

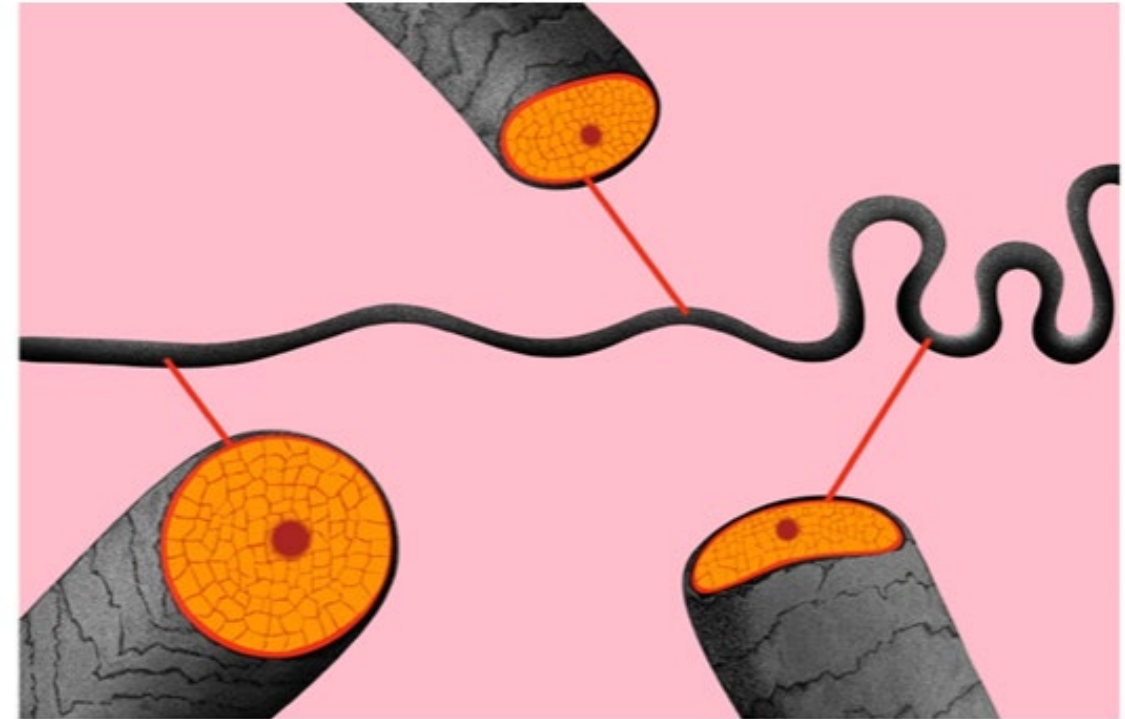
From Fibre to Feeling: Interdisciplinary Hair Research for Innovation

Dr Gabriela Daniels: Director of Science Programmes, University of the Arts London

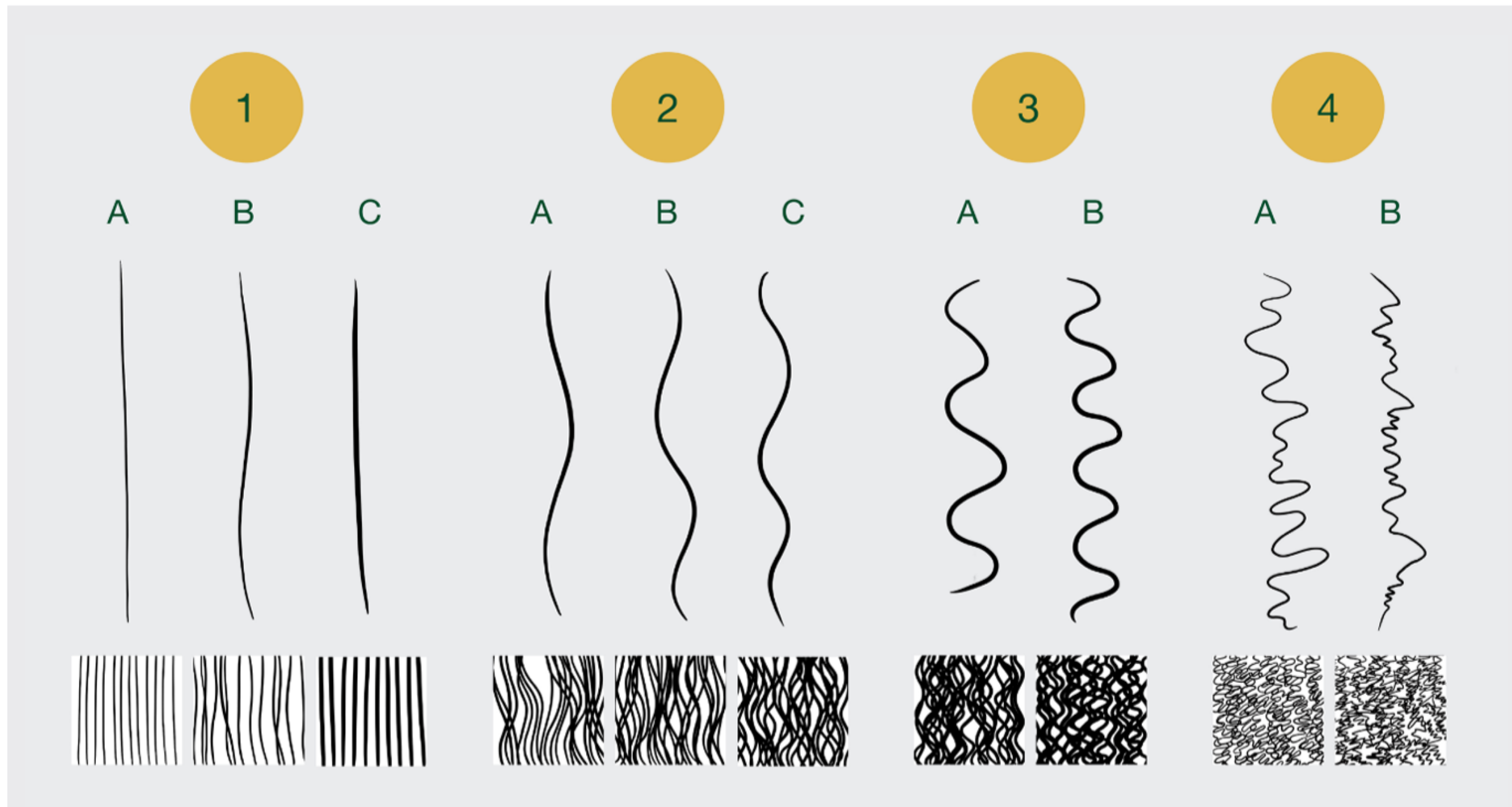
Hair diversity

Reported variations of fibre characteristics and properties

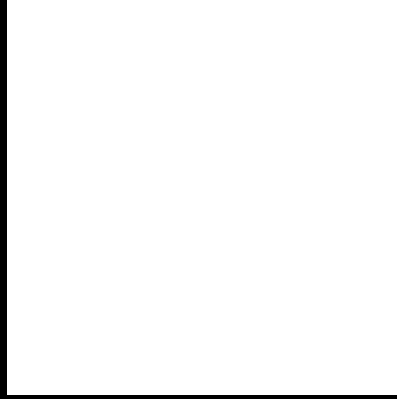
straight (types 1 and 2)	wavy	wavy to curly	curly	very curly/kinky (types 7 and 8)
low ellipticity	moderate ellipticity		high ellipticity	
diameter varies from <70µm to >80µm			major diameter ca 60-80µm	
black colour	dark brown to blond and red		black colour	
cuticle thickness=8-10 layers			cuticle thickness 5-8 layers	
ortho and para-cortex cells homogenous distribution			ortho and para-cortex cells bilateral distribution	
lower lipid content			high lipid content	
eumelanin	eumelanin and pheomelanin in variable ratios		eumelanin	
break stress and survival probability=high			break stress and survival probability=low	
water content=varied			water content=low	
lustre=high	lustre=medium and colour dependent		lustre=low	



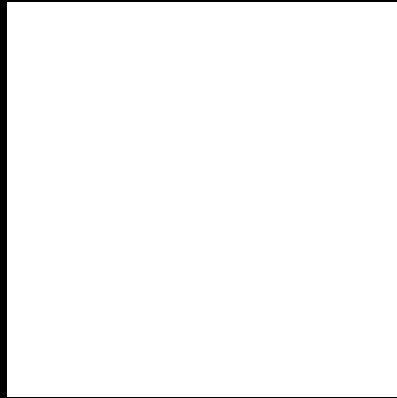
Daniels, G., Fraser, A. and Westgate, G.E., 2023. How different is human hair? A critical appraisal of the reported differences in global hair fibre characteristics and properties towards defining a more relevant framework for hair type classification. *International Journal of Cosmetic Science*, 45(1), pp.50-61.



Daniels, G. and Heitmayer, M., 2024. Towards a taxonomy for assessing and classifying the needs of curly hair: A mixed-method, ethnographic and quantitative data study. *International Journal of Cosmetic Science*, 46(5), pp.746-760.



AI-facilitated approaches to hair diversity explorations



Human hair diversity: The Mildred Trotter's hair collection 1920s–1950

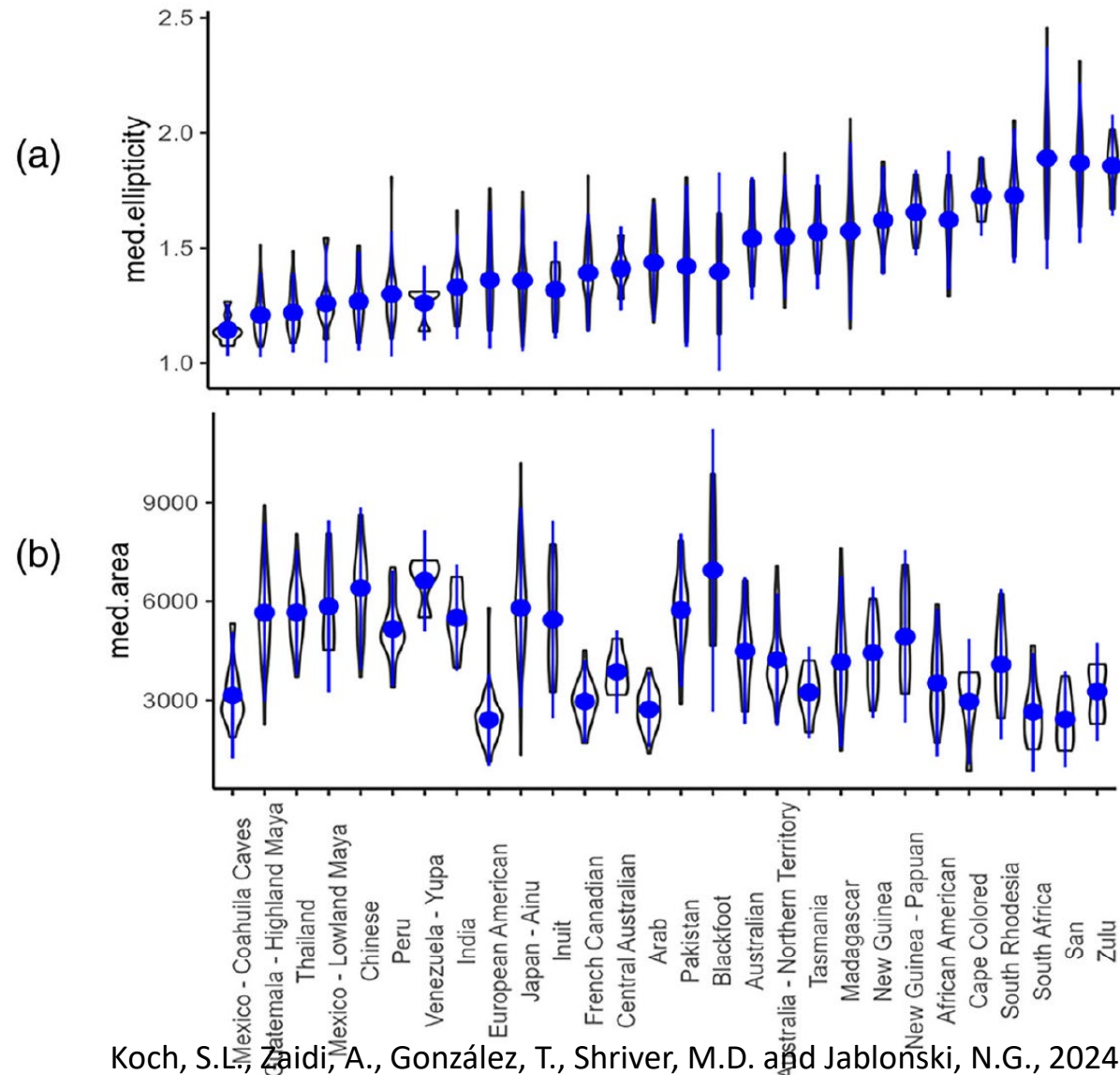
- ❑ 6215 fibres from 29 ethnographically defined populations
- ❑ 3000 samples from 16 individuals tracked over the life span



FIGURE 1 Map of populations from whom hairs were collected for Trotter Collection. Trotter's description of population names was used except for Inuit, which was changed to reflect the current group preferences.

Koch, S.L., Zaidi, A., González, T., Shriver, M.D. and Jablonski, N.G., 2024. The Trotter collection: A review of Mildred Trotter's hair research and an update for studies of human variation. *American Journal of Biological Anthropology*, 184(3), p.e24930.

Cross-sectional area fibre analysis based on Transmission Electron Microscopy



Koch, S.L., Zaidi, A., González, T., Shriver, M.D. and Jablonski, N.G., 2024. The Trotter collection: A review of Mildred Trotter's hair research and an update for studies of human variation. *American Journal of Biological Anthropology*, 184(3), p.e24930.

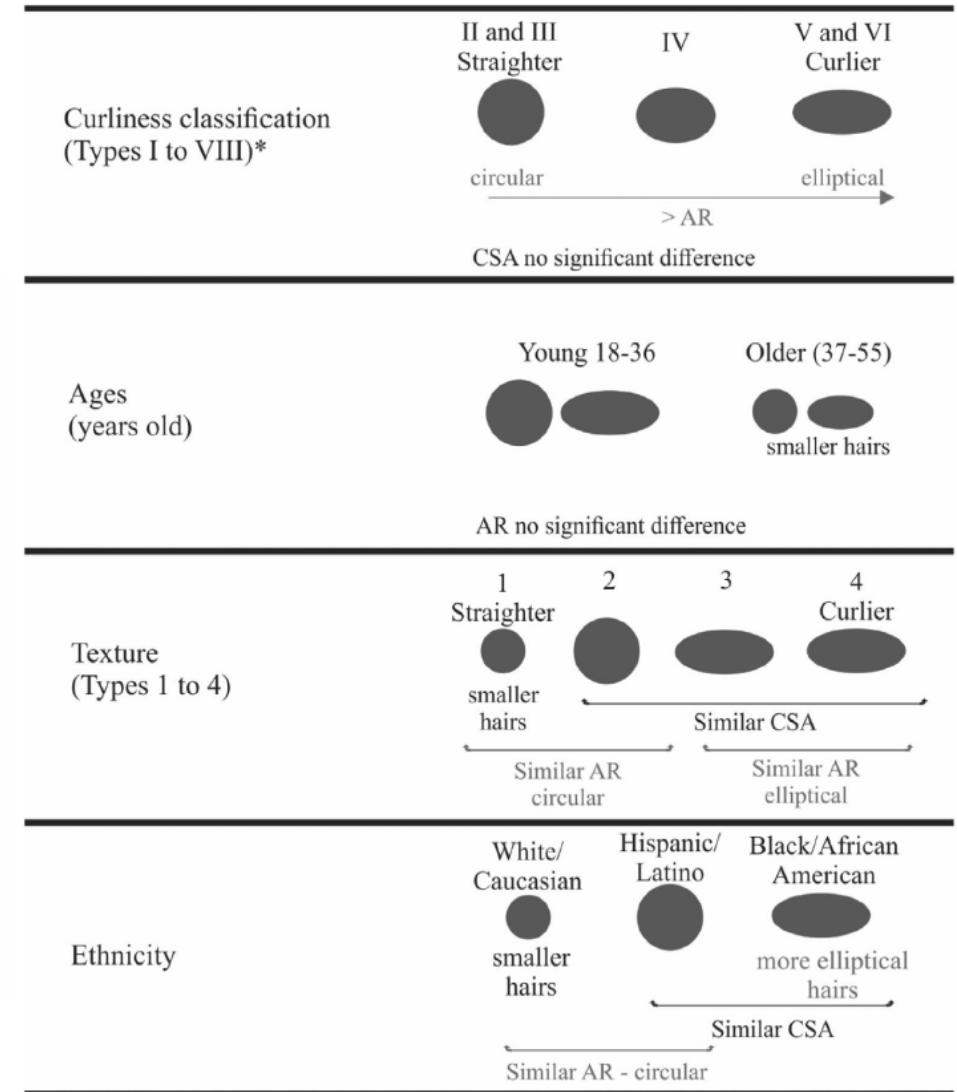
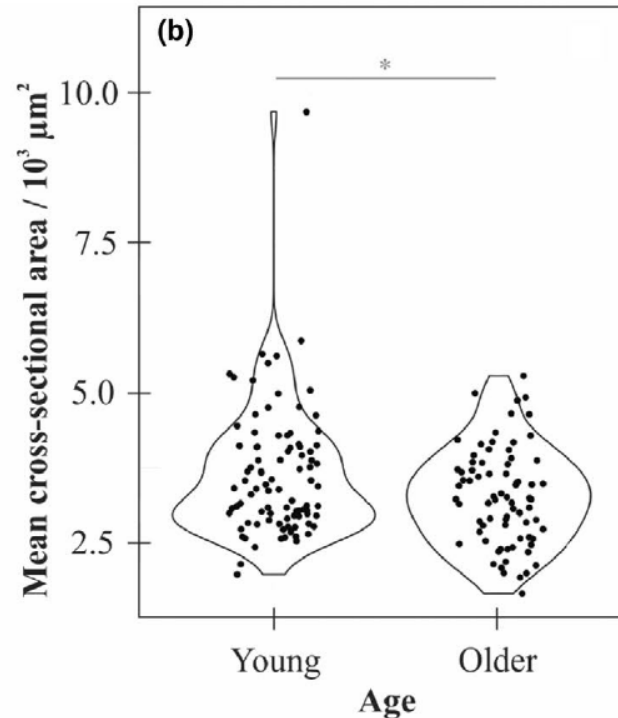
USA population study

191 participants (USA)
stratified equally
across 4 hair types,
three ethnicities and
two age groups: 18-
36;37-55

(100 fibres per person)

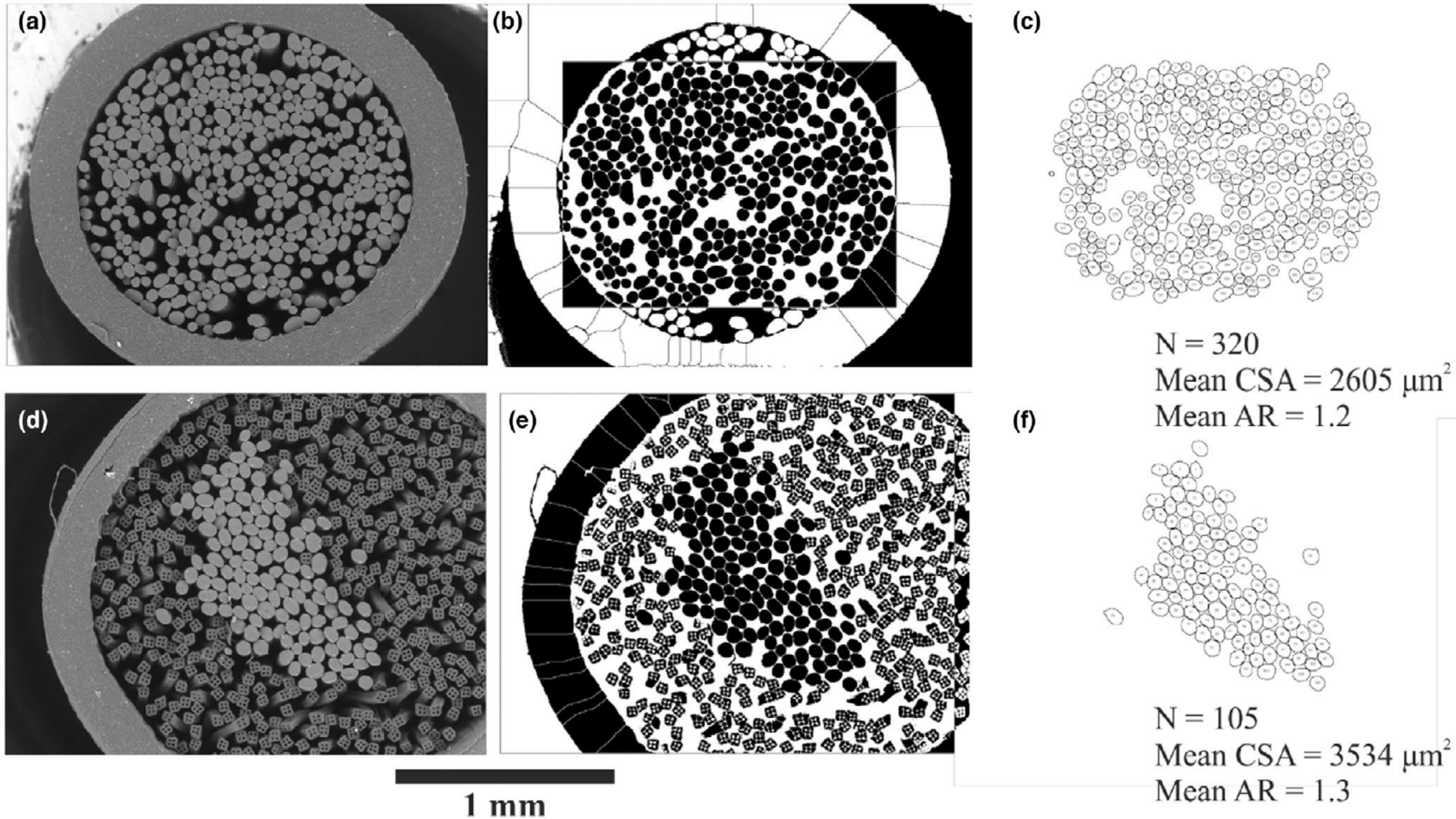
Analysis based on
Scanning Electron
Microscopy

Richena, M., Noble, A., Parker, K., Bhogal, R.K., Messenger, D., Clerens, S. and Harland, D.P., 2025. Simultaneous morphological analysis of large numbers of hair cross sections as a tool for investigation of population-level trends. *International journal of cosmetic science*, 47(4), pp.676-690.



* I and VII under-represented and VIII no measurements

FIGURE 9 Summary of the results: Significant differences between cross-sectional measurements in the curliness classification and clinical classification (p -values < 0.05). Statistical analysis is in Supplementary S5.



Richena, M., Noble, A., Parker, K., Bhogal, R.K., Messenger, D., Clerens, S. and Harland, D.P., 2025. Simultaneous morphological analysis of large numbers of hair cross sections as a tool for investigation of population-level trends. *International journal of cosmetic science*, 47(4), pp.676-690.

Hair fibre's 3D form

- ❑ High-resolution medical Computed Tomography scanner
- ❑ Fibres representing low, medium and high curl (21;20;21 each) were scanned and reconstructed
- ❑ Surface profile, cross-sectional area, and surface topography were measured
- ❑ Agreement with traditional methods re fibre geometry but not surface, noted fibre torsion

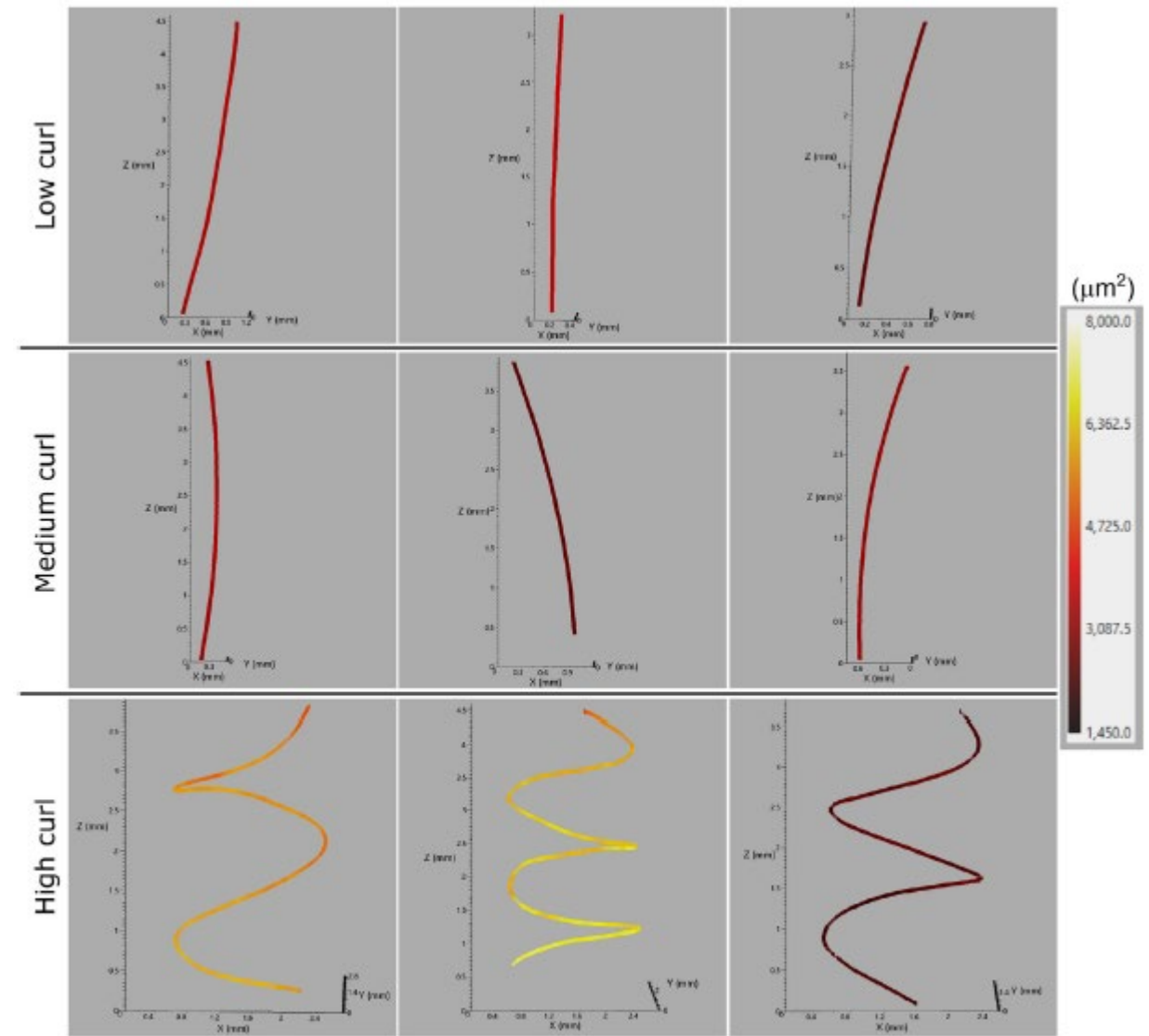


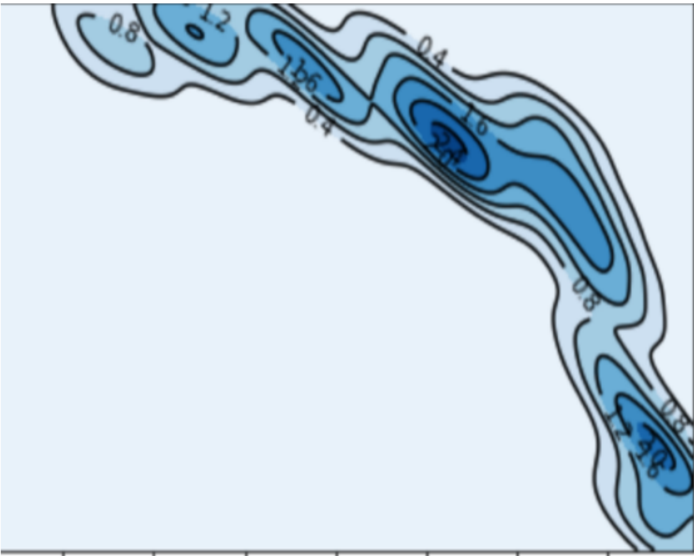
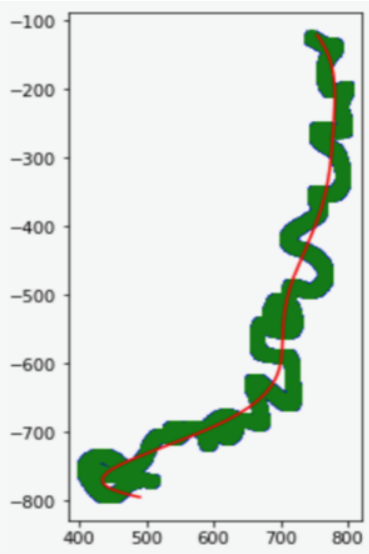
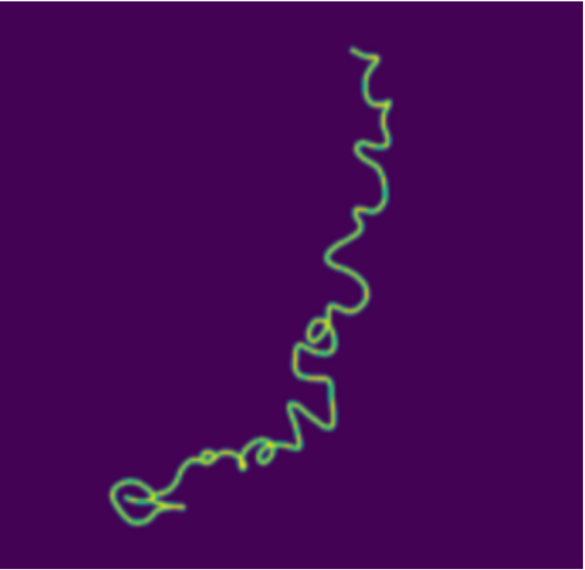
FIGURE 13 3-D view of the centrelines showing individual cross-sections coloured by CSA_{Ellipse}.

Berg, C.V.D., Khumalo, N.P. and Ngoepe, M.N., 2025. Quantifying whole human hair scalp fibres of varying curl: A micro-computed tomographic study. *Journal of Microscopy*, 297(2), pp.227-251.

Mapping geometric transitions in highly textured hair via single-fibre image analysis and machine learning

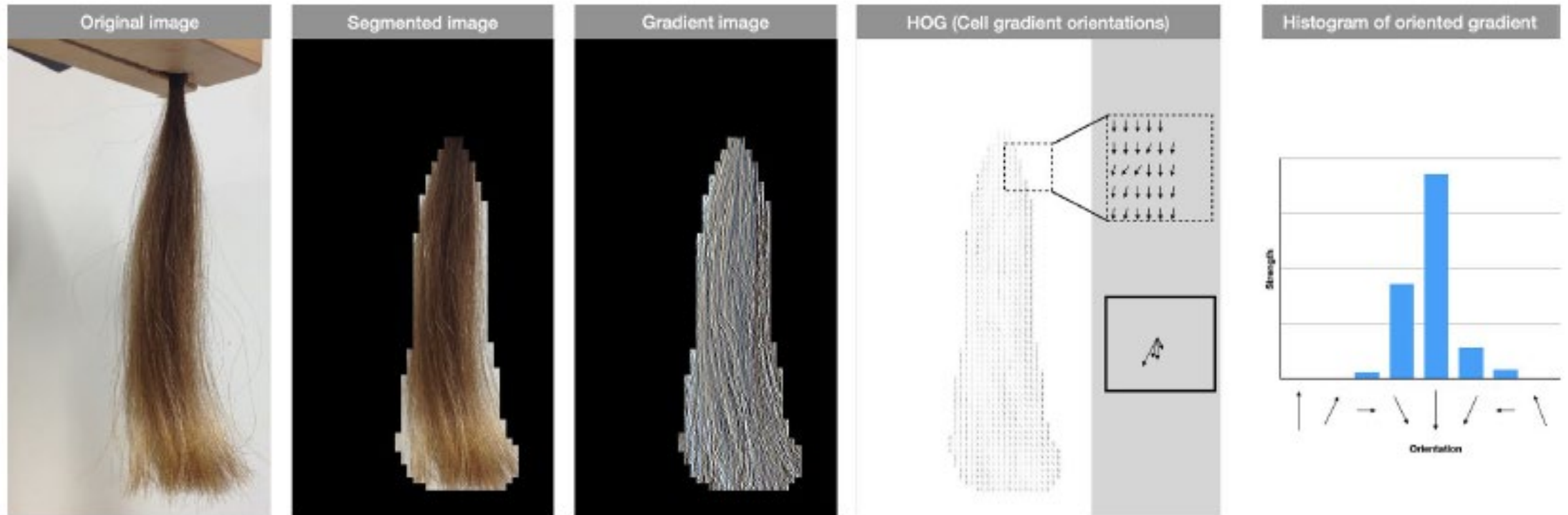
	Number of intersects	Estimated number of curves	Average curvature	Curvature 1 st quartile	Curvature 2 nd quartile	Curvature 3 rd quartile	Curvature 4 th quartile	Normalised area
t0 mean value	41.76	56.56	56.73	8.05	26.00	11.96	64.03	0.31
t1 mean value	40.81	51.91	80.12	5.32	14.15	15.04	92.22	0.32
Difference	0.95	-4.65*	-23.39*	2.72*	11.86*	-3.08*	-28.20*	-0.01

80 fibres (Type 4B)



Daniels, G., Hameed, A., Tamburic, S., Gervasoni, G., Bhamidipati, S. and Guan, Y. (2024). *Challenges with textured hair analysis: single fibre and hair assembly assessments and statistical explorations*. Poster and paper presented at IFSCC Congress, Brazil,

Hair alignment and volume assessment via computer vision and machine learning



Daniels, G., Tamburic, S., Benini, S., Randall, J., Sanderson, T. and Savardi, M., 2021. Artificial Intelligence in hair research: A proof-of-concept study on evaluating hair assembly features. *International Journal of Cosmetic Science*, 43(4), pp.405-418.

Hair volume and alignment features

		Predicted					
		Virgin hair			Bleached hair		
		t_0	t_1	t_2	t_0	t_1	t_2
Ground truth	t_0	17	1	1	15	0	2
	t_1	0	10	7	1	8	2
	t_2	2	3	13	0	9	11
		t_0	$(t_1 + t_2)$		t_0	$(t_1 + t_2)$	
		t_0	17	2	15	2	
		$(t_1 + t_2)$	2	33	1	30	

Table III: Confusion matrices. Correct results in bold.

Daniels, G., Tamburic, S., Benini, S., Randall, J., Sanderson, T. and Savardi, M., 2021. Artificial Intelligence in hair research: A proof-of-concept study on evaluating hair assembly features. *International Journal of Cosmetic Science*, 43(4), pp.405-418.



1. TRAINING DATA SET

Virgin and bleached hair



2. IMAGE DATASET

- Three images per tress
- 80 tresses per condition
- Total: **1,088** images



3. FEATURES EXTRACTED

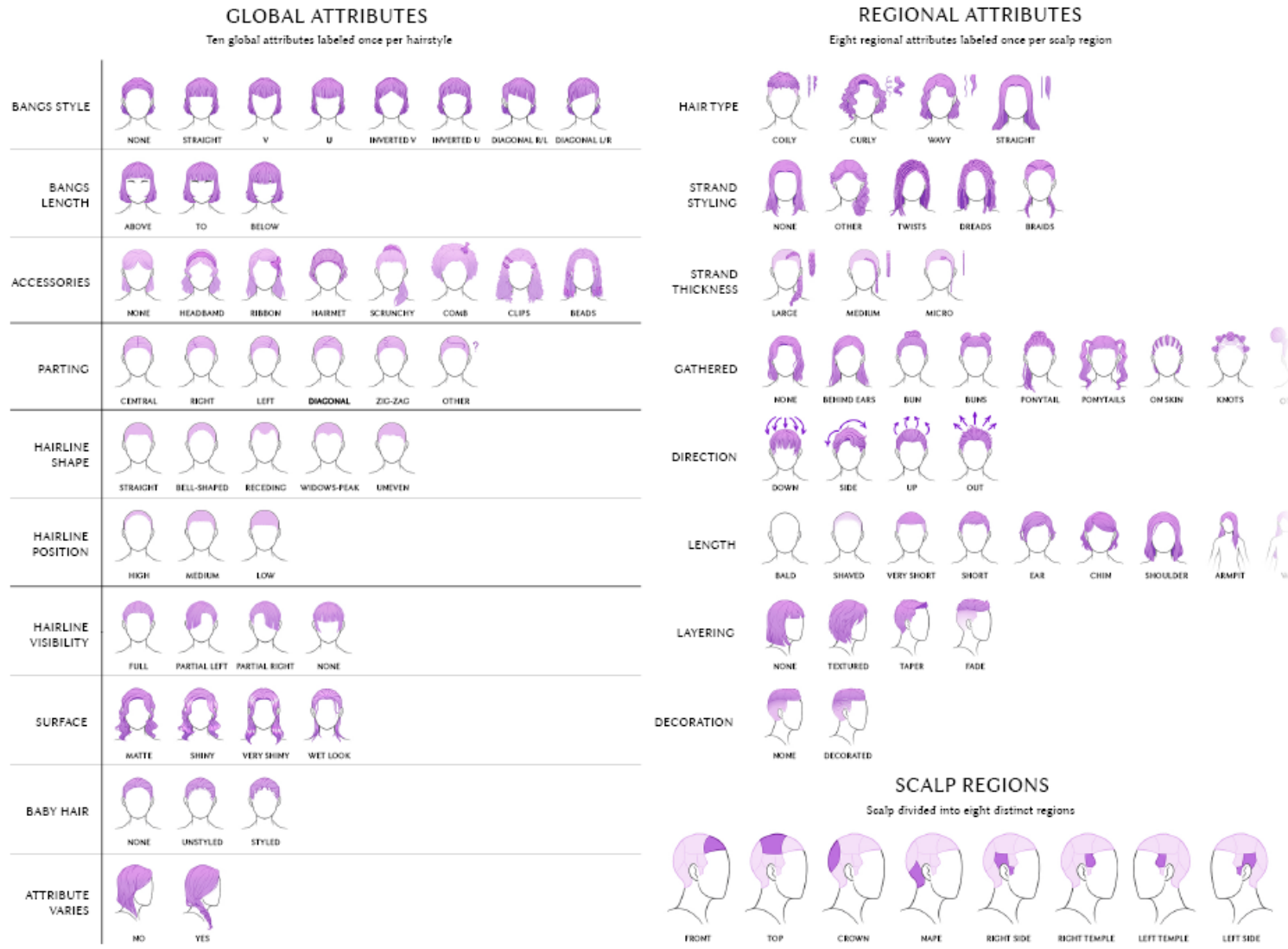
Five features describing hair volume and alignment



4. CLASSIFICATION SCOPE

Untreated (virgin and bleached) and treated (with shampoo and conditioner) hair

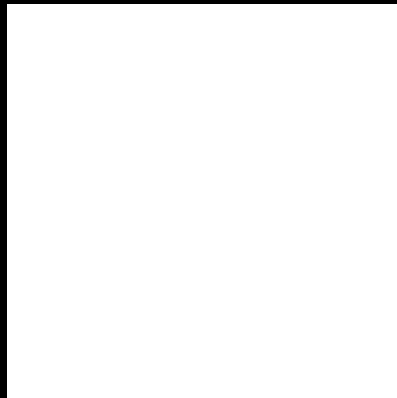
AI-based hair style prediction



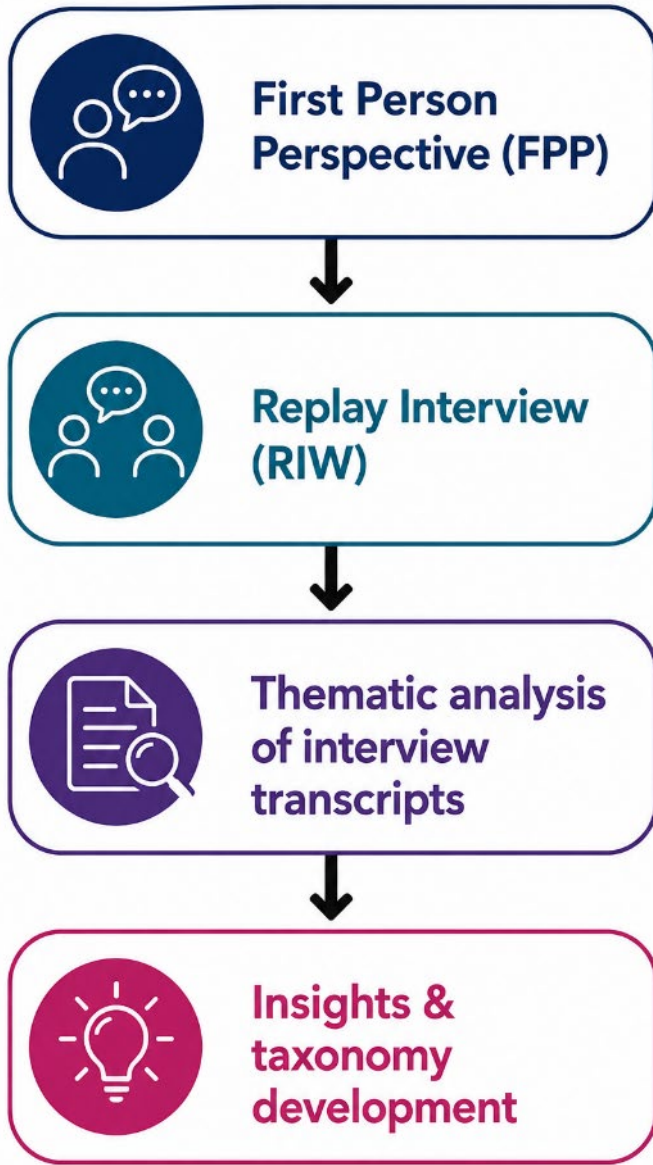
- ❑ Synthetic training dataset = **100,000** rendered images representing **480 hairstyles**
- ❑ Training data set labelled by 10 global hair style attributes, 8 scalp regions, and 8 local attributes
- ❑ Testing dataset: 1805 real images
- ❑ Prediction of style successful across a wide and inclusive range of styles



Behavioural dimensions of hair manageability



Subjective Evidence-Based Ethnography: A study of curly hair manageability

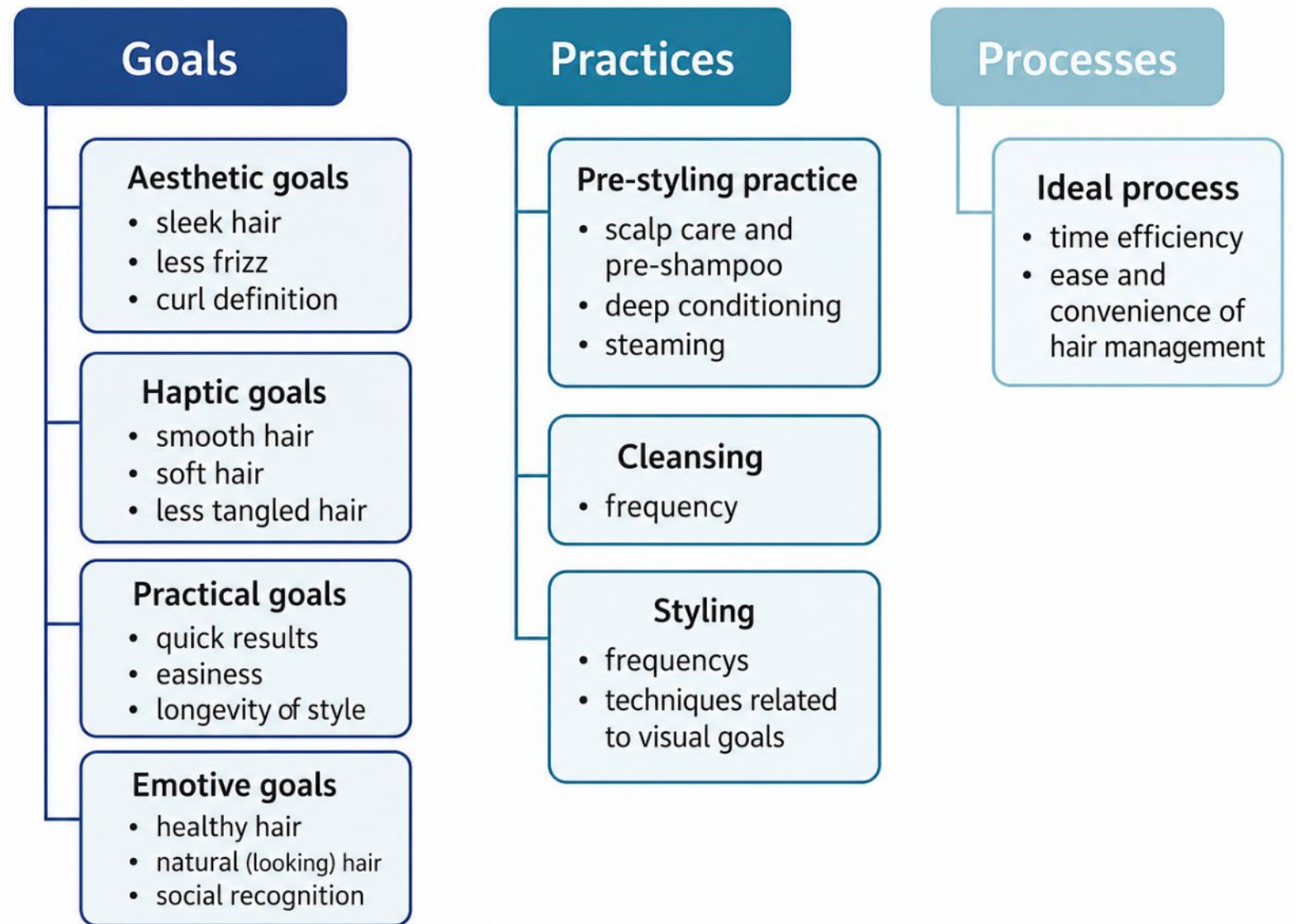


Daniels, G. and Heitmayer, M., 2024. Taxonomy for the assessment of the subjective experience of curly hair manageability. *International Journal of Cosmetic Science*, 46(6), pp.1074-1087.

Qualitative data summary

n =14

Daniels, G. and Heitmayer, M., 2024. Taxonomy for the assessment of the subjective experience of curly hair manageability. *International Journal of Cosmetic Science*, 46(6), pp.1074-1087.



Hair goals and hair esteem

TABLE 3 Correlations between the four hair goals and hair esteem.

	Aesthetic goals	Practical goals	Haptic goals	Emotive goals	Hair esteem
Aesthetic goals	1				
Practical goals	0.297*** <i>p</i> < 0.001	1			
Haptic goals	0.400*** <i>p</i> < 0.001	0.319 <i>p</i> < 0.001	1		
Emotive goals	0.360*** <i>p</i> < 0.001	0.329*** <i>p</i> < 0.001	0.299*** <i>p</i> < 0.001	1	
Hair esteem	0.160** <i>p</i> = 0.003	0.089* <i>p</i> = 0.047	0.126* <i>p</i> = 0.005	0.275*** <i>p</i> < 0.001	1

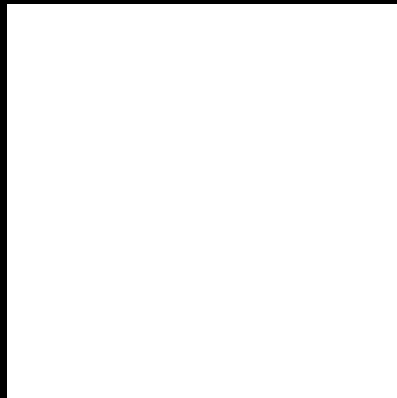
Note: * = significant at the 0.05 level, ** = significant at the 0.01 level, *** = significant at the 0.001 significance level.

Cronbach alpha=>0.7 for aesthetic, haptic and emotive goals, HE>0.9

Daniels, G. and Heitmayer, M., 2024. Taxonomy for the assessment of the subjective experience of curly hair manageability. *International Journal of Cosmetic Science*, 46(6), pp.1074-1087.



Personal and social significance of hair



Measuring Quality-of-Life (QoL) in relation to hair



- ☐ The Hairdex statements are distributed over five QoL domains
- ☐ **Symptoms** (8 items), **Functioning** (12 items), **Emotions** (11 items), **Self-confidence** (9 items) and **Stigmatisation** (8 items)
- ☐ In the final Hairdex instrument, these 48 statements were changed by replacing skin with hair- and scalp-related statements
- ☐ High internal validity

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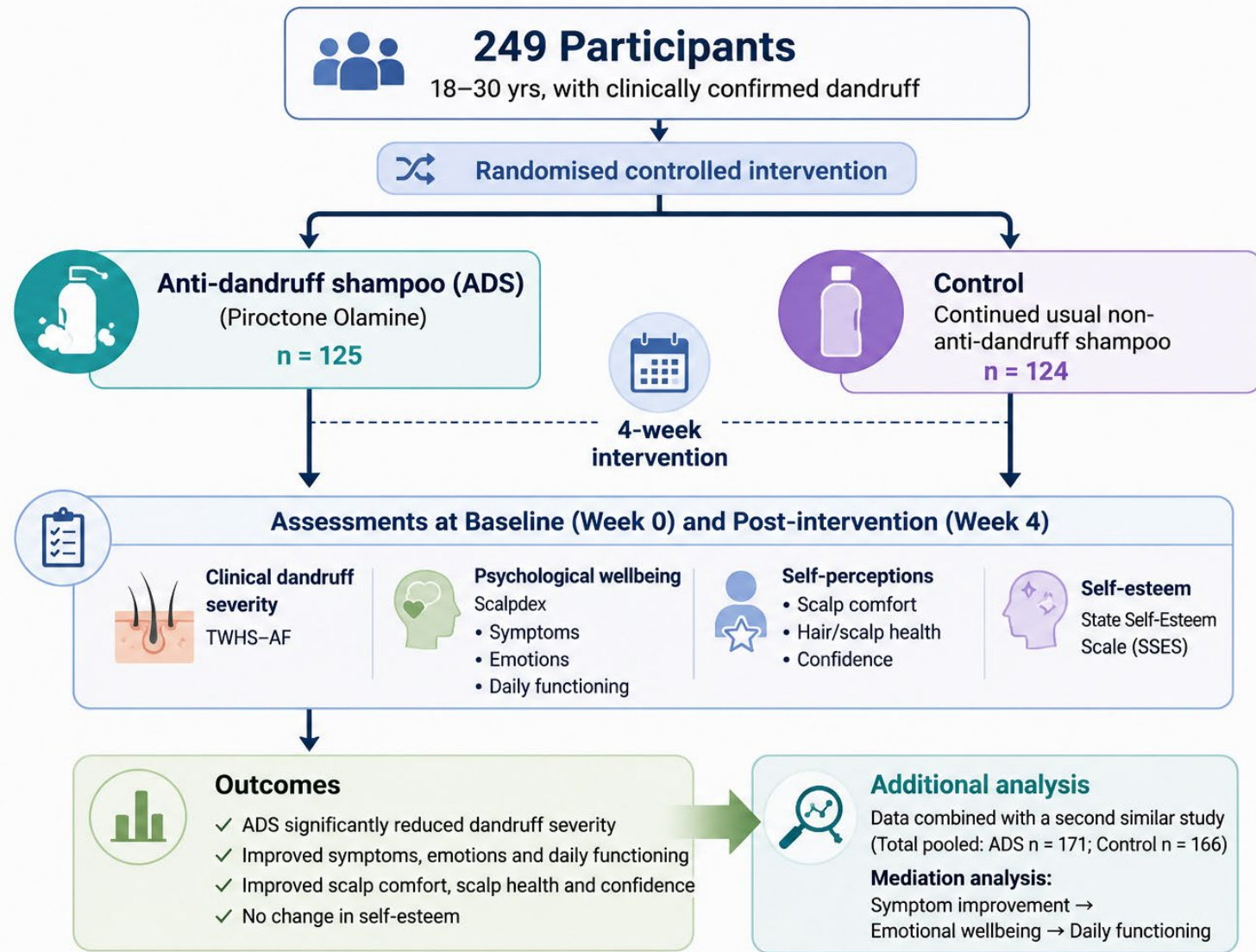
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Freites-Martinez, A., Chan, D., Sibaud, V., Shapiro, J., Fabbrocini, G., Tosti, A., Cho, J., Goldfarb, S., Modi, S., Gajria, D. and Norton, L., 2019. Assessment of quality of life and treatment outcomes of patients with persistent postchemotherapy alopecia. JAMA Dermatology, 155(6), pp.724-728.

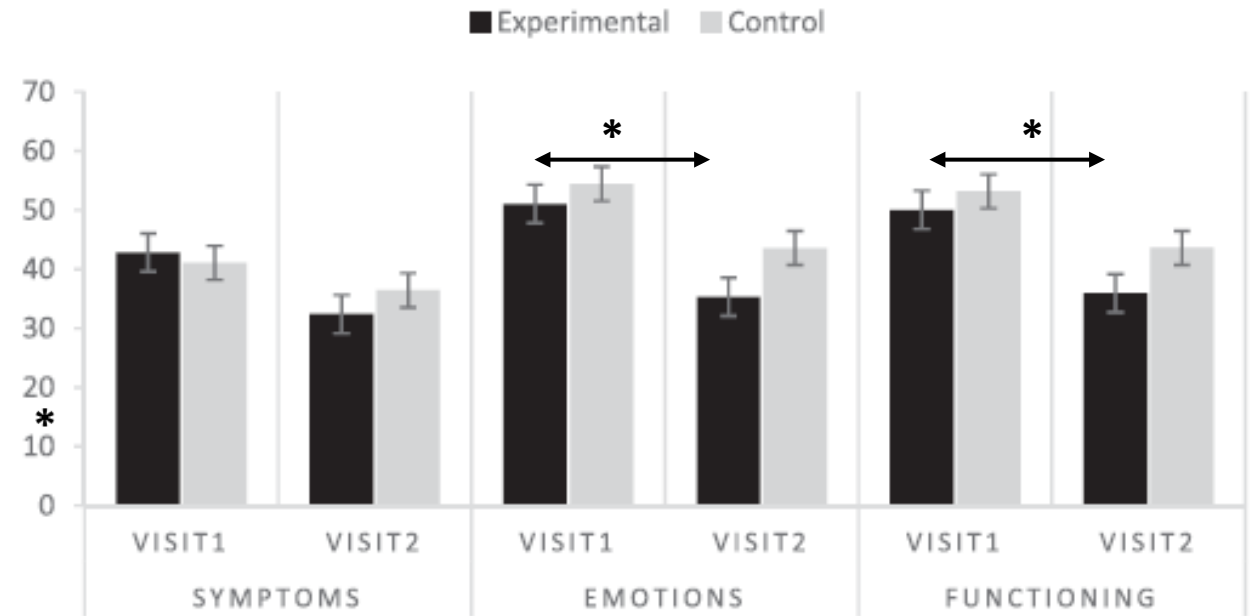
Dandruff and well-being

Newton-Fenner, A., Roberts, H., Scott, M., Jones, T., Collins, L., Godbehere, A. and Giesbrecht, T., 2025. Clear scalp, clear mind: Examining the beneficial impact of dandruff reduction on physical, emotional and social wellbeing. *International Journal of Cosmetic Science*, 47(3), pp.466-475.



Dandruff and wellbeing

- Total Weighted Head Score (Adherent Flakes), reduced after 4 weeks for treatment group
- Scalpdex: **symptoms, emotions, functioning**, all values reduced for treatment group after 4 weeks
- Other well-being measures improved, self-esteem (instrument) no change



Newton-Fenner, A., Roberts, H., Scott, M., Jones, T., Collins, L., Godbehere, A. and Giesbrecht, T., 2025. Clear scalp, clear mind: Examining the beneficial impact of dandruff reduction on physical, emotional and social wellbeing. *International journal of cosmetic science*, 47(3), pp.466-475.

Hair Esteem instrument

- Hair Esteem 1 HE_1 On the whole, I am satisfied with my hair.
- Hair Esteem 2* HE_2 At times, I think my hair is no good at all.
- Hair Esteem 3 HE_3 I feel that my hair has a number of good qualities.
- Hair Esteem 4 HE_4 I am able to care for my hair as well as most other people.
- Hair Esteem 5* HE_5 I feel I do not have much to be proud of about my hair.
- Hair Esteem 6 HE_6 I feel that my hair is as beautiful as any other person's.
- Hair Esteem 7 HE_7 I feel that my hair is attractive.
- Hair Esteem 8 HE_8 I feel I have much to celebrate about my hair.
- Hair Esteem 9 HE_9 Overall, I am satisfied with my hair.

Rosenberg, M., 1965. *Society and the adolescent self-image* (Vol. 11, p. 326). Princeton, NJ: Princeton university press.

Hair longevity study

In-depth interviews

n=31,
14 males, 17 females
19-79 years of age

Daniels *et al*, unpublished data



Key takeaways

- ❑ AI is enabling more objective and scalable assessment of human hair diversity.
- ❑ Human-centred research provides context for consumer-relevant outcomes.
- ❑ Integrating fibre science, AI and human-centred research supports more relevant innovation.



Lady Lilith by Dante Gabriel Rossetti - Delaware Art Museum, Public Domain,
<https://commons.wikimedia.org/w/index.php?curid=6055292>

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