



Examination of Phalangeal Friction Ridge Flow Trends

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Unlike the friction ridge skin on the fingertips, palms and even the soles of the feet, the friction ridge skin on the medial and proximal phalanges has been little studied



REVIEW OF THE LITERATURE

What do we know?

'Down and Out' Ridge Flow



Smith, R. 2009, *Demystifying Palm Prints*, pp.39

"Although *empirical studies have not* been conducted on this subject, there are *several consistencies* that can be used very successfully used for orientation purposes"

'Wavy' Ridge Flow



Smith, R. 2005, *Demystifying Palm Prints*, pp.40



Ploetz-Radmann's Phalangeal Classification System

Marie Ploetz-Radmann's 1937

'Skin Ridge Patterns of the Lower Two Phalanges of the Human Hand'

- Devised classification system for the ridge configurations of the medial & proximal phalanges
- 12 General pattern types
- On the basis of direction, she found **29 sub-types**

Aus dem Kaiser-Wilhelm-Institut für Anthropologie, menschl. Erblehre und Eugenik, Berlin-Dahlem. Direktor Prof. Dr. EUGEN FISCHER.

Die Hautleistenmuster der unteren beiden Fingerglieder der menschlichen Hand.

Von Maria Ploetz-Radmann.

Mit 21 Textabbildungen und 13 Tabellen im Text und auf 3 Tabellenbeilagen.

Inhalt.

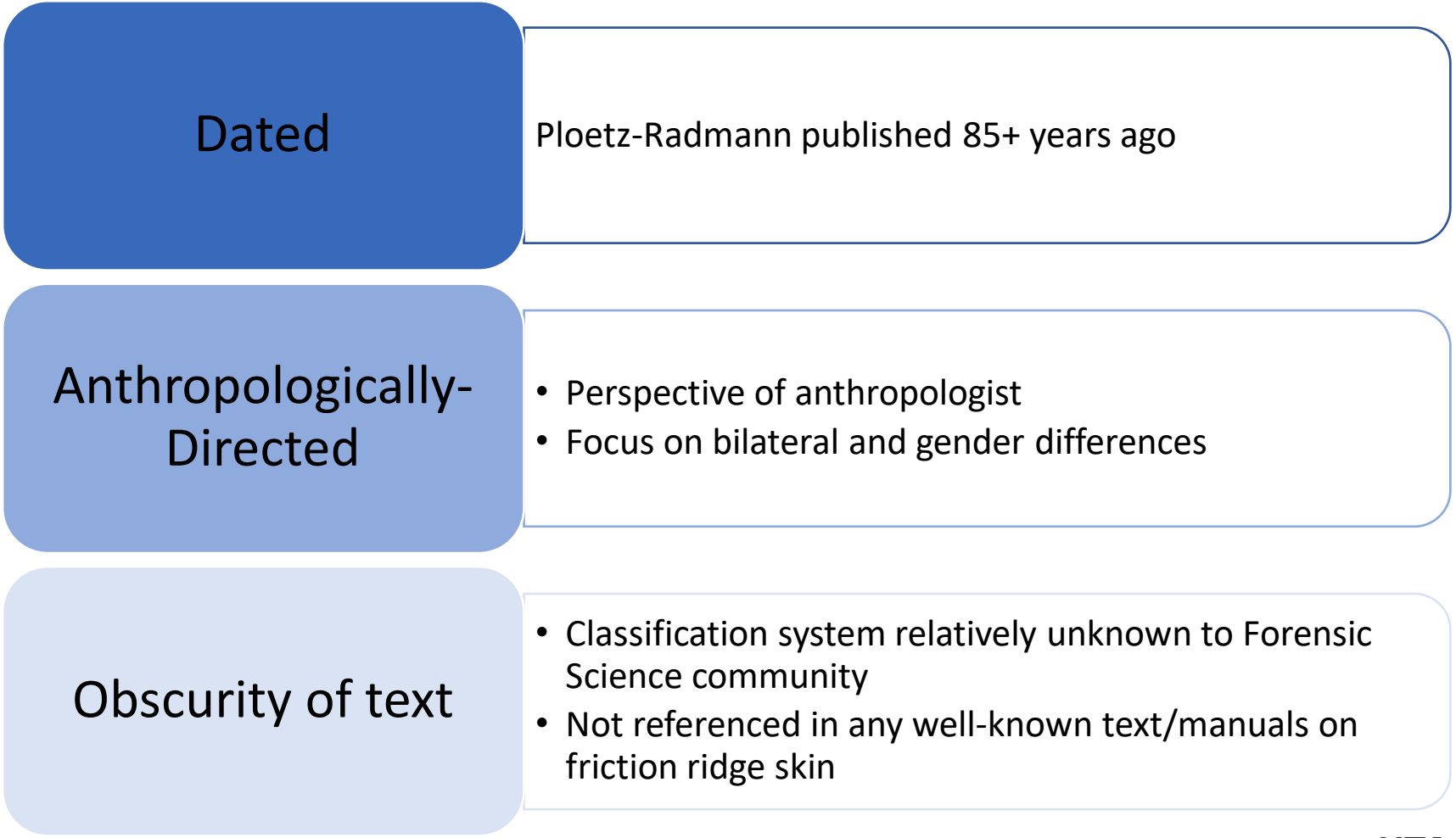
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1. Einleitung.

Die Hautleistenbilder der menschlichen Handteller und Fingerbeeren haben in immer steigendem Umfang an Interesse und Bedeutung gewonnen für menschliche Erblehre, für Rassenkunde und, praktisch, für gerichtlich-medizinische Zwecke. Das hierauf bezügliche Schrifttum ist sehr umfangreich. Es sei auf die grundlegenden Arbeiten von K. BONNEVIE, CUMMINS, KLAATSCH, SCHLAGINHAUFEN, WHIPPLE und H. H. WILDER verwiesen.



Considerations with Prior Research






AIMS AND RESEARCH QUESTIONS


Aims and Research Questions

Aim: **Validate** Ploetz Radmann's study to determine whether consistent universal trends exist in the ridge flow on the phalanges of the fingers

Can the friction ridges on the middle and proximal phalanges be classified into patterns?

1 

Are there trends in the **distribution and frequency of patterns** found on the phalanges?

2 

Are there trends in the **direction of ridges** on the phalanges of the fingers?

3 



MATERIALS AND METHODS

Methodology

Fingerprint
Collection



Pattern
classification



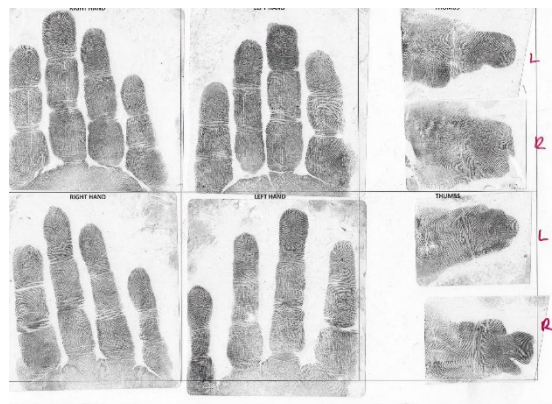
Using Ploetz-
Radmann's
classification system



Statistical Analysis



Data Collection



1. Black Fingerprint Powder + White Adhesive Lift + Transparent Sheet



2. Fingerprints Provided by the NSWPF

207 Participants = 5796 phalangeal prints

All fingerprints **deidentified**

Ethics Approval Number: ETH18-2521

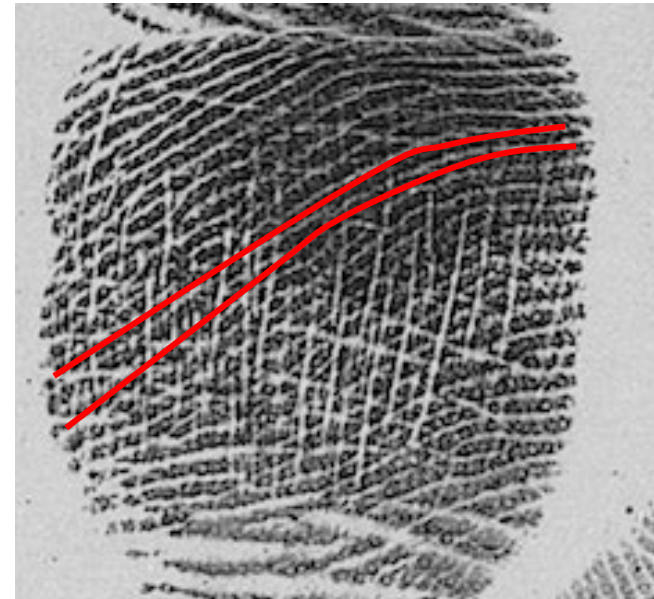


PLOETZ-RADMANN'S CLASSIFICATION SYSTEM

12 PATTERN TYPES

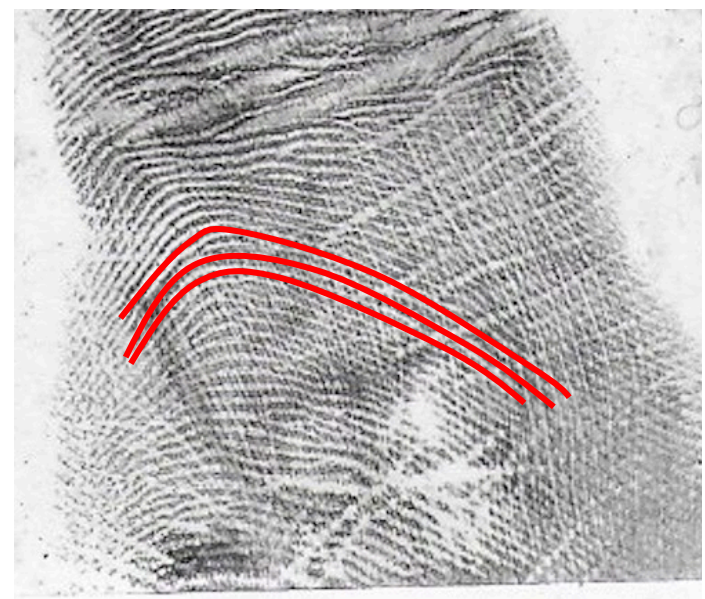
1. Stripe

A group of ***straight, parallel ridges*** that can be either diagonal or horizontal



2. Hook

Similar to *Stripe* except the ridges start or end with a ***small curve or 'hook'***



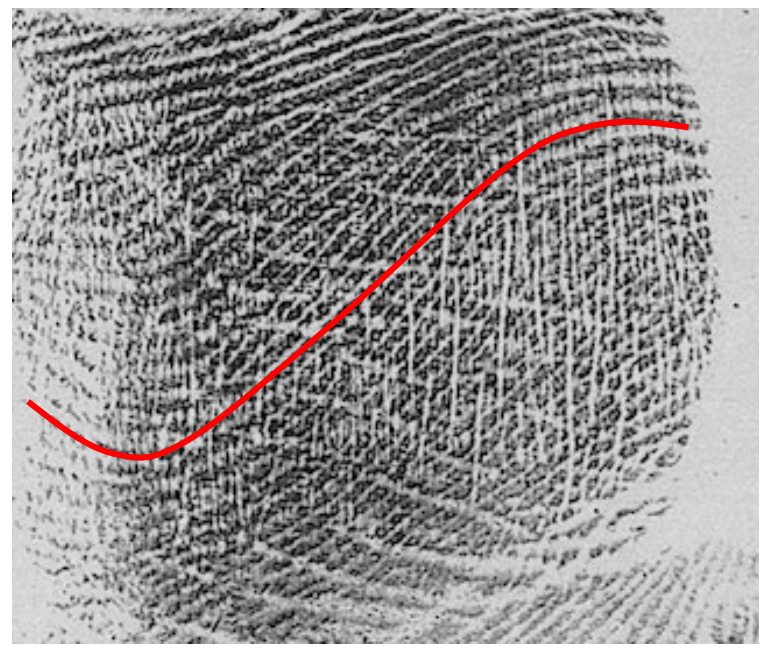
3. Bow

Ridges *form a curve/arch* horizontally across the phalange



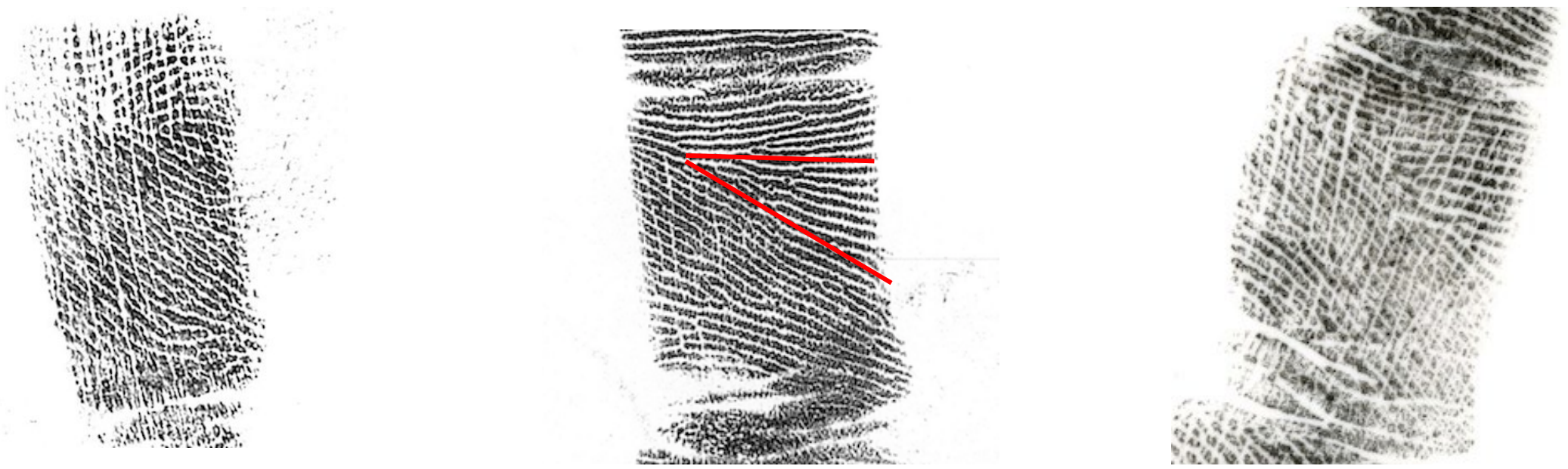
4. Wave

A wave, as it sounds, consists of **two arcs joined together**
Typically flows horizontally



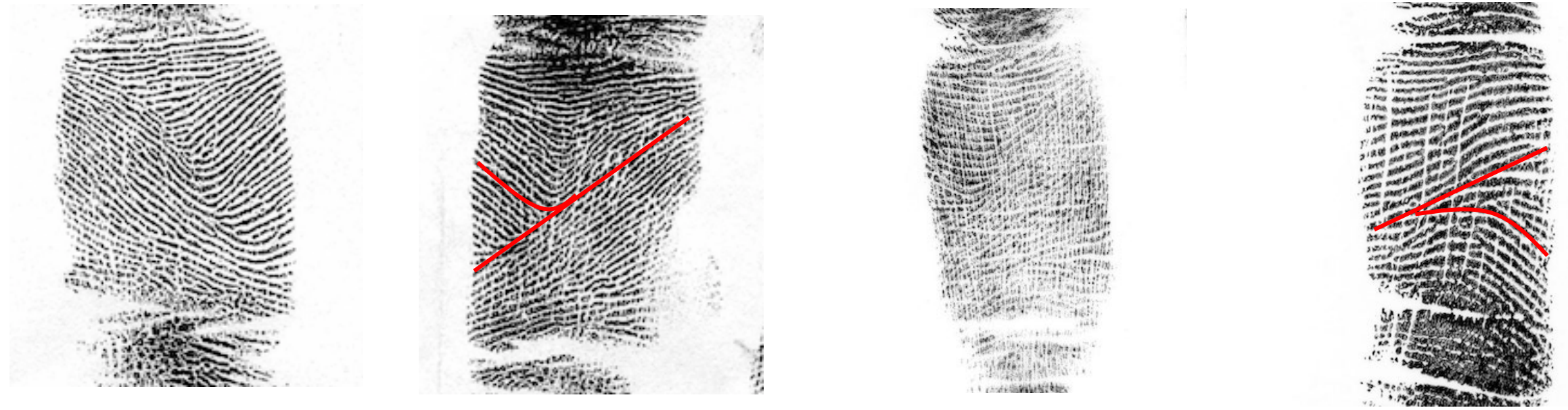
5. Angle

Two directions of *ridges meet at an angle*.
One set of ridges run parallel to finger creases
The other set of ridges run diagonally



6. Arc Angle

Similar to Angle except ridges running parallel to creases will ***form a curve or an 'arc'***



7. Double Angle

The double angle pattern, as it sounds, is the *combination of two angles*



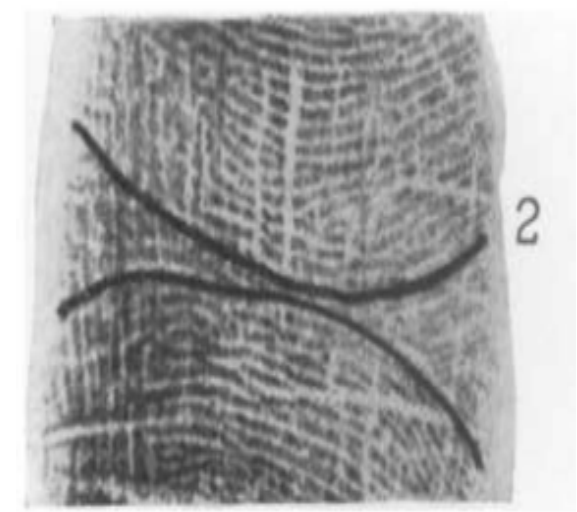
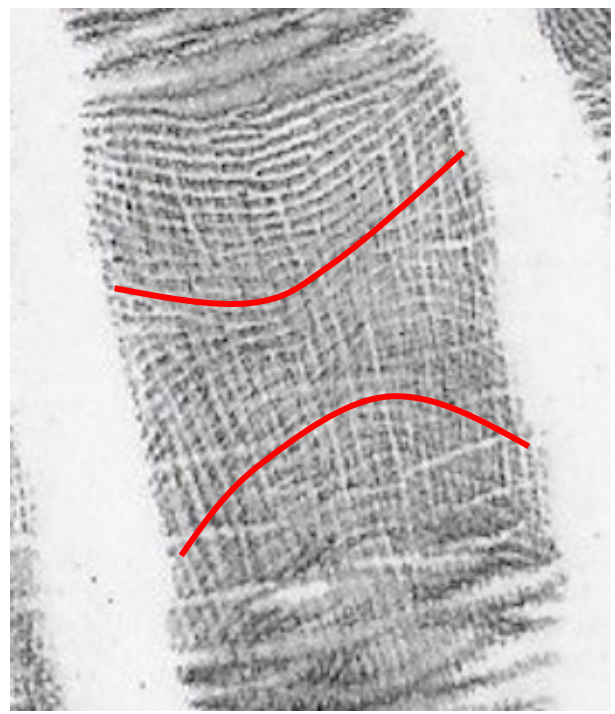
8. Double Arc Angle

The *combination of two arc angles*



9. Double Sheet

Two *arcs/curves meeting back to back*
Often in the approximate midline of the phalange



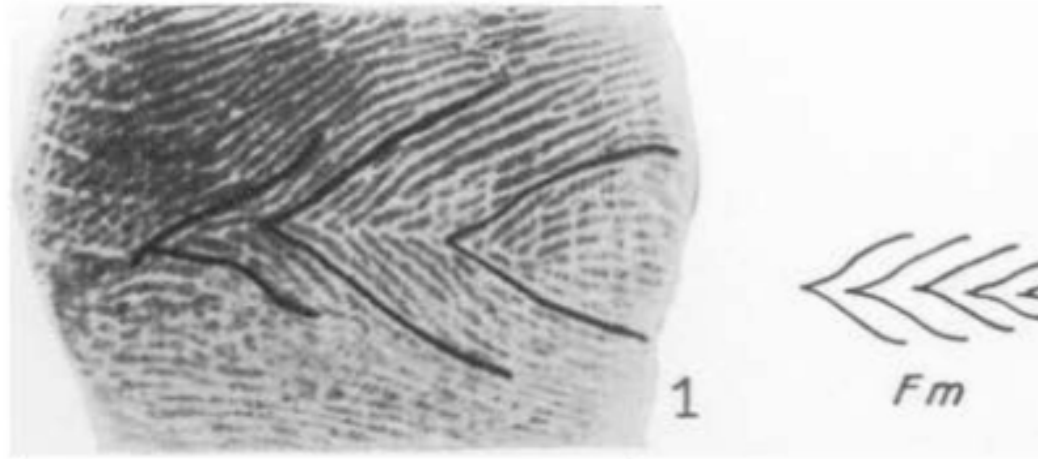
10. Inclusion

Typically contains a *spindle-shaped core*
Can be completely enclosed or opened to the left or right side



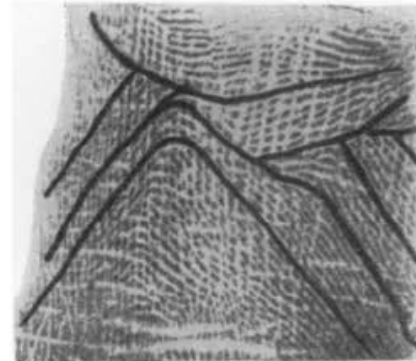
11. Feather

Arrangement of *acute to obtuse angles* forming horizontally across the phalange.

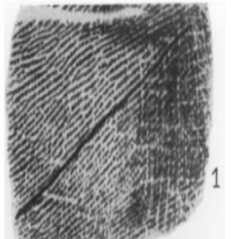


12. Rare

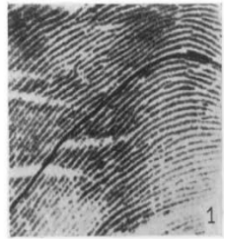
Any pattern that *could not be classified* into previous 11 patterns



Ploetz-Radmann's Phalangeal Classification System



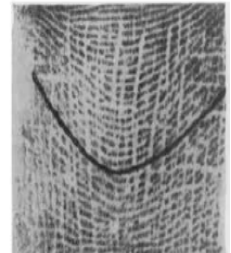
1
Stripe (S)



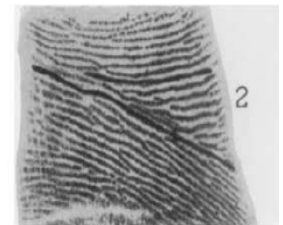
2
Hook (H)



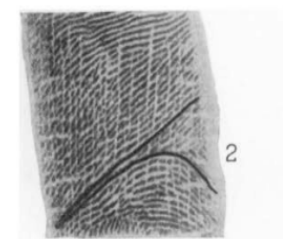
3
Wave (WI)



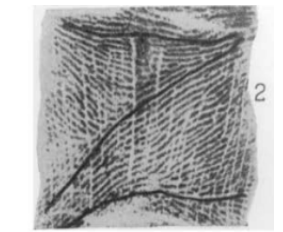
4
Bow/Arch (B)



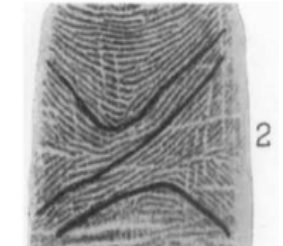
5
Angle (N)



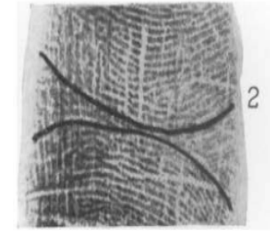
6
Arc Angle (AN)



7
Double Angle (DN)



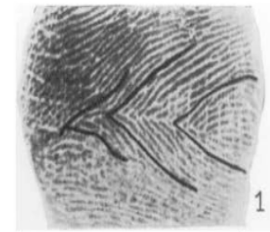
8
Double Arc Angle (DAN)



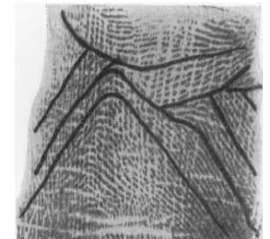
9
Double Sheet (C)



10
Inclusion (C)



11
Feather (C)



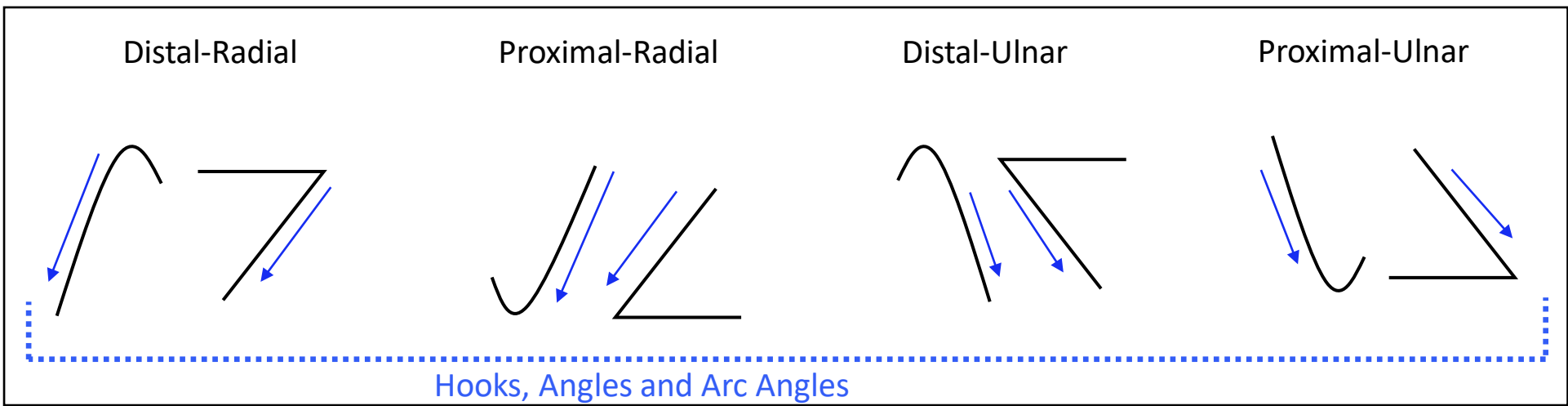
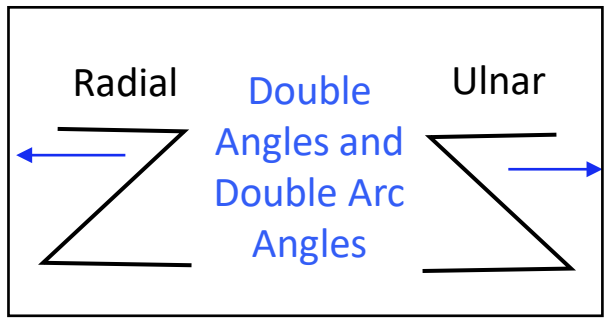
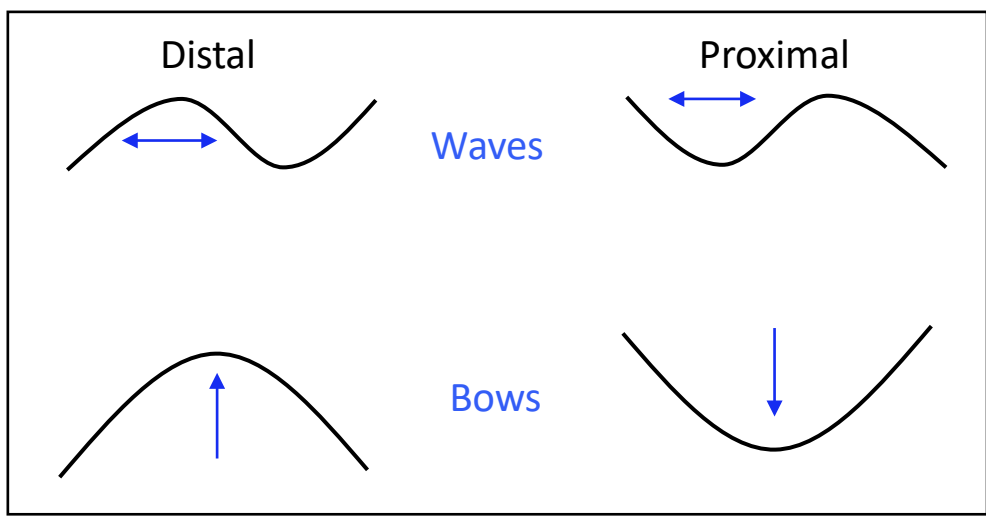
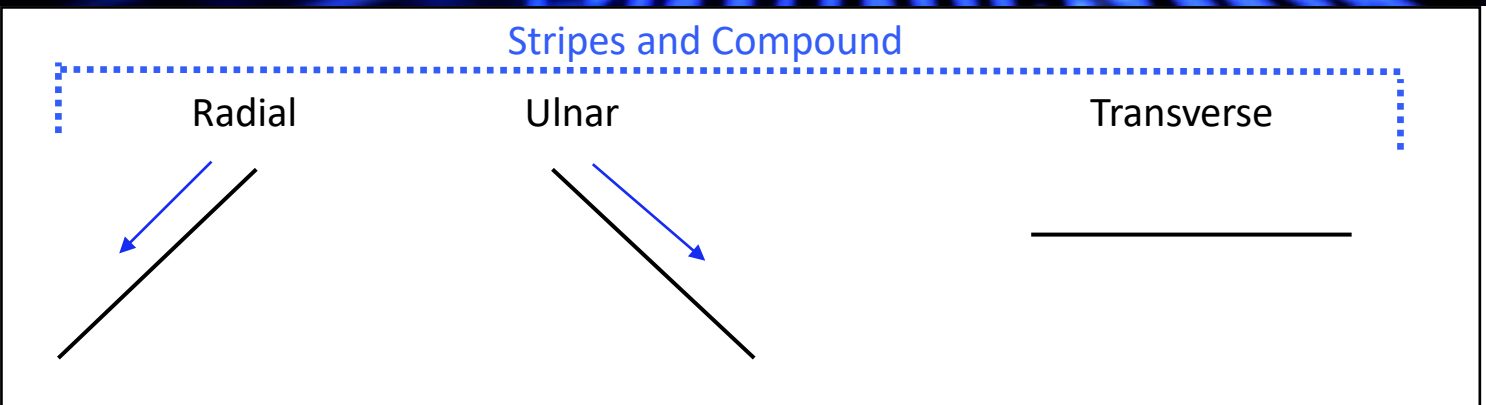
12
Rare (C)

9
**Compound/
Combination**

Images gathered from: Ploetz-Radmann, M 1937, 'Hautleistenmuster der unteren beiden Fingerglieder der menschlichen Hand', Zeitschrift für Morphologie und Anthropologie, vol. 26, pp. 281-310.



Ridge Direction



Right hand perspective



RESULTS



Population Frequencies of Patterns

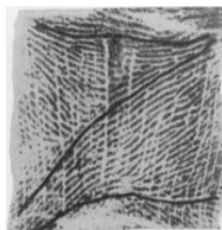
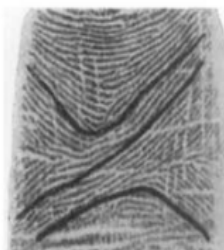
	Frequencies of Individual Patterns		
	<i>Pattern</i>	<i>Total</i>	<i>Frequency of patterns (%)</i>
Phalange Patterns:	Stripe (S)	492	16.15%
	Hook (H)	910	29.87%
	Wave (W)	74	2.43%
	Arch (B)	296	9.71%
	Angle (N)	551	18.08%
	Arc Angle (AN)	386	12.67%
	Double Angle (DN)	122	4.00%
	Double Arc Angle (DAN)	71	2.33%
	Combination (C)	145	4.76%
	<i>Total of classified phalanges:</i>	3047	
<i>Distal Phalange Patterns</i>	Loop (L)	1132	61.56%
	Arch (A)	76	4.13%
	Whorl (W)	631	34.31%
<i>Not Classified (lack of detail)</i>	NA	910	15.70%
	<i>Total:</i>	5796	

- Hook – most frequent pattern followed by Angle and Stripe
- Wave & Double Arc Angle rarely observed

Frequency of Patterns on Individual Fingers

Frequency/Distribution by Finger	Finger (1-10)										Total
	1	2	3	4	5	6	7	8	9	10	
Angle	5	102	24	19	154	7	75	19	26	120	551
Arc Angle	0	51	78	70	10	2	46	66	63	0	386
Bow/Arch	0	7	55	72	1	5	21	101	34	0	296
'Combination'	0	5	32	23	0	0	39	37	9	0	145
Double Angle	0	19	15	22	7	0	27	16	10	6	122
Double Arc Angle	0	2	20	19	0	0	3	8	19	0	71
Hook	40	110	130	114	50	38	127	87	157	57	910
NA - Unclassified	240	30	24	37	101	251	31	35	50	111	910
Stripe	13	92	24	20	100	7	41	35	29	131	492
Wave	0	2	15	20	0	0	6	11	20	0	74
Total	298	420	417	416	423	310	416	415	417	425	3957

- **Double Arc Angles** not on thumb or little finger
- **Double Angles** not on thumbs
- **Bows** characteristic of middle and ring fingers
- Thumbs and Little fingers = less variety of patterns
- NA = not enough ridge detail to classify



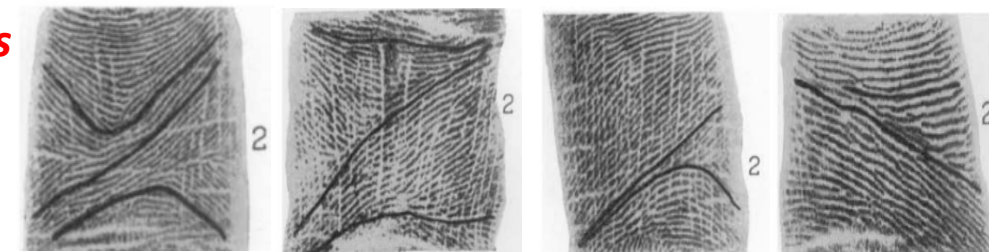
Frequency of patterns on medial phalanges

100% of all **Double Arc Angle** patterns were found on the **medial phalanges**

92.6% of all **Double Angle** patterns occur on the **medial phalanges**

91.45% of all **Arc Angle** patterns occur on the **medial phalanges**

85.66% of all **Angle** patterns occur on **medial phalanges**



Frequency/Distribution by Phalange

Finger (1-10)

M

M
Total

P

P
Total

Total

Pattern	2	3	4	5	7	8	9	10	M Total	P	1	2	3	4	5	6	7	8	9	10	P Total	Total
'Combination'	1	0	5	0	10	1	1	0	18	0	4	32	18	0	0	29	36	8	0	127	145	
Angle	75	14	14	153	58	13	26	119	472	5	27	10	5	1	7	17	6	0	1	79	551	
Arc Angle	43	74	70	10	39	56	61	0	353	0	8	4	0	0	2	7	10	2	0	33	386	
Bow/Arch	1	19	35	1	15	73	18	0	162	0	6	36	37	0	5	6	28	16	0	134	296	
Double Angle	18	10	22	7	26	14	10	6	113	0	1	5	0	0	0	1	2	0	0	9	122	
Double Arc Angle	2	20	19	0	3	8	19	0	71	0	0	0	0	0	0	0	0	0	0	0	71	
Hook	16	62	18	14	29	23	47	34	243	40	94	68	96	36	38	98	64	110	23	667	910	
NA - Unclassified	5	1	16	17	6	8	18	22	93	149	19	20	19	75	148	23	26	29	78	586	679	
Stripe	46	4	5	5	16	8	3	26	113	13	46	20	15	95	7	25	27	26	105	379	492	
Wave	0	3	3	0	5	3	4	0	18	0	2	12	17	0	0	1	8	16	0	56	74	
Total	207	207	207	207	207	207	207	207	1656	207	207	207	207	207	207	207	207	207	207	207	2070	3726

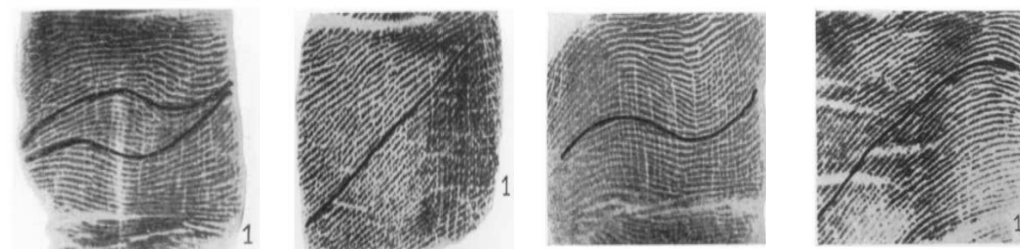
Frequency of patterns on proximal phalanges

87.6% of all **combination** patterns occur on the **proximal phalanges**

77.03% of all **stripe** patterns occurred on the **proximal phalanges**

75.68% of all **wave** patterns occur on the **proximal phalanges**

73.30% of all **hook** patterns occur on the **proximal phalanges**



Frequency/Distribution by Phalange	Finger (1-10)										M Total	P										P Total	Total
	M	2	3	4	5	7	8	9	10	1		2	3	4	5	6	7	8	9	10			
'Combination'	1	0	5	0	10	1	1	0	18	0	4	32	18	0	0	29	36	8	0	127	145		
Angle	75	14	14	153	58	13	26	119	472	5	27	10	5	1	7	17	6	0	1	79	551		
Arc Angle	43	74	70	10	39	56	61	0	353	0	8	4	0	0	2	7	10	2	0	33	386		
Bow/Arch	1	19	35	1	15	73	18	0	162	0	6	36	37	0	5	6	28	16	0	134	296		
Double Angle	18	10	22	7	26	14	10	6	113	0	1	5	0	0	0	1	2	0	0	9	122		
Double Arc Angle	2	20	19	0	3	8	19	0	71	0	0	0	0	0	0	0	0	0	0	0	71		
Hook	16	62	18	14	29	23	47	34	243	40	94	68	96	36	38	98	64	110	23	667	910		
NA - Unclassified	5	1	16	17	6	8	18	22	93	149	19	20	19	75	148	23	26	29	78	586	679		
Stripe	46	4	5	5	16	8	3	26	113	13	46	20	15	95	7	25	27	26	105	379	492		
Wave	0	3	3	0	5	3	4	0	18	0	2	12	17	0	0	1	8	16	0	56	74		
Total	207	207	207	207	207	207	207	207	1656	207	207	207	207	207	207	207	207	207	207	2070	3726		

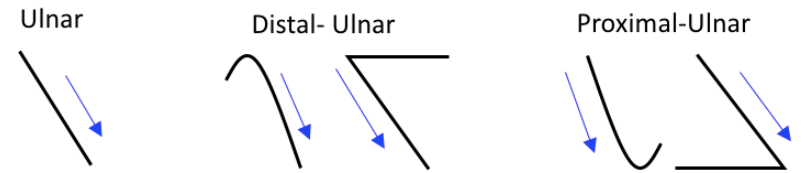
3 Ridge Direction Trends

Ridge Direction Directions	Fingers (1-10)										Totals
	1	2	3	4	5	6	7	8	9	10	
distal	0	5	39	48	1	2	12	24	23	0	154
distal-radial	56	240	136	33	1	54	202	23	3	0	748
distal-ulnar	0	2	11	104	218	0	2	84	209	183	813
proximal	0	3	33	44	0	0	15	89	32	0	216
proximal-radial	0	26	70	69	0	0	34	6	12	0	217
proximal-ulnar	0	0	15	5	0	0	11	58	26	2	117
transverse	0	2	11	15	0	1	15	22	5	0	71
radial	26	121	67	53	0	22	98	20	5	0	412
ulnar	0	0	17	12	124	0	2	60	58	148	421
Totals	82	399	399	383	344	79	391	386	373	333	3169

- Thumbs & Index fingers – radial trend
- Little Fingers + Left Ring – ulnar trend
- Right Ring finger + Middle fingers show greater variability with directions

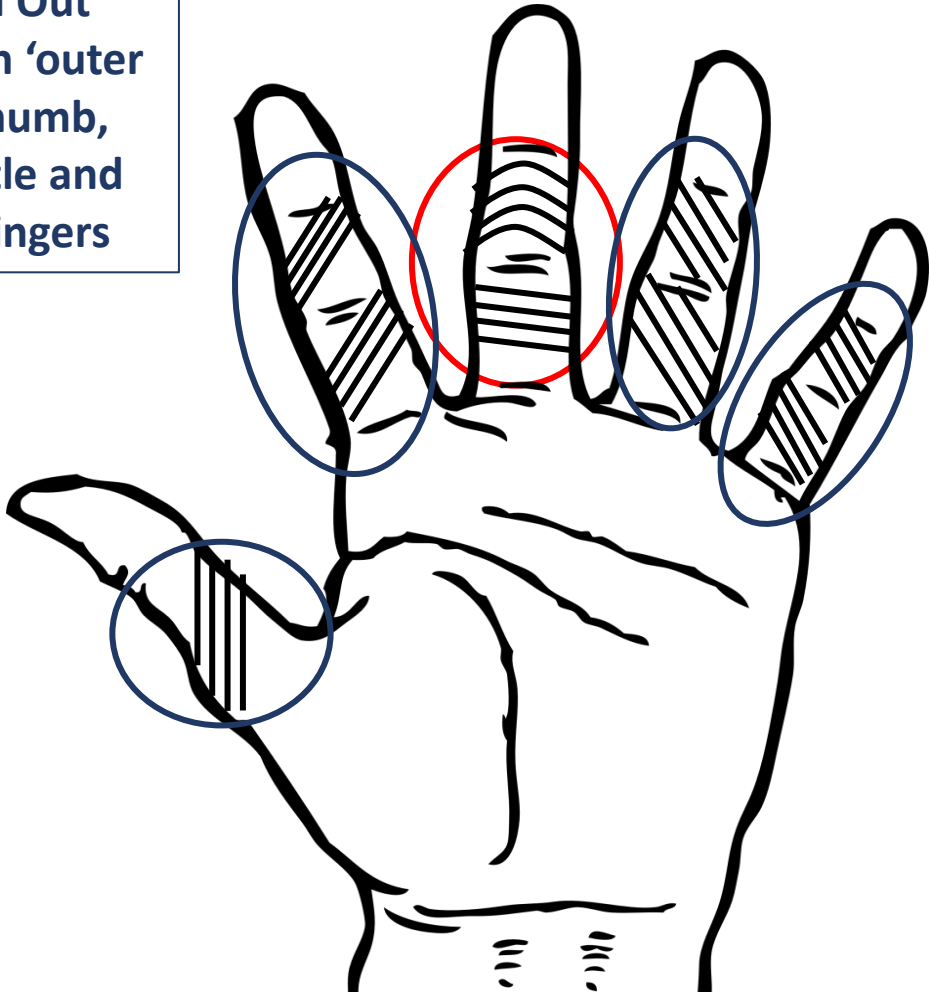


Right hand perspective

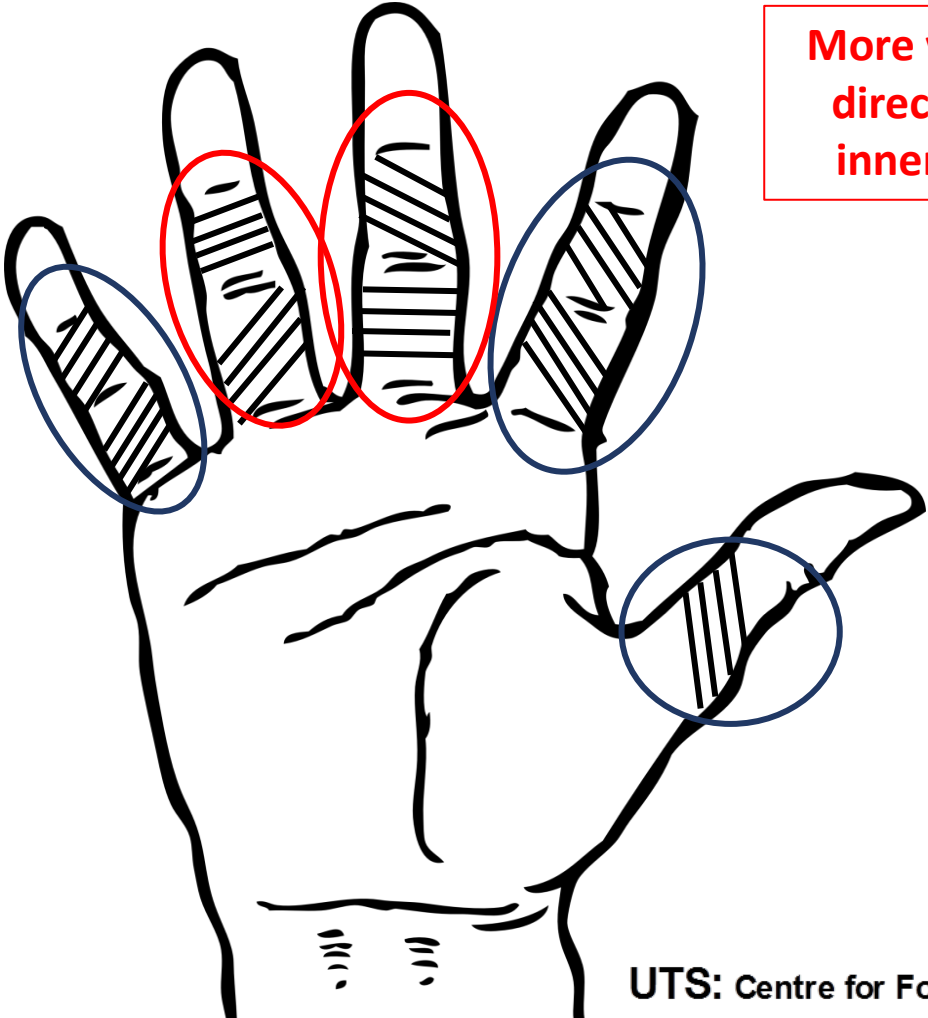


3 Ridge Direction Trends

'Down and Out' ridge flow on 'outer fingers': Thumb, Index & Little and Left Ring Fingers



More variety of directions on inner fingers





3 Ridge Direction Trends

Ridge Direction Directions	Fingers (1-10)										Totals
	1	2	3	4	5	6	7	8	9	10	
distal	0	5	39	48	1	2	12	24	23	0	154
distal-radial	56	240	136	33	1	54	202	23	3	0	748
distal-ulnar	0	2	11	104	218	0	2	84	209	183	813
proximal	0	3	33	44	0	0	15	89	32	0	216
proximal-radial	0	26	70	69	0	0	34	6	12	0	217
proximal-ulnar	0	0	15	5	0	0	11	58	26	2	117
transverse	0	2	11	15	0	1	15	22	5	0	71
radial	26	121	67	53	0	22	98	20	5	0	412
ulnar	0	0	17	12	124	0	2	60	58	148	421
Totals	82	399	399	383	344	79	391	386	373	333	3169

- **Thumbs**
 - Left – 96.2% radial-oriented
 - Right – 100% radial-oriented
- **Little Fingers**
 - Left – 100% ulnar-oriented
 - Right – 99.4% ulnar-oriented



3 Ridge Direction Trends

LEFT HAND

54% of directions are ulnar-oriented

30% of directions are radial-oriented

Left hand shows a slight trend towards an **ulnar direction**

Ridge Direction Directions	Fingers (1-10)		Totals
	LH	RH	
distal	61	93	154
distal-radial	282	466	748
distal-ulnar	478	335	813
proximal	136	80	216
proximal-radial	52	165	217
proximal-ulnar	97	20	117
transverse	43	28	71
radial	145	267	412
ulnar	268	153	421
Totals	1562	1607	3169

RIGHT HAND

56% of directions are radial-oriented

31% of directions are ulnar-oriented

Right hand shows a slight trend towards a **radial direction**



Statistical Tests of Significance

Moods Median Test

Population Medians

Were population medians equal for:

- Pattern types on different fingers
- Pattern types on different phalanges

Chi-Square Test

Association Between Two Variables

Is there an association between pattern type and:

- phalange
- hand
- finger



Population Medians – Mood's Median Test

Pattern-type vs. Finger

Test

Null hypothesis ~~— H_0 : The population medians are all equal —~~

Alternative hypothesis ~~— H_1 : The population medians are not all equal —~~

DF	Chi-Square	P-Value
9	132.03	0.000

Pattern-type vs. Phalange

Test

Null hypothesis ~~— H_0 : The population medians are all equal —~~

Alternative hypothesis ~~— H_1 : The population medians are not all equal —~~

DF	Chi-Square	P-Value
1	772.08	0.000

p < 0.05 = reject null hypothesis

Population medians are not all equal



Association Between Two Variables - Chi-Square Test

Pattern and Phalange

Chi-Square Test

	Chi-Square	DF	P-Value
Pearson	1149.441	8	0.000
Likelihood Ratio	1294.412	8	0.000

Pattern and Finger

Chi-Square Test

	Chi-Square	DF	P-Value
Pearson	1378.545	72	0.000
Likelihood Ratio	1466.812	72	0.000

$p < 0.05 =$
reject null hypothesis

~~Null hypothesis H_0 : The two variables are not associated~~

Alternative hypothesis H_1 : The two variables are associated

Pattern and Hand

Chi-Square Test

	Chi-Square	DF	P-Value
Pearson	17.137	8	0.029
Likelihood Ratio	17.180	8	0.028

***There is an association between pattern and:
phalange, finger and hand***



DISCUSSION & CONCLUSION



Operational Uses

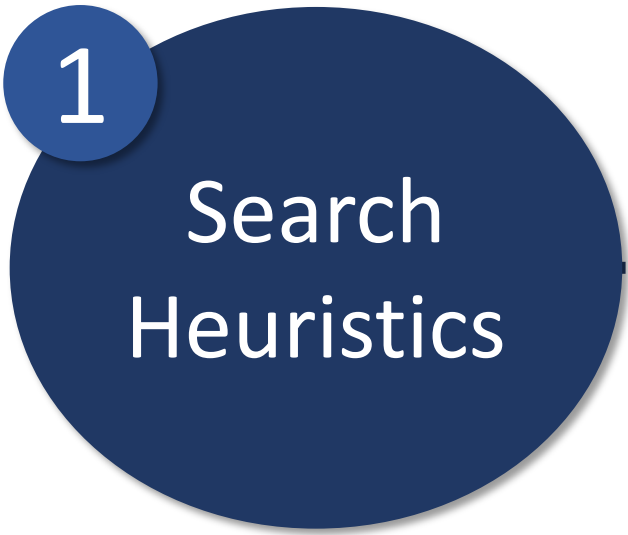
1

Search
Heuristics

2

Training
Fingerprint
Practitioners

Search Heuristics



Finger Nomination

Results can assist examiners to narrow down a search by nominating a finger(s), or hand (left or right) for their searches

Can be used in *conjunction* with distal phalanges

Training Fingerprint Practitioners

2 Training Fingerprint Practitioners

*'A lack of training and experience can affect an examiner's ability and confidence in determining proper **orientation** of partial latent prints'*
- Ron Smith (2005)

- Knowledge of typical patterns/phalangeal ridge flow can:
1. Help examiners **locate and orient** phalangeal impressions from a crime scene
 2. Aid in **determination of anatomical source** (i.e. knowing its from a phalange rather than palm, fingertip or foot)



Limitations & Future Direction

Population design

All fingerprints de-identified - can't be sure whether we have a representative population in terms of age, ancestry and gender

Different collection methods

2 fingerprint collection methods utilised. Handprints resulted in large number of unclassified phalanges of the thumb

Classification System

Classification system proposed by Ploetz-Radmann (and used in this study) could be refined to make it more user friendly in a forensic science context.



Conclusion

Ploetz-Radmann's article has shown that phalange ridge flow **can** be classified into distinct patterns

There are **observable trends** in both pattern frequency and distribution and ridge direction

Results of this study can aid in determining finger **nomination** and **orientation**



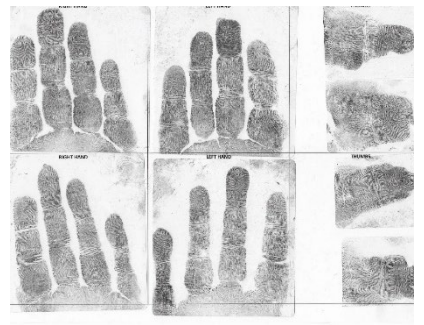
Acknowledgements



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Jennifer Raymond



Thank you to the donors who provided their fingerprints



**THANK YOU FOR YOUR
TIME AND ATTENTION**

QUESTIONS?

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