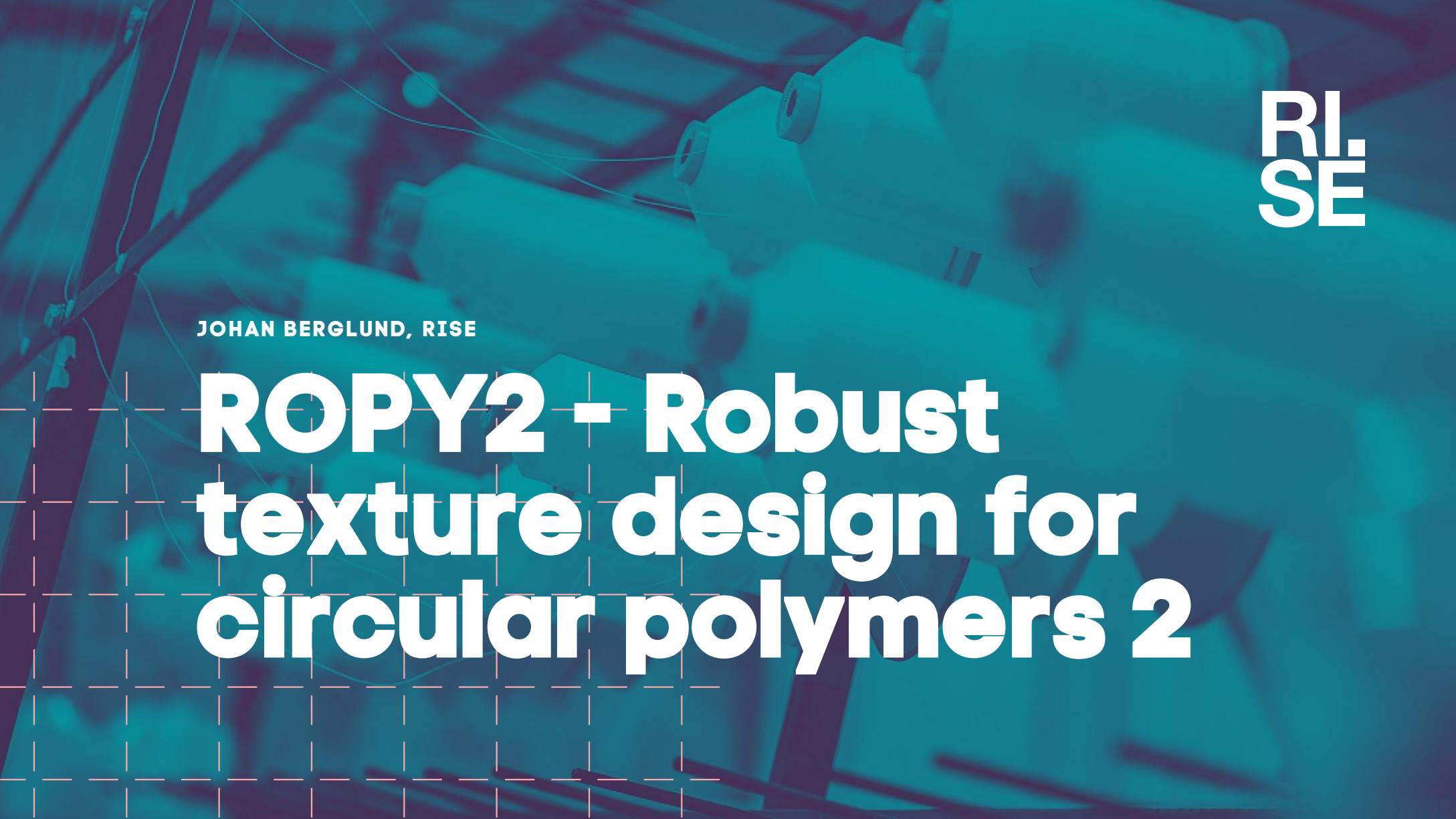

JOHAN BERGLUND, RISE

ROPY2 - Robust texture design for circular polymers 2

Context: Automotive interior polymer parts

- Injection moulded parts
- Specifically designed surface textures
  - Look and feel, branding
  - Other requirements (durability, cleanability etc.)
  - Manufacturability (mould texturing, replication on part)
- Predictable replication of mould texture is critical

RI.
SE

Recycled polymers

- Increased use of recycled polymers is expected

- Challenges:
  - Material variability
  - Contamination
  - Mechanical properties

Uncertainty regarding replication fidelity

Barrier for increasing circularity

RI. SE

ROPY2 Consortium

- Cross-disciplinary research challenges
  - Manufacturing process
  - Materials
  - Design
  - Perception
  - Quality control and measurement techniques
- Cross-disciplinary project consortium with large range of competences and methods available

- 3 Industry partners
  - Scania
  - Volvo Trucks
  - Volvo Trucks
- 2 Academic partners
  - Chalmers
  - Halmstad University
- 2 Institutes
  - Polymertekniska institutet
  - RISE

RI.
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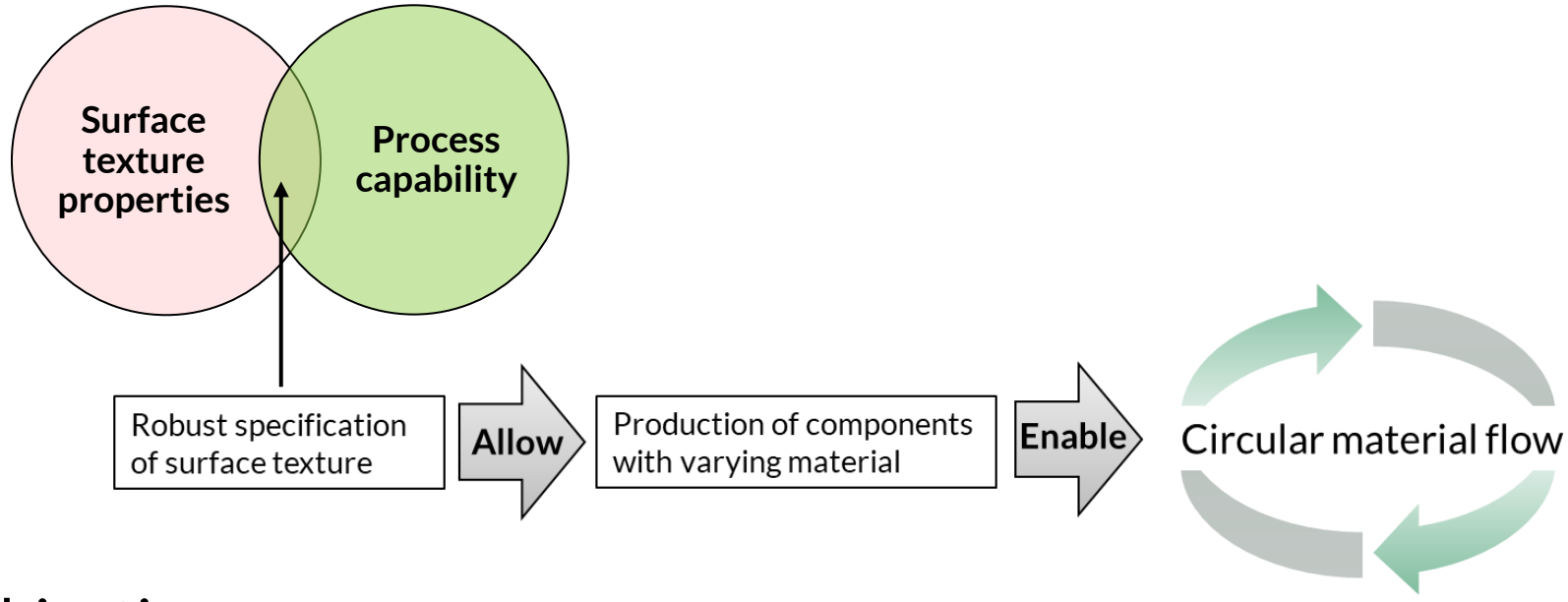
Robust texture design for circular polymers 2

The project is funded by Vinnova through the research programme Fordonsstrategiskt Forskning och Innovation FFI, grant no. 2023-02619, and the industrial partners.

Project logic



Project objective

Develop methods, tools and guidelines for robust specification of surface texture to allow design and manufacture of automotive interior polymer components with larger material variations, thereby enabling circular material flow.

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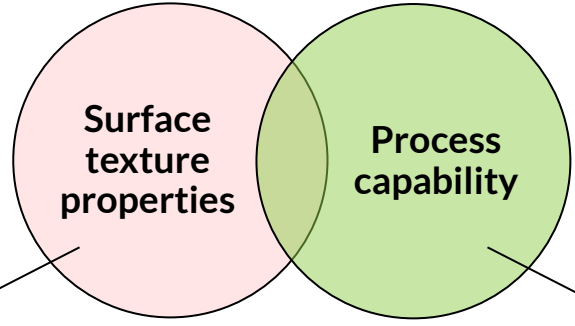
Research questions



1. What are the desired surface properties?

- Development of model for quality assessment

2. What are the possible manufacturing outcomes?

- Development of model for replication quality

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Development of model for quality assessment

Background

Currently, quality assessments are made using a combination of subjective and quantitative methods.

It is difficult to predict the quality assessment results of combinations of new texture designs and material variations.

Key research topics

- How to specify a surface to match a reference surface well enough. Perception (which aspects are important?) and tolerances (what is good enough?)
- How to evaluate appropriately (methods for measurement and analysis). R&D lab, product/process development and in-line, quality control

Subjective assessments
- Industry methods
- RISE Perception methods

Quantitative measurements
- Topography, gloss, colour etc.
- Data filtration, parameterisation etc.

Model of quality assessment based on AI/ML
- Relating quality assessments with measurements
- *Enabling prediction of quality assessments*

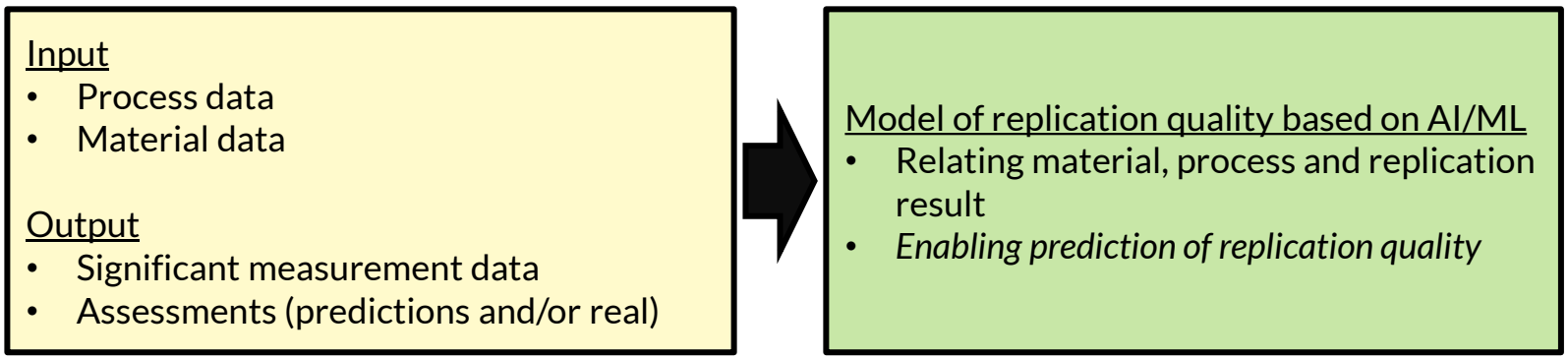
Development of model for replication quality

Background

Increased use of recycled content in polymers is expected to impact replication quality. However, the effects are not fully understood at the level of detail needed for predicting the quality of surface texture replication.

Key research topic

- How to predict the effect of process parameter settings on surface replication quality? How can AI/Machine Learning and affective surface engineering be used to model and understand the effect of varying process parameters and material properties on the resulting surface?



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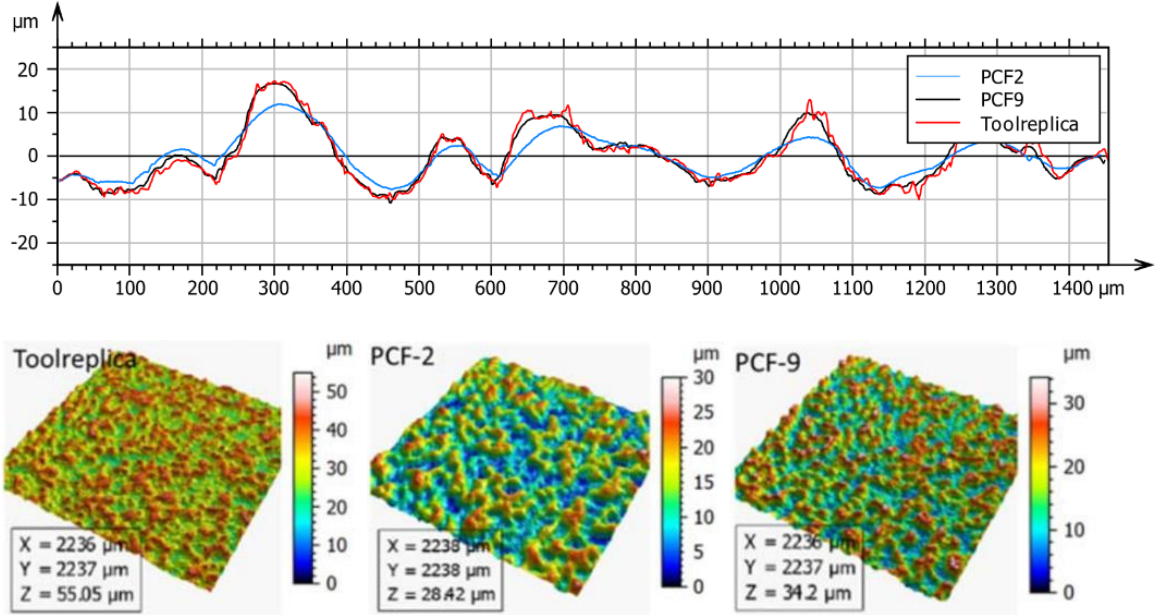
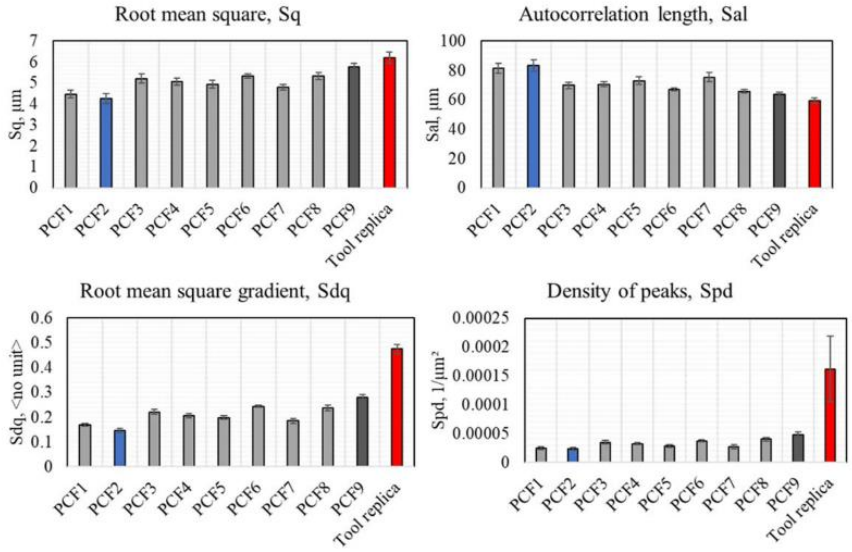
On-going work

Evaluation of analysis techniques – E.g. Relocation and comparison (review of previous work)





Vijeth V Reddy et al 2023 Surf. Topogr.: Metrol. Prop. 11 014003 https://doi.org/10.1088/2051-672X/acb4b0

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On-going work

Preparing for developing models

- Learning from historical data, investigating reasons for assessments (OK/Not OK)

Logistic regression on 'Overall OK' with Gloss and Color judgements

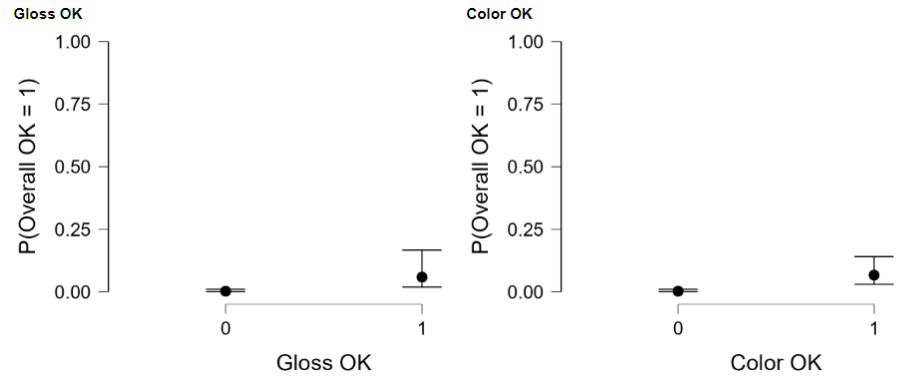
Model Summary - Overall OK

Model	Deviance	AIC	BIC	df	X^2	p	McFadden R^2	Nagelkerke R^2
H_0	623.603	625.603	629.739	461				
H_1	429.832	435.832	448.238	459	193.771	< .001	0.311	0.462

Coefficients

				Wald Test		
	Estimate	Standard Error	z	Wald Statistic	df	p
(Intercept)	−5.987	0.729	−8.216	67.498	1	< .001
Gloss OK (1)	3.215	0.440	7.308	53.407	1	< .001
Color OK (1)	3.351	0.607	5.524	30.517	1	< .001

Note. Overall OK level '1' coded as class 1.

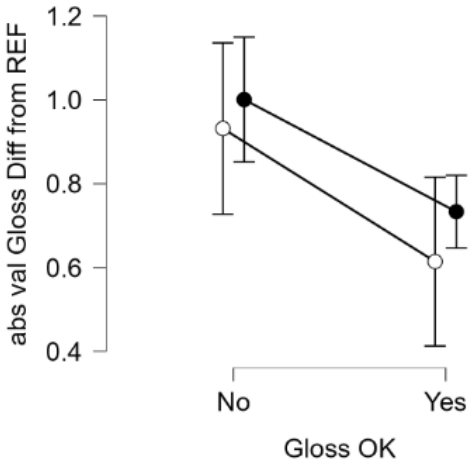


Error bars represent 95% Confidence Interval

On-going work

Preparing for developing models

- Learning from historical data, investigating reasons for assessments (OK/Not OK)



Error bars represent 95% Credible Interval

Gloss measurement higher or lower than reference

- ○ higher
- ● lower

Samples whose gloss measurements were further from the reference measurement were more likely to be judged as 'Not OK'

Samples with gloss measurements below (less glossy than) the reference value needed a higher magnitude of difference to be judged as 'Not OK' than those with a value higher (glossier) than the reference.

Model Comparison

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model	0.250	0.027	0.082	1.000	
Gloss OK	0.250	0.794	11.598	29.836	7.884×10^{-4}
gloss higher or lower than ref + Gloss OK	0.250	0.176	0.640	6.605	2.412
gloss higher or lower than ref	0.250	0.003	0.009	0.113	0.153

Bayesian ANOVA on absolute value of the gloss measurement difference from a reference by gloss judgment and direction of difference

On-going work

Preparing for developing models

- Learning from historical data, investigating reasons for assessments (OK/Not OK)

Logistic regression on 'Color OK' with color 'distance' from reference value (TOLdC-dC), and mentions of each color in a 'part comment' (0/1 color name present in description)

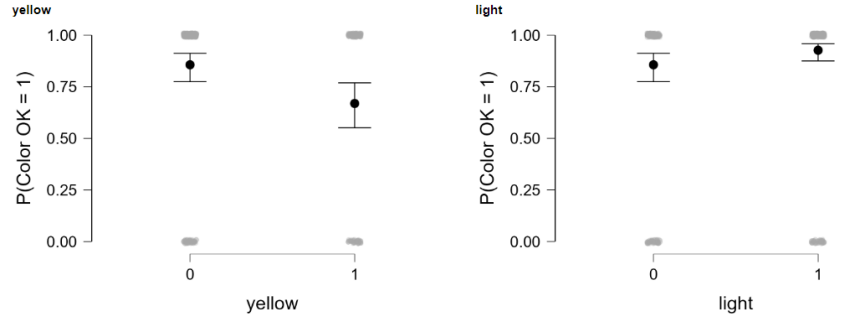
Model Summary - Color OK

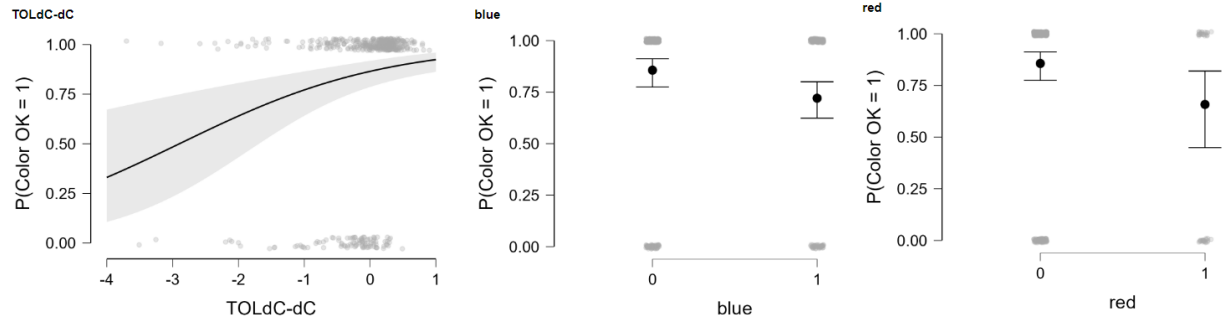
Model	Deviance	AIC	BIC	df	X^2	p	McFadden R^2	Nagelkerke R^2
H_0	478.639	480.639	484.769	458				
H_1	424.397	436.397	461.172	453	54.242	< .001	0.113	0.172

Coefficients

	Estimate	Standard Error	z	Wald Test Wald Statistic	df	p
(Intercept)	1.854	0.282	6.584	43.355	1	< .001
TOLdC-dC	0.640	0.170	3.776	14.259	1	< .001
blue (1)	−0.838	0.318	−2.635	6.944	1	0.008
red (1)	−1.130	0.374	−3.020	9.123	1	0.003
yellow (1)	−1.081	0.325	−3.327	11.066	1	< .001
light (1)	0.750	0.247	3.031	9.186	1	0.002

Note. Color OK level '1' coded as class 1.





On-going work

Preparing for experimental work

- Choice of materials (suppliers, products, recycled content etc.)
- Design and manufacture of new moulding tool

- Planning of experimental campaign

Learnings so far
(In this specific project, but also in general)

+ Great open discussions
+ You learn many new things when exposed to new application areas

– It takes longer than expected to get a new collaboration going, especially true for cross-disciplinary collaborations
– Administrative tasks (e.g. project agreements) can be more challenging than expected, every time

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