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A NOVEL CLASSIFICATION FOR FINGER FRICTION RIDGES (DERMATOGLYPHIC PATTERNS)

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ABSTRACT
Since 200 BC till date, researchers and investigators have studied the fingerprint patterns for extensive purpose using different classifications that have proven useful in personal identification, hereditary, genetic predisposition, diseases and susceptibility, psychosocial status, behaviour, and criminality, as well as Intelligence Quotient (IQ). This study examined newer classification techniques for dermatoglyphic patterns, in the view to broaden its applicability in scientific research. The study utilised the general fingerprint types; Arch (A), Loop (L) and Whorl (W) without consideration of their variations. The digits (D) were number D1 to D5 or 1D to 5D depending on the researcher's choice, which corresponded to the 1st finger (thumb) to the 5th finger (little). $A^{1\text{-}5}$, $L^{1\text{-}5}$, and $W^{1\text{-}5}$ were assigned for the thumb to the little finger of the right (R) and left (L) digits respectively and four (4) classifications were introduced. The distribution on corresponding fingers for both hands were presented as follows; Arch (RA, LA [A1]; RA, LL [A2], RA, LW [A3]), Loop (RL, LL [L1], RL, LA [L2], RL, LW [L3], Whorl (RW, LW [W1], RW, LA [W2], RW, LL [W3]). Identical (symmetrical) patterns on corresponding fingers were regarded as superscript of same alphabetic representation (A^A, L^L, and W^W) while unidentical (asymmetrical) patterns were regarded as subscript of the other alphabetic representation ($A_{L,W}$, $L_{A,W}$, $W_{A,L}$), which are combinations of either of the three (3) patterns (AL, AW; LA, LW; WA, WL) with reference to the right finger (95% right hand bias) as the normal script. In this regard, study introduced finger ridge count for the paired digits; FRC_1D-5D, finger ridge count for the right hand; RFRC, and the left hand; LFRC. In consideration of the inheritance pattern, this study disregarded the right-hand bias, thus reclassifying the patterns into six (6); A, L, W, AL, AW, and LW. This current individual classification is simple, direct and does not require any mathematical manipulations. This new classification can find use in clinical and forensic anatomy, anthropology and genetics.

KEYWORDS: *Combination patterns, finger friction ridges, inheritance, novel classification.*

INTRODUCTION
Since BC 200s till date, researchers and investigators have studied the fingerprint patterns for extensive reasons which includes, but not limited to personal identification (Alexander, 1973; Raloti *et al*., 2013; Dorjee *et al*., 2014), hereditary (Bansal and Bhattacharya, 1972; Juberg, 1980; Karmakar *et al*., 2006), genetic predisposition, disease susceptibility (Joshi *et al*., 1992; Oladipo *et al*., 2009; Agarwal *et al*., 2015), psychosocial status, behaviour and criminality (Malhotra *et al*., 1992; Gustavson *et al*., 1994), as well as intelligence quotient (Offei *et al*., 2015). These variabilities have been studied using different classification ranging from Sir Francis Galton (1888) to the 20th-century classifications (Coulier, 1863; Quinche *et al*., 1863; Bowman, 2004).

Harold Cummins who is regarded as the father of Dermatoglyphics established the theory of Dermatoglyphics in 1926 after he reviewed his works and other existing research by other scientists (Fogle, 1990). Marcello Malpighi (1628 - 1694) was the first to scientifically study fingerprints, while in 1685, Gouard Bidloo wrote the first book with detailed drawings of fingerprints. Sir Francis Galton in 1893 examined the relationship between skin grains and genes among different families and people for clearer scientific classification of the skin grains (Holt, 1962).

Finger and toe prints have three (3) general ridge patterns for classification; Loop ''60-65% of the population has loops'', Whorl ''30-35%'' and Arch ''5%'' (Henry, 1900; Schauman and Meier, 1989; Robert and Coope, 1979). However, for human identification and various investigations, different classification patterns have been developed (Cummins and Mildo, 1926; FBI, 1988; Senior, 2001). There are over fifty (50) finger pattern types of classification systems developed by researchers,

which are used in different countries and organization (Hutchins, 2011). A major setback for some of these classifications are the complexities, and disregard for possible genetic undertone; as they were developed for individualization. Therefore, this study was carried out to examine a new classification of finger friction ridges for a broader scientific application.

METHODOLOGY

The study observed the three general classification types; arch, loop, and whorl of the right and left hand and tabulated in Excel sheet. The samples used in this study for demonstration of the application of these new classification patterns were digitally obtained using an HP Scanjet 300 Flatbed Photo Scanner connected directly to a laptop. Informed consent was obtained from only ten (10) volunteer subjects.

The introduced classification techniques in this study were as follows;

1. Individual classification of the fingerprint types
2. Classification based on side comparison of corresponding digits
3. Reclassification for ridge counts
4. Classification based on genetic composition

I. Individual classification of the fingerprint types

Table 1: Distribution of fingerprint type considering the individual finger expression.

Print Pattern	Right [R] or Left [L]				
	D1	**D2**	**D3**	**D4**	**D5**
Arch [A]	A^1	A^2	A^3	A^4	A^5
Loop [L]	L^1	L^2	L^3	L^4	L^5
Whorl [W]	W^1	W^2	W^3	W^4	W^5

Note: *D=digit (D1=thumb, D2=index, D3=Middle, D4=Ring, D5=little).*

Table 1a: The distribution of fingerprint pattern of randomly selected 10 volunteer subjects*

S/N	Right					right-hand distribution	Left					Left-hand distribution
	D1	**D2**	**D3**	**D4**	**D5**		**D1**	**D2**	**D3**	**D4**	**D5**	
1	A	L	L	L	L	A^1L^{2-5}	L	L	L	L	L	L^{1-5}
2	L	W	L	W	L	$L^{1,3,5}W^{2,4}$	L	W	L	W	L	$L^{1.3,5}W^{2,4}$
3	W	L	L	L	L	W^1L^{2-5}	L	L	L	L	L	L^{1-5}
4	A	A	A	A	A	A^{1-5}	A	A	A	A	L	$A^{1-4}L^5$
5	A	L	A	A	L	$A^{1,3,4}L^{2,5}$	A	L	L	L	L	A^1L^{2-5}
6	L	W	W	W	W	L^1W^{2-5}	L	W	W	W	W	L^1W^{2-5}
7	L	A	L	L	L	$L^{1,3-5}A^2$	L	L	L	L	L	L^{1-5}
8	A	L	L	L	A	$A^{2,5}L^{2-4}$	A	L	A	L	A	$A^{1,3,5}L^{2,5}$
9	L	A	W	L	A	$L^{1,4}A^{2,5}W^3$	L	L	W	L	A	$L^{1,2,4}W^3A^5$
10	L	L	W	W	L	$L^{1,2,5}W^{2,3}$	L	L	W	W	L	$L^{1,2,5}W^{3,4}$

Note: *D=digit (D1=thumb, D2=index, D3=Middle, D4=Ring, D5=little) Superscript 1-5 correspond to the first to fifth digits respectively*

***These samples were taken for the purpose of describing "this" technique and not for inferential purposes.*

II. Classifying finger (based on side comparison of corresponding digits)

Table 2: Fingerprint types and indications.

Arch (A)	indication	Loop (L)	indication	Whorl (W)	indication
RA, LA	**A1**	RL, LL	**L1**	RW, LW	**W1**
RA, LL	**A2**	RL, LA	**L2**	RW, LA	**W2**
RA, LW	**A3**	RL, LW	**L3**	RW, LL	**W3**

Note: *The first letter indicates the side (right [R] or left [L]) while the next is the type of fingerprint*

RA, LA = Both hands "arch" *(Identical arch) = A^A*
RA, LL = Right hand "arch" and left hand "loop" *(Mixed arch) = A_L*
RA, LW = Right hand "arch" and left hand "whorl" *(Mixed arch) = A_W*

RL, LL = Both hands "loop" *(Identical loop) = L^L*
RL, LA = Right hand "loop" and left "arch" *(Mixed loop) = L_A*
RL, LW = Right hand "loop" and left "whorl" *(Mixed loop) = L_W*

RW, LW = Both hands "whorl" *(Identical whorl) = W^W*
RW, LL = Right hand "whorl" and left "arch" *(Mixed whorl) = W_A*
RW, LA = Right hand "whorl" and left "loop" *(Mixed whorl) = W_L*

The exhibited pattern of distribution (Similarity and differences)
Pattern symmetry and asymmetry when corresponding fingers (right [RD] and left [LD]) are compared.

Table 2b: Finger pattern combinations and indications.

Digit	Pattern								
	Arch			Loop			Whorl		
Right digit (RD)	A	A	A	L	L	L	W	W	W
Left digit (LD)	A	L	W	L	A	W	W	A	L
Indication (Symbol)	**A1**	**A2**	**A3**	**L1**	**L2**	**L3**	**W1**	**W2**	**W3**

Note: A1, L1 and W1 *=Symmetrical (both fingers have the same pattern)*
A2, A3, L2, L3, W2 and W3 *= Asymmetrical (fingers have different patterns)*

(1) Symmetry can be divided into two parts;
a. Complete symmetry
b. Point symmetry

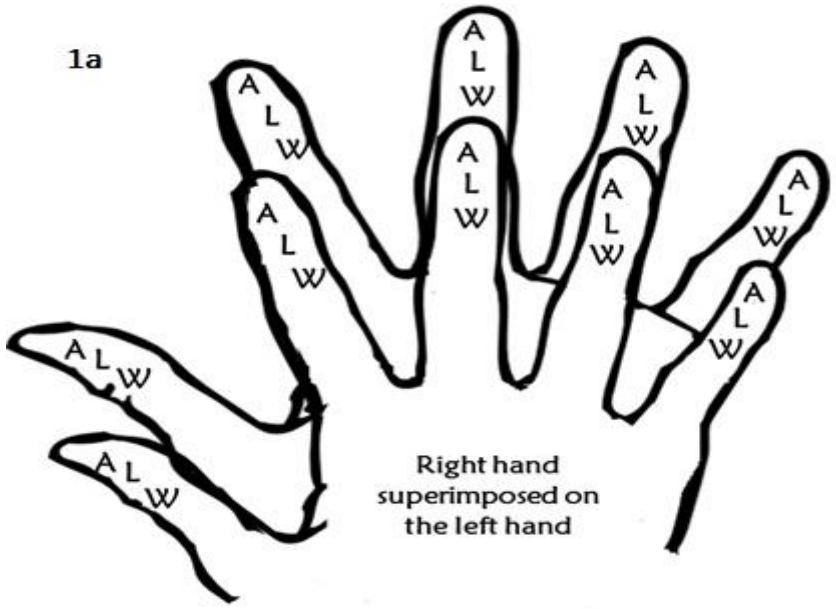

Figure 1: Complete symmetry indicating D1-5 have the same combinations (L and R) of patterns (either all A, L or W).

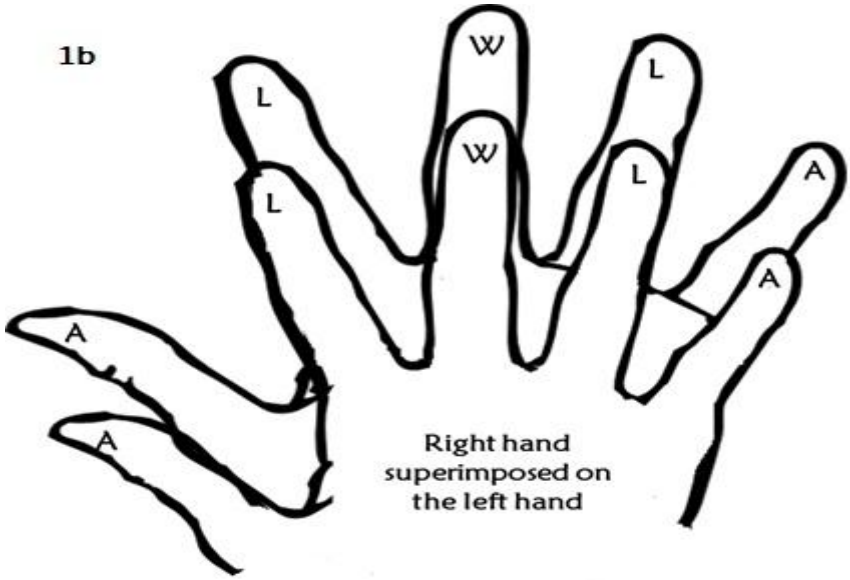

Figure 2: Point symmetry indicating the same pattern in all corresponding D1-5 (L and R) but not the entire finger.

(2) Asymmetry can be divided into two parts;
a. Complete Asymmetry
b. Point symmetry

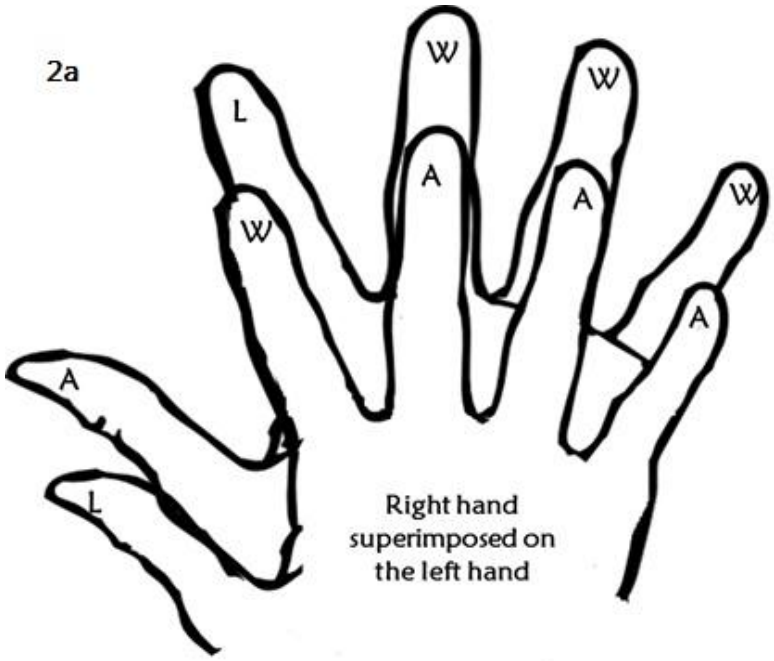

Figure 3: Complete asymmetry indicating D1-5 have different combinations (L and R) of patterns.

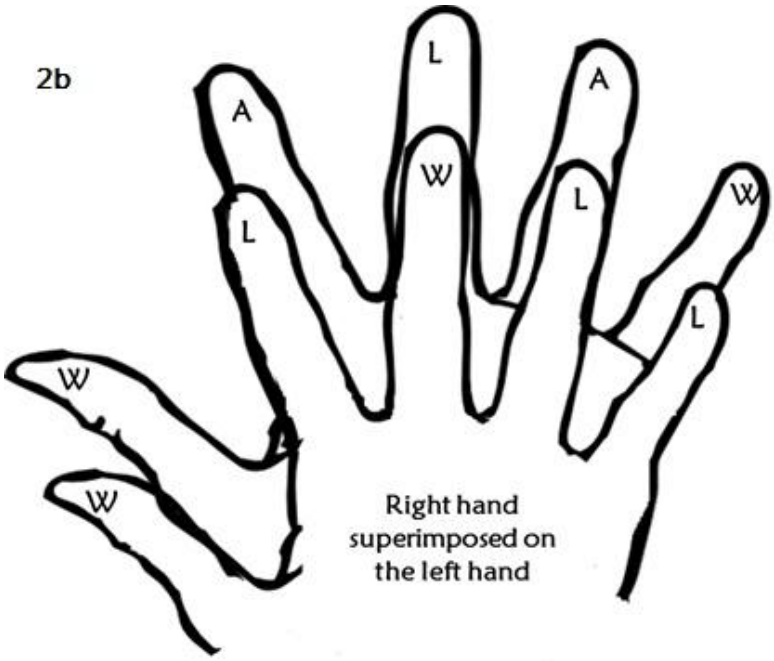

Figure 4: Point asymmetry indicating one or more, but not all of D1-5 have the same combinations (L and R) of patterns, while others are different.

III. Reclassification for ridge counts

The study re-classified finger ridge count (FRC) considering the left and right as a unit, both hands as individual units and the total fingers (originally used)

$FRC = [FRC_{RD1\ldots.5}, FRC_{LD1\ldots.5}]$ (existing)

$FRC_{digit} = [FRC_{RD1\ldots.5} + FRC_{LD1\ldots.5}]$

…… (*Equation 1*)

$FRC_{right\ hand}\ (RFRC) = FRC_{RD1} + FRC_{RD2} \ldots\ldots\ldots\ldots + FRC_{RD5}$

…… (*Equation I1*)

$FRC_{left\ hand}\ (LFRC) = FRC_{LD1} + FRC_{LD2} \ldots\ldots\ldots\ldots + FRC_{LD5}$

…… (*Equation I1I*)

$TFRC = FRC_{right\ hand} + FRC_{left\ hand}$ (existing)

IV. Classifying finger (based on genetic composition)

Table 3: Finger pattern combinations and indications.

Finger	Identical combinations	Distribution (Indication)	different combinations	Distribution (Indication)	different combinations	Distribution (Indication)
Right	**A1**	A	**A2**	A	**A3**	A
Left		A		L		W
Right	**L1**	L	**L2**	L	**L3**	L
Left		L		A		W
Right	**W1**	W	**W2**	W	**W3**	W
Left		W		A		L

Note: A1, L1 and W1 *=Symmetrical (both fingers have the same pattern)*
A2, A3, L2, L3, W2 and W3 *= Asymmetrical (fingers have different patterns)*

RESULTS

For the ten fingers, an individual can present with any combination of the print. On the hand (R or L), the pattern observed is recorded with a superscript corresponding to the digit (Table 1). For example, Table 1a represents a group of individuals whose fingerprints were digitally observed with the presented classification.

From the classification with consideration of the corresponding digits, as shown in Table 2, there are 9 possible display of the fingerprint patterns; 3 identical and 2 mixed patterns for each of the fingerprint type. Additionally, the display of complete pattern; all similar was regarded as symmetry, while observed differences were regarded as asymmetry (Table 2b). Symmetric (Fig 1 and 2) and asymmetric (Fig 3 and 4) patterns were further divided into two (2); complete and point respectively. Identical (symmetrical) patterns on corresponding fingers were regarded as superscript of same alphabetic representation (A^A, L^L, and W^W) while unidentical (asymmetrical) patterns were regarded as subscript of the other alphabetic representation ($A_{L,W}$, $L_{A,W}$, $W_{A,L}$), which are combinations of either of the three (3) patterns (AL, AW; LA, LW; WA, WL) with reference to the right finger (95% right hand bias) as the normal script.

In addition to the original ridge counts (that is; FRC for individual fingers and TFRC for the total fingers), this study introduced finger ridge count for the paired digits; FRC_1D-5D (*eq. 1*), finger ridge count for the right hand; RFRC (*eq. 1I*) and the left hand; LFRC (*eq. 1II*).

Based on genetic composition, it is observed that A1, L1, W1 are identical combinations of arch, loop or whorl on both fingers and can simply be represented as A, L, and W respectively. The description A2 and L2 represent patterns that are a combination of arch and loop on either finger and therefore can be regarded as “AL”, A3 and W2 represents patterns that are combinations of arch and whorl on either fingers and therefore can be regarded as “AW” while L3 and W3 represent patterns that are combinations of loop and whorl on either finger and therefore can be regarded as "LW". Based on the above, six possible combinations have been identified; A, L, W, AL, AW, and LW (Table 3).

DISCUSSION

This current individual classification is simple, direct and does not require any mathematical manipulations. It can be effectively applied to studying the similarities and differences in the biosocial characteristic of individuals. For the purpose of personal identification, it can be combined with other classification methods (Senior, 2001; Hutchins, 2011); in other to strengthen the outcomes. Additionally, there was the need to reclassify the original ridge count; FRC for individual fingers, and TFRC for both hands (Holt, 1968; Spence *et al*., 1973) because of the introduction of the paired classification. This will give room for alternatives and additional parameters useful for comparative evaluation of trends in the quantitative analysis of dermatoglyphic patterns. It would not be strange that there could be trends dermatoglyphic patterns and arrangements in individuals who share certain predisposition and disease susceptibility (Joshi *et al*., 1992; Oladipo *et al*., 2009; Agarwal *et al*., 2015), and this could be useful in determining expressivity and also find use in evaluating psychosocial status for both clinical and forensic purposes (Malhotra *et al*., 1992; Gustavson *et al*., 1994).

Dermatoglyphic has often been considered individualistic (Alexander, 1973; Raloti *et al*., 2013; Dorjee *et al*., 2014), and this has limited the application in determining its heritability. Most of the challenges encountered could be associated with the unidirectional thinking and investigation of the inheritance pattern of dermatoglyphics. This current thinking about the inheritance of finger ridges is based on the concept of restricted finger expression with non-side-specificity (right or left finger). This can further be explained as the situation in which parents (father and mother) are arch, loop or whorl on the same thumb of a particular side (assume the right finger); therefore it may be assumed that the offspring would express the inherited friction ridge on the same side. However, such inheritance for finger dermatoglyphic have not been reported to be side specific, therefore this study came up with the expressions; A, L, W, AL, AW, and LW, where A, L, and W represent symmetry (AA, LL, and WW respectively) and AL, AW, and LW are combination of the patterns without consideration of sides. This suggests that the side of the exact pattern is inconsequential but

what is considered is the combination of the patterns on the finger of interest.

This assumption is drawn from the expression of birthmarks when inherited by an offspring, such that when an offspring inherits a birthmark, it is non-specific to the region of the body located on the parent(s); which means that there is no region-specific genetic regulation that codes the exact location of the birthmark of the parents unto the offspring; thus it could express itself on any part of the offspring, but in similar characteristics as the parent. Thus, in studying the inheritance pattern of dermatoglyphics, it is suggested that both fingers be considered as a single unit which can express the inherited traits in a non-side-specific but fingers specific fashion.

CONCLUSION

This current classification can find use in clinical and forensic anatomy, anthropology and genetics. The study also encourages further scientific inquiries into how these new classification patterns could be modified for a more desirable scientific application.

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