Choice of Colourmaps for Radiotherapy

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The University of Manchester

Maidstone and Tunbridge Wells NHS Trust

Colourmaps & Data Science

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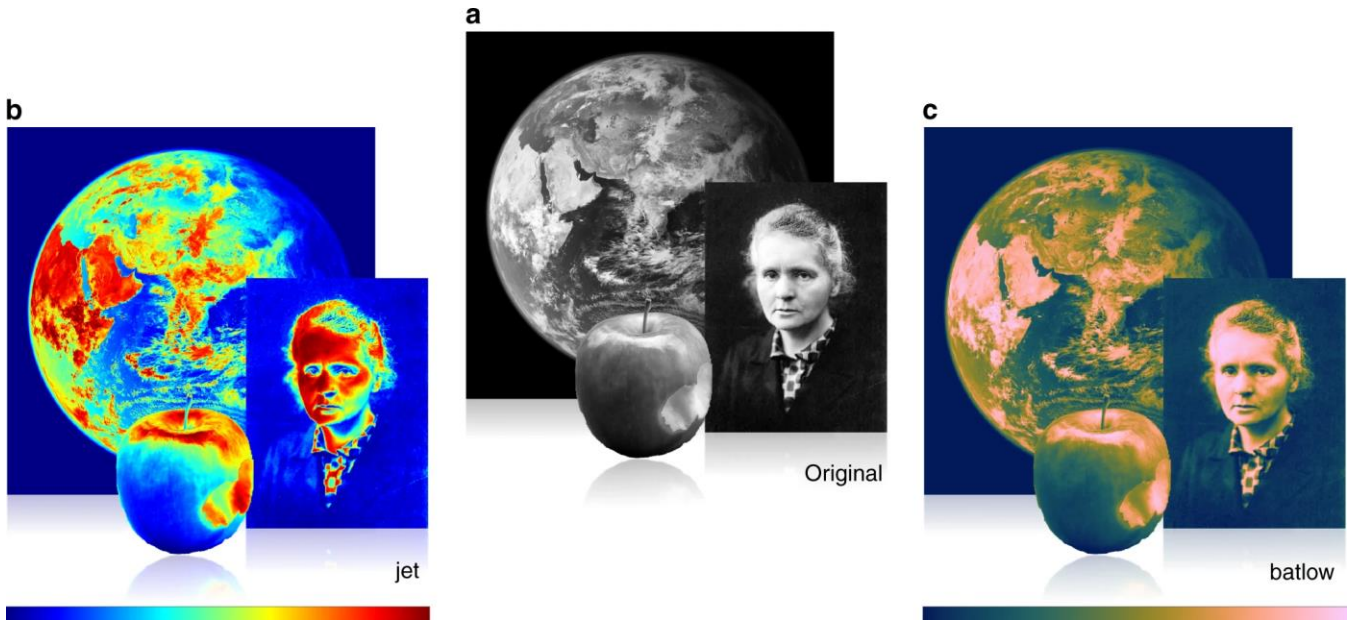
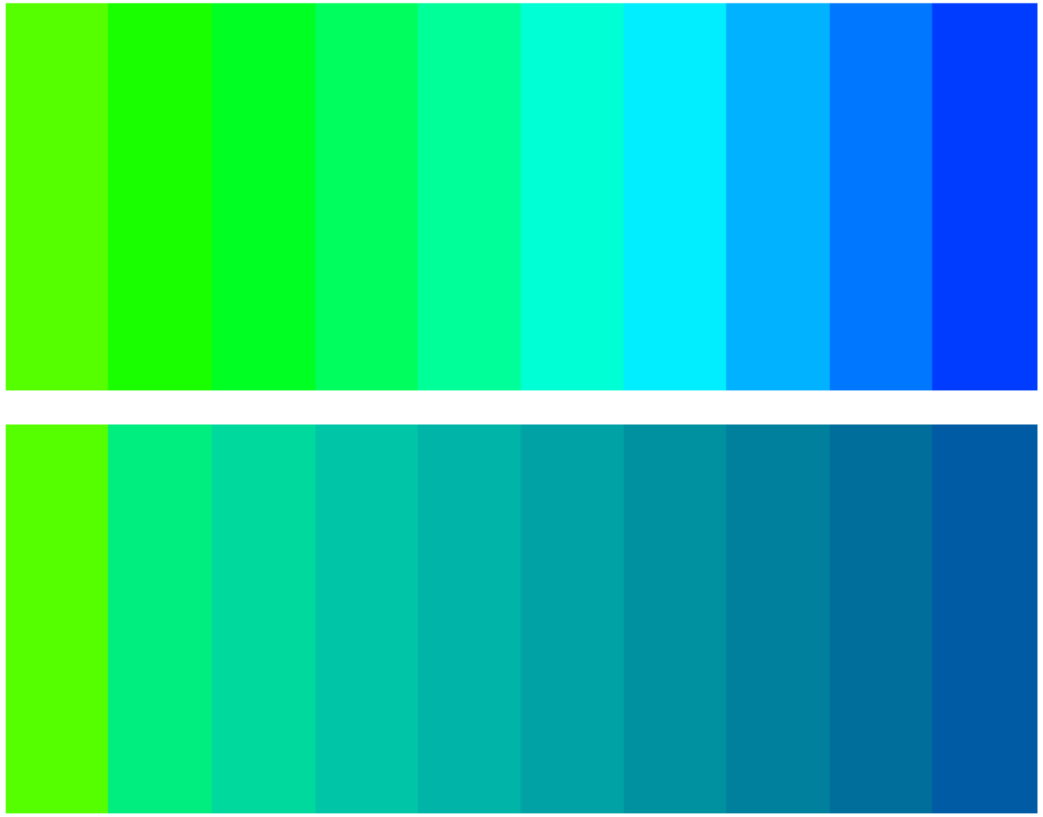
The misuse of colour in science communication

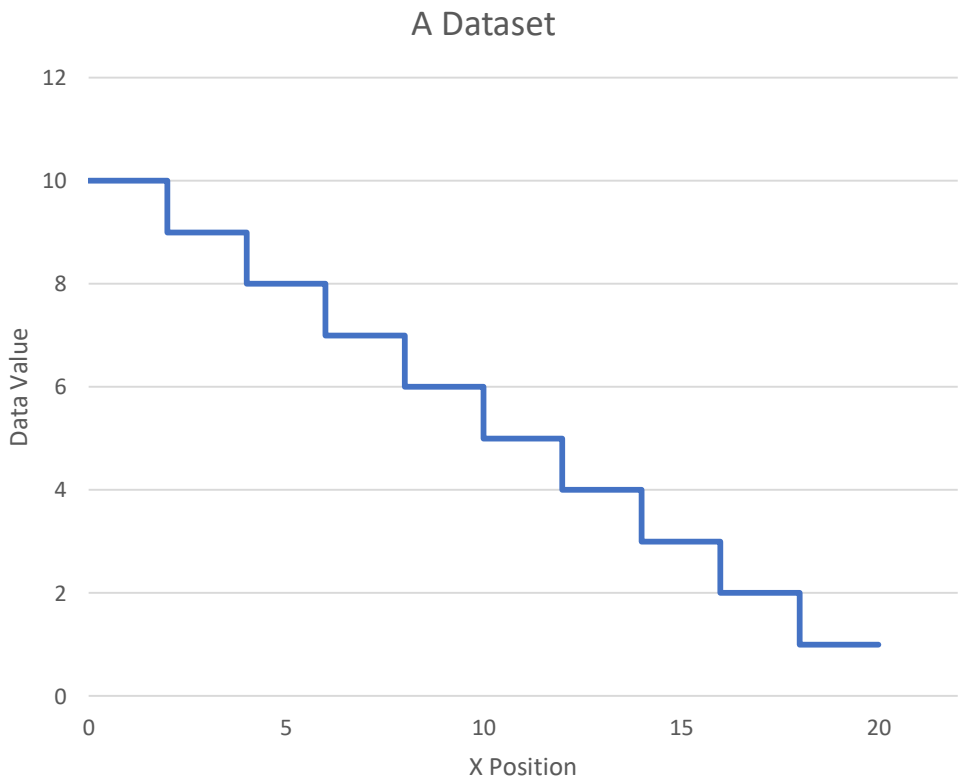
Fabio Crameri, Grace E. Shephard & Philip J. Heron

Nature Communications **11**, Article number: 5444 (2020)



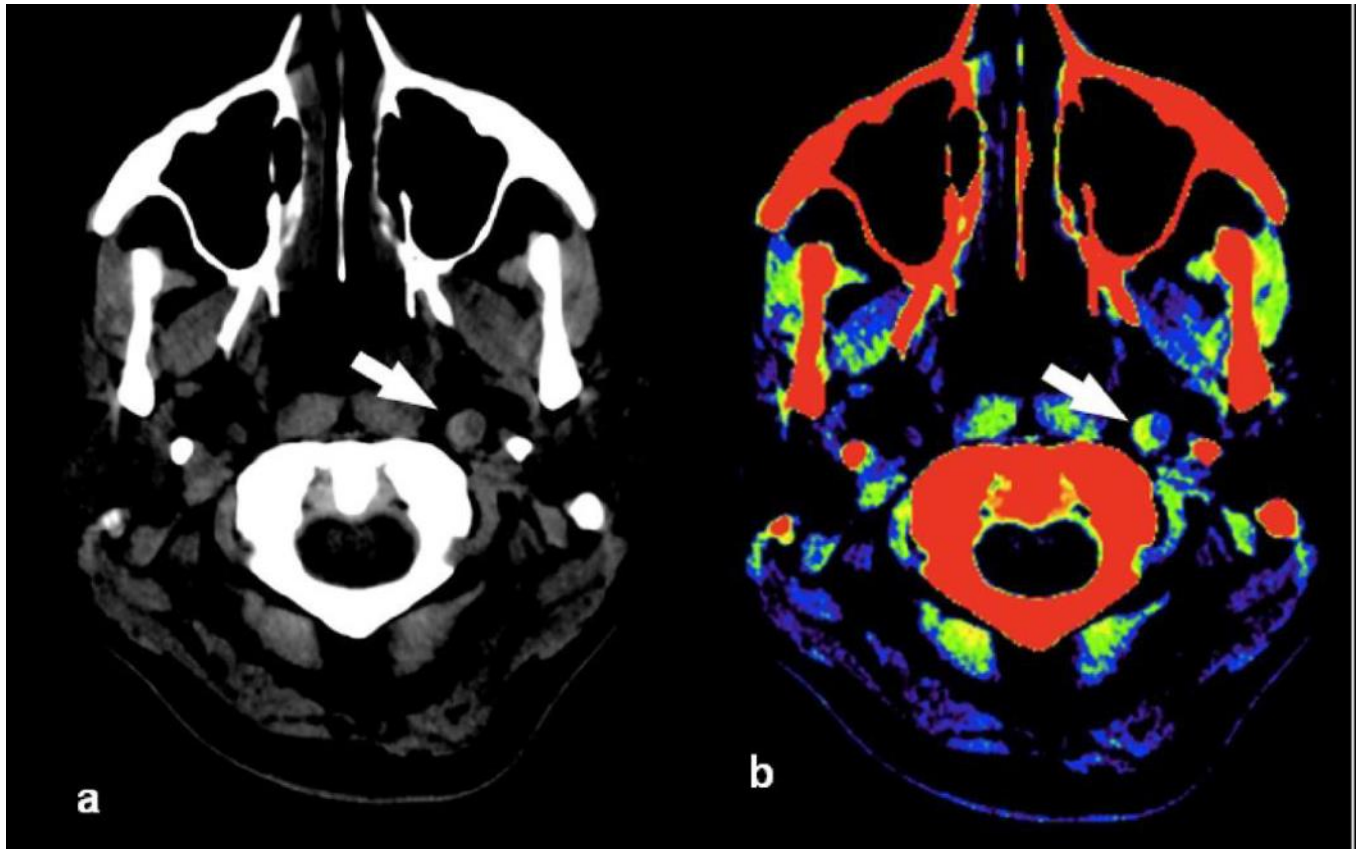
Perceptual Linearity





Adapted from: Madsen, R. (2022). *Programming Design Systems* [Online]. Available at: https://programmingdesignsystems.com/.

Alternative Colourmaps in Medical Imaging



Saba, L., Argiolas, G. M., Raz, E., Sannia, S., Suri, J. S., Siotto, P., Sanfilippo, R., Montisci, R., Piga, M. & Wintermark, M. (2014). 'Carotid artery dissection on non-contrast CT: Does color improve the diagnostic confidence?', *European Journal of Radiology,* 83(12), pp. 2288-2293.

Radiotherapy Imaging Tasks

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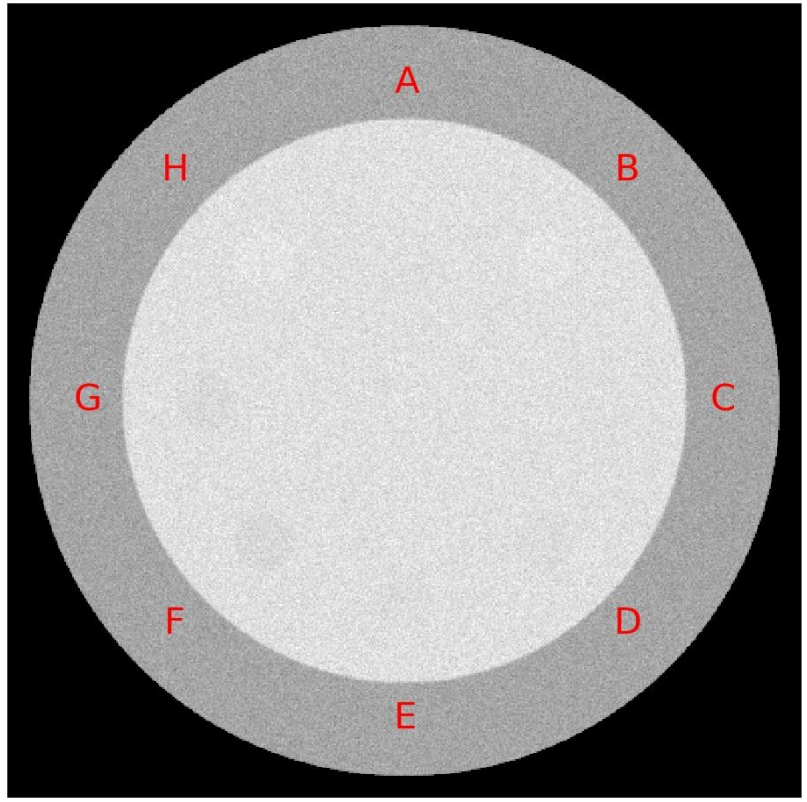
1. **Detection:** *“Can we see the tumour”?*

2. **Delineation:** *“Can we draw around the target?”*

3. **Registration:** *“Can we align these two datasets?”*

Artificial Low Contrast Phantom

- Created artificial phantom based on CatPhan® CTP515 module using Python (v3.10.9) , Numpy (v1.23.5), and Matplotlib (v3.7.0) modules.
- 8 ROI values randomised, and Gaussian image noised added using CV2 (v4.8.0) module.



Colourmaps

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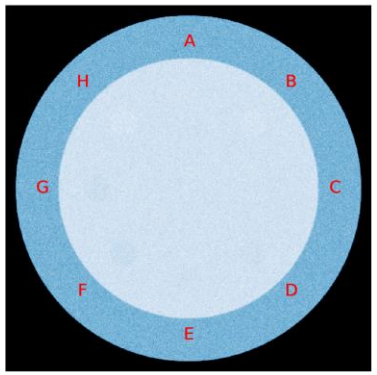
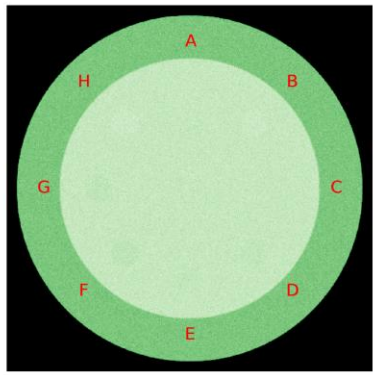
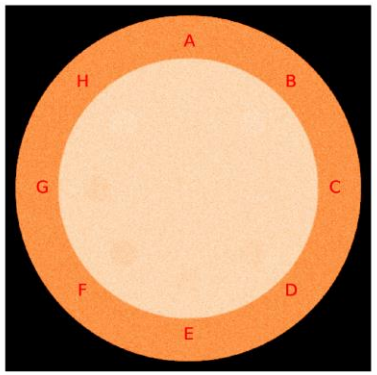
Blue



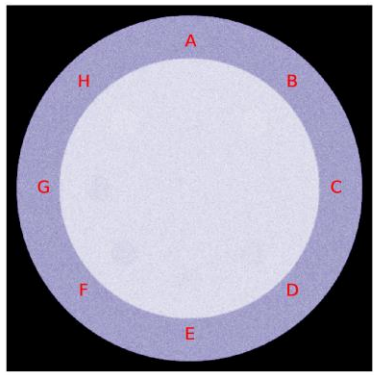
Green



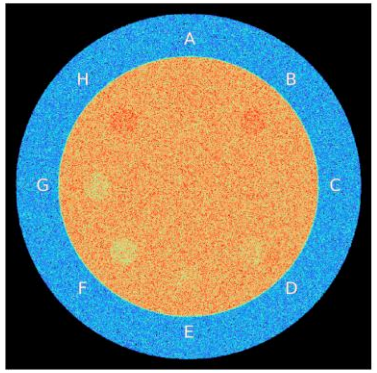
Orange



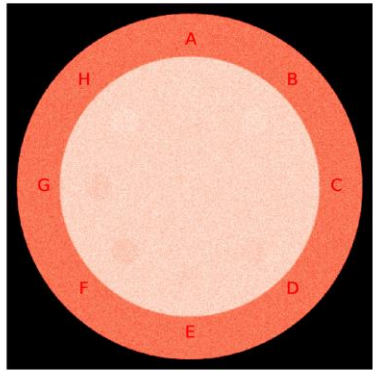
Purple



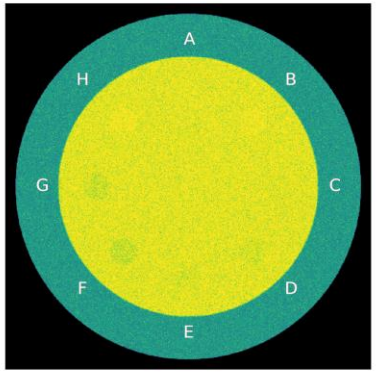
Rainbow



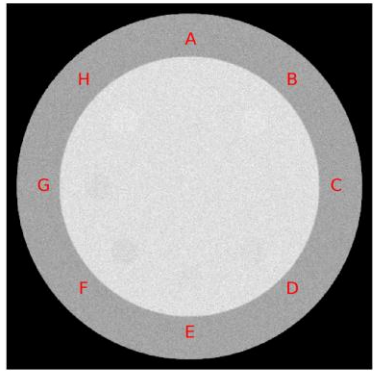
Red



Viridis

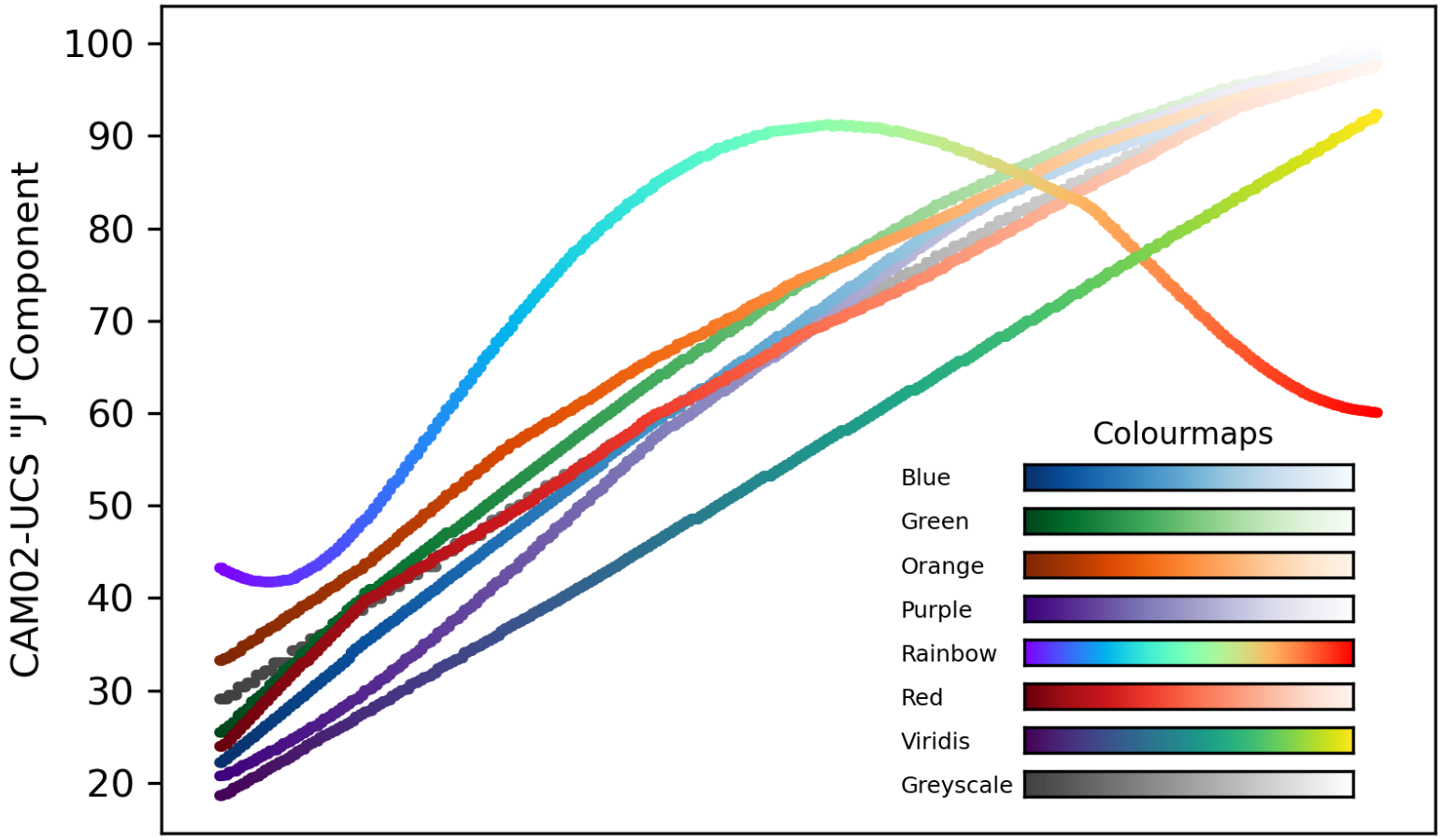


Greyscale



Colorspacious (v1.1.2)

- Images assessed with CAM02-UCS model
- Colourmaps with linear lightness (J) are thought to have better perceptual linearity.
- Matplotlib rendering settings adjusted to ensure comparable phantom lightness between colourmaps



Colourmap Survey

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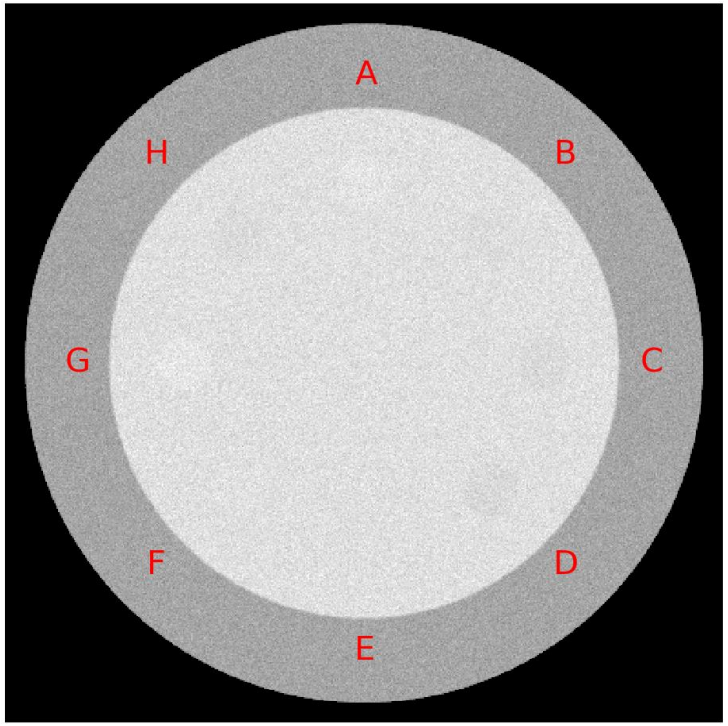
- Script run 3x generating three sets of eight colourmaps (24 images).
- QualtricsXM™ survey asked respondents which “test regions” were visible (A-H).
- Shared in local departments, and UK Medical Physics Mailbase.
- No restrictions on role or equipment to participate.

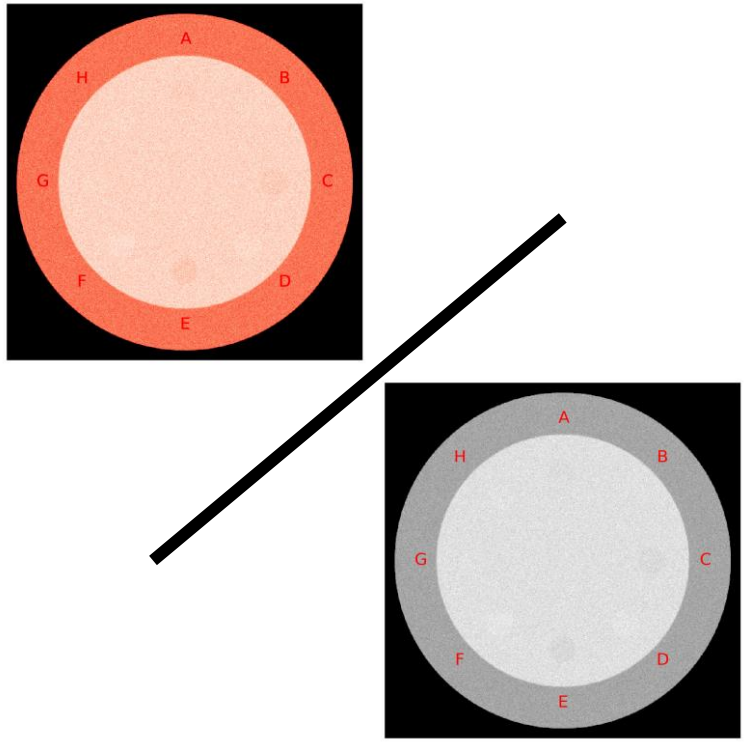


Please click the buttons below to show which test regions are visible. Then click the arrow at the bottom right to save your selections and continue to the next image.

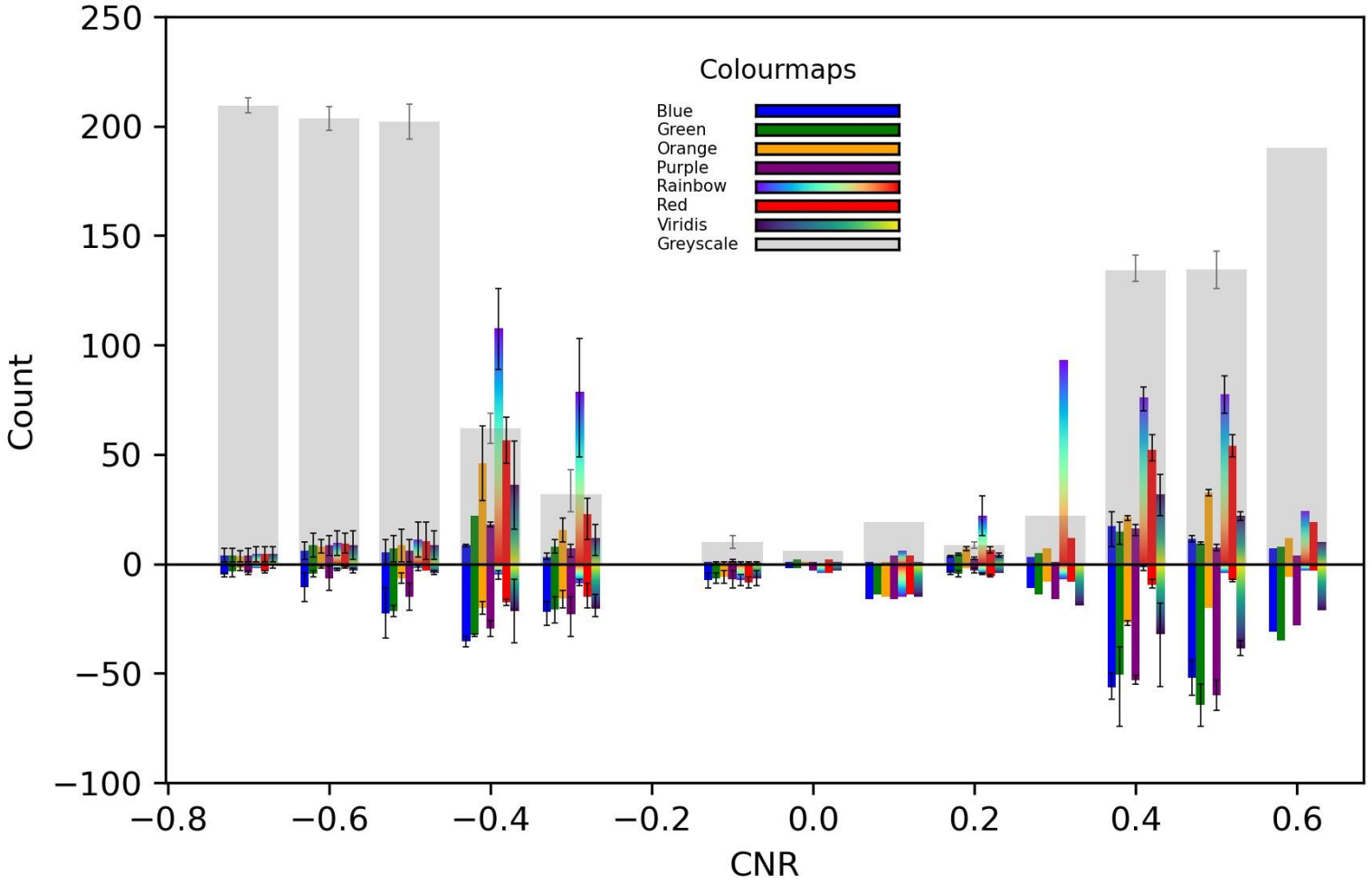
A B C D
E F G H

Results 1

- 214 responses with range of roles & experience.
- Survey not in controlled conditions!
- Calculated relative benefit of each colourmap by comparing responses to matching greyscale image.



Results 2



- Grey bars show total number of visible regions in grayscale images.
- Positive colour bars show test regions detected by users in the displayed colourmap but not in greyscale (and vice versa).
- Benefit to using Rainbow, Red, Orange, & Viridis colourmaps.

Respondent Clustering

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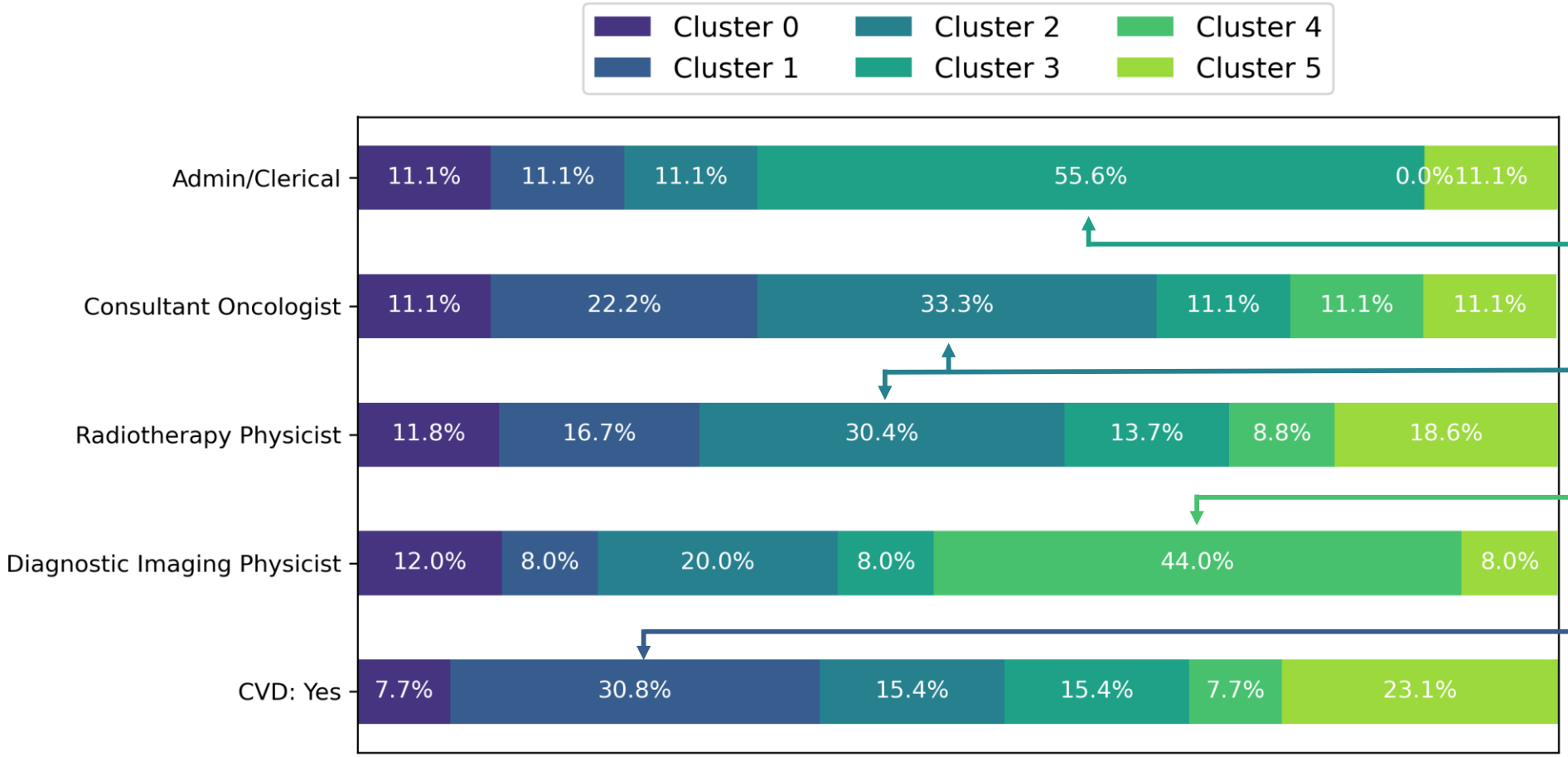


Cluster Features

Consistent Benefit to Red & Rainbow.

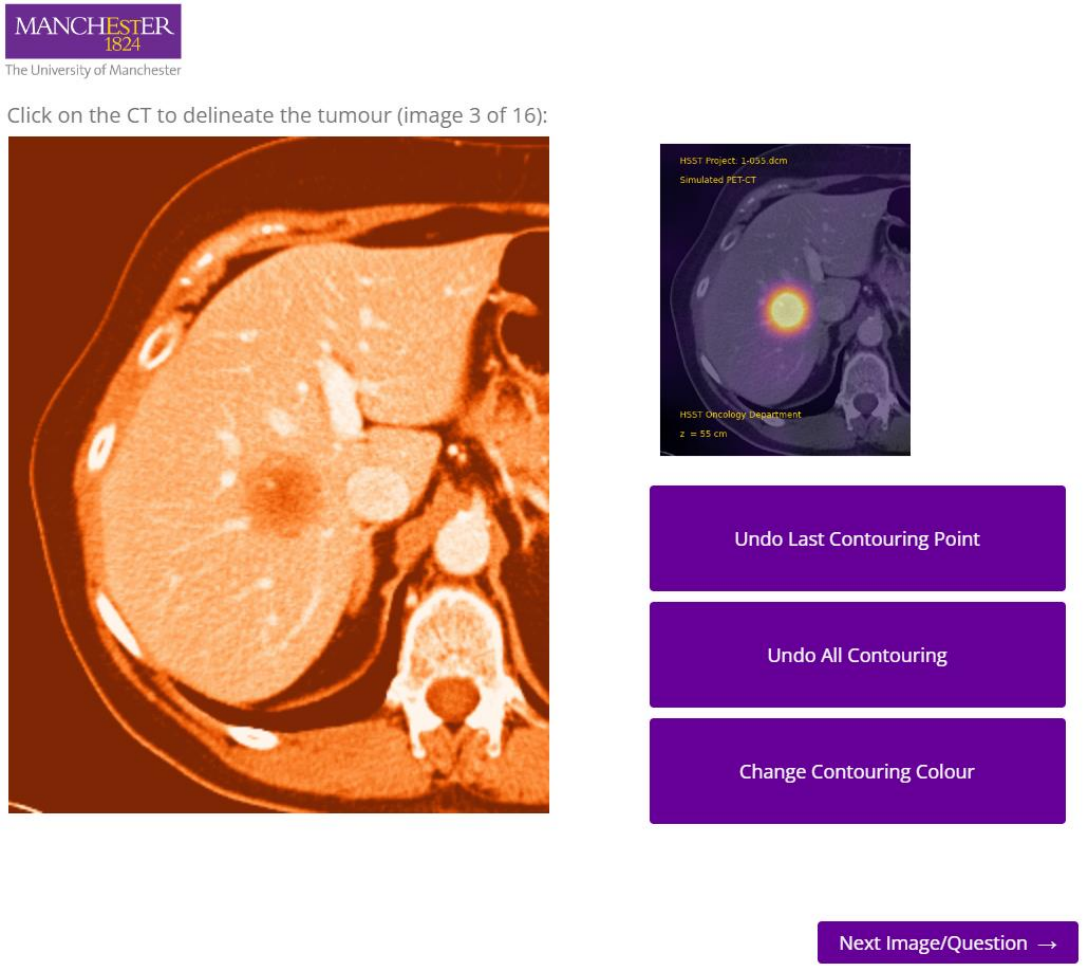
Most Significant Benefit to Rainbow. Colour benefit generally at negative CNR.

Cluster with least benefit to colourmaps.

Variable benefit in colourmaps across CNR.

Next Steps…

- Is target delineation affected by colourmap?
- Artificially generated 8 lung and 8 liver tumours on a patient CT.
- Custom-made QualtricsXM™ survey to compare contouring submissions to “ground truth”.



Conclusions

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- More test regions seen in rainbow, red, and orange colourmaps than greyscale.
- Clustering within responses, and within roles.
- Colourmaps beneficial to less experienced observers.
- Observers unsure of own colourmap preference.
- Use of alternative colourmaps in delineation to be investigated.

Please consider completing the delineation questionnaire: