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Differentiation of Identical Twins by Facial Morphological Comparison: An Exploratory Study and Implications for Forensic Science

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Abstract— This study aimed to explore the ability of facial morphological comparison to differentiate monozygotic twins and identify which facial components were most useful for this purpose. The research was carried out on facial images of 09 pairs of twins (18 people), where 12 facial components were identified using the morphological comparison method. Each of these components were compared in each pair of twins, so we identified those components that were similar or different. Subsequently, the frequencies of similarities and differences for each facial component were calculated. Next, an analysis of variance was applied between the components identified as different and similar. The results suggested that such a method was useful for differentiating identical twins and that some facial components were more useful than others. In this sample, facial markings and the ear were the most discriminating components. These results would set the tone for future research in this area.

Keywords- Facial identification, identical twins, facial morphological comparison.

I. Introduction

The exponential growth of criminal acts during the last decades has led to an increase in the installation of closed-circuit television (CCTV) systems at strategic points in cities. In many cases, the only evidence available for these crimes is digital images captured by CCTV systems. In this context, the field of facial identification emerges, a forensic discipline that aims to identify (or exclude) unknown persons through the comparative analysis of facial features visible in digital images.

A variety of facial identification methods are currently available: automated facial recognition [1,2], image overlay [3, 4], photoanthropometry [5, 6, 7], and morphological comparison [8, 9, 10, 11, 12]. In either case, facial identification using images is limited by factors beyond the analyst's control: image quality, camera angle and proximity, or subject orientation. Although these factors have been studied [13], there are other problematic factors that have been little explored and need to be addressed, such as the differentiation of identical twins. Monozygotic twins or identical twins as shown in Fig. 1 are formed from a single fertilized egg which divides into two separate embryos during the early stages of fetal development, which share the same genetic information, detailing that in many cases the legal system requires this distinction to be made reliably.

Figure 1: Monozygotic twins

In the field of automated facial recognition, twin differentiation is considered a challenge for face recognition algorithms [14]. Research on this issue has identified the inefficiency of biometric systems in differentiating facial components from identical twins [15, 16, 17]. However, Klare et al. [18] suggest that facial marks (scars, moles) may contribute to overcoming this limitation.

On the other hand, a study of 2D-3D image superimposition [3] maintains that there are no significant differences between the distances of anatomical points on the faces of twins, complicating their individualization by this method. However, this study warned that the morphological

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evaluation of the ears made it possible to distinguish calves effectively.

In the same line of study, Biswas et al. [14] conducted an experimental study that explored the ability of untrained people to differentiate identical twins through the non-systematic observation of facial features, concluding that moles, scars, and freckles (facial marks) were the most useful features.

This previous research demonstrates the limitations of facial recognition algorithms and morphometric methods to differentiate identical twins, suggesting that comparative analysis of facial morphological features is a viable way to overcome this problem. In fact, the Scientific Working Group on Facial Identification (FISWG) suggests that morphological analysis is the most reliable method for facial identification in the forensic field [10, 11].

In that sense, this study aims to explore the ability of facial morphological comparison to differentiate identical twins and identify which facial features were most useful for this purpose.

It is worth mentioning that, due to the exploratory nature of this research, the results are not intended to be generalized. However, this study would help set the tone for future research.

In addition, it will allow us to know the capacity of the morphological method proposed by the FISWG to differentiate identical twins. To the best of the authors' knowledge, no study of twin differentiation has been carried out using this methodology.

1. MATERIALS AND METHODS

The study sample consisted of 18 participants (nine pairs of identical twins) aged between 14 and 58 years (mean: 28.7 years), of which 07 were women and 02 were men. All participants were Peruvian nationals.

Images of the facial region were documented with a digital camera. Faces were documented in different views (frontal and profile), facial expressions (neutral and smiling) and types of environments as shown in Fig. 2 showing some of the study participants.

This study employed the method of facial morphological comparison [10, 11] to identify those facial features that were similar or different between identical twins. Morphological analysis as a method of comparison consisted of the visual evaluation of the shape, appearance, presence and/or location of facial features.

According to the methodological proposal of the FISWG, facial features were divided into components (anatomical structures, e.g., the nose), characteristics (component-specific elements, e.g., the nasal bridge), and descriptors (specific features, e.g., the shape of the nasal bridge) (Table 1).

Facial features were systematically compared at the level of descriptors in each pair of twins in order to identify those similar or different facial features between the twins. Subsequently, the frequencies of similar and different features were calculated for each facial component evaluated. Finally, the total number of similar features were compared among the facial components using a median comparison analysis of variance (Kruskal-Wallis H). The same procedure was performed for traits identified as different.

Table 1 : Facial features according to FISWG's methodological proposal.

Components	**Characteristics**
HEAD/FACE CONTOUR	Cranial vault shape; Face Shape
HAIR	Hair (general); forehead and lateral hairline; Cranial baldness pattern
FOREHEAD	Forehead shape; *brow-ridge*
EYES	Intercanthal distance; interpupillary distance; opening of the fissure (contour); upper and lower eyelid (including eyelashes); the prominence of the eyeball; sclera of the eye; iris; the middle edge; the lateral edge; Asymmetry
CHEEKS	Cheekbone (overall shape), the shape of the cheek
NOSE	Nasal contour (front and profile); nasal root (bridge); nasal body; the tip of the nose; the nasal base; alae (wings of the nose); nostrilis (nasal openings); Columella (soft tissue between the nostrilis)
EARS	Ear (general shape); asymmetry; protrusion; upper/lower helix; tubers (Darwin's tuber); antihelix; antihelix crura (upper crux, lower crux); triangular fossa; helix crus; scaphoid fossa; shell (top, bottom); tragus; antitragus; intertragal/intertragic notch; anterior notch; atrial sulcus; Right earlobe
MOUTH	Palate (general shape); filtrum; upper lip; lower lip; cleft lip (opening between the lips); general dental occlusion (contact between the upper and lower teeth); gnathism (projection of the upper and/or lower teeth); Detail of the teeth

JAW	Chin (front view and profile), jawline, gonial angle
FACIAL LINES	Front lines; vertical glabellar line(s); fold of nasion; lateral nasal lines; bifid fold of the nose; adjacent periorbital lines; superior eyelid fold; inferior eyelid fold; infraorbital folds; mentholic sulcus; nasolabial fold; puppet lines; cleft chin; buccal folds; wrinkles in the neck
SCARS	location, shape, orientation, size, color/hue, depth, or prominence
FACIAL MARKINGS	Freckles; Moles; acne; rosacea; birthmarks; Bruises; Abrasions; vitiligo and dark or light spots

Figure 2: Pairs of identical twins

In this way, the author [3] infers that in order to use neural networks, they must first be trained with data to learn patterns and relationships in the data and, subsequently, it is used to predict the future performance of candidates and make decisions according to the process that has been decided to be used. In his research, he used neural networks in the validation and detection of masks in an institution, concluding that it is advisable to have images that present a single background in the database, as this facilitates the training process. It is also suggested to have a greater number of images so that the convolutional neural network can yield more accurate results.
Figure 3 shows neural network training
particular convolutional.

II. RESULTS

Frequencies of similar and different features in each facial component

As a result of the facial morphological comparison in each pair of identical twins, the frequencies of similar and different features were obtained for each of the facial components: contour of the head, hair, forehead, eyes, cheeks, nose, ears, mouth, jaw and facial lines. The frequencies are shown in detail in Figures 3-12.

While morphological differences were observed in all facial features compared, the frequencies of similar and different features were highly variable among the features of each facial component. Below we will detail the most useful characteristics to differentiate identical twins: in the contour of the head it was the shape of the face (Fig. 7), in the hair it was the hairline (Fig. 8), in the forehead it was the shape of the forehead (Fig. 9), in the eyes it was the lower eyelid, upper eyelid and the opening of the fissure (Fig. 10), on the cheeks it was the cheekbone (Fig. 11), on the nose it was the base, tip, body and nasal contour (Fig. 12), on the ear it was the helix (Fig. 3), the intertragic notch, Darwin's antihelix and tubercle (Fig. 13), in the mouth it was the upper and lower lip (Fig. 4 and 14), on the jaw it was the contour of the chin (Fig. 15) and, finally, in the facial lines were the nasolabial fold, mentholabial fold and superior eyelid fold (Figs. 5 and 16).

It should be noted that scars and facial marks (e.g., moles, freckles, spots) were not present in all cases, but when observed they contributed to differentiating the twins in all comparisons (Fig. 6). In other words, these components served as individualizing traits.

Figure 3: Morphological differences in the helix (component: ear) in a pair of twins (upper) and twins (lower).

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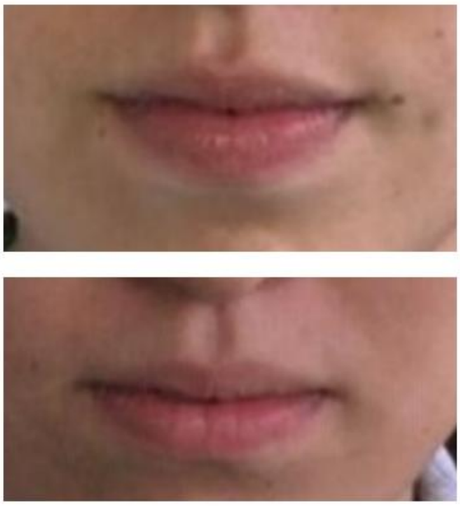

Figure 4: Morphological differences in the lower lip (component: mouth) in a pair of twins

Figure 5: Morphological differences in the lower lip (component: mouth) in a pair of twins

Figure 6: Morphological differences in the lower lip (component: mouth) in a pair of twins

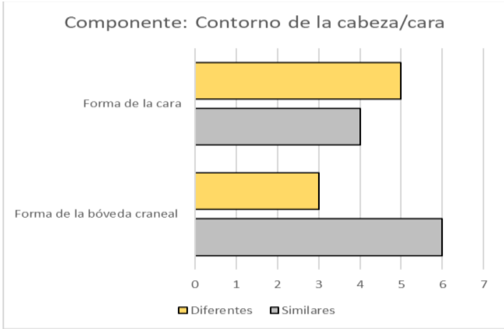

Figure 7: Head/Face Contour

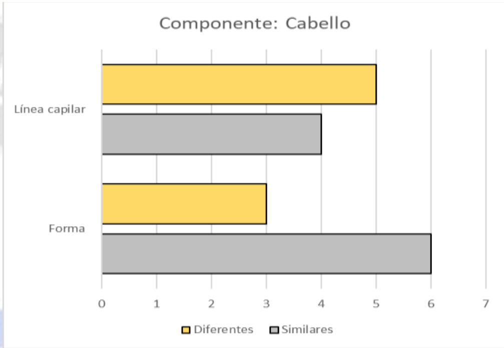

Figure 8: Hair

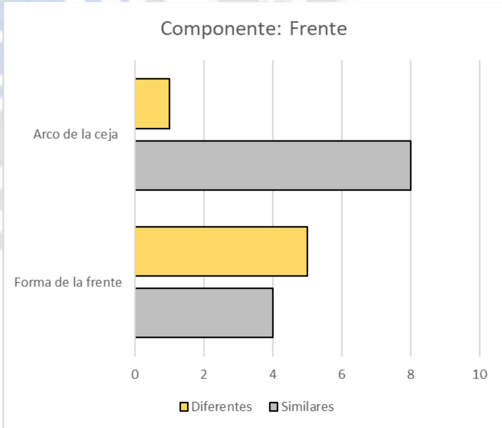

Figure 9: Forehead

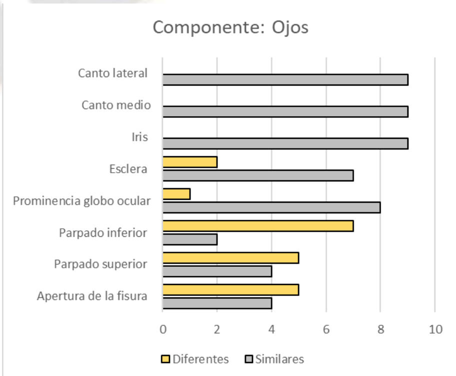

Figure 10: Eyes

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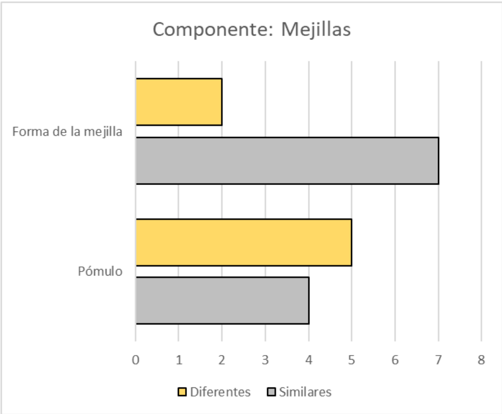

Figure 11: Cheeks

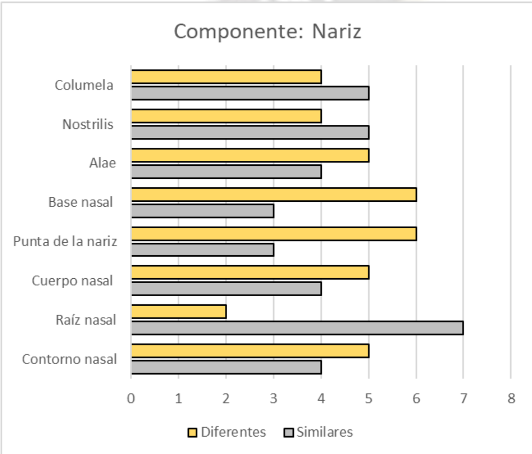

Figure 12: Nose

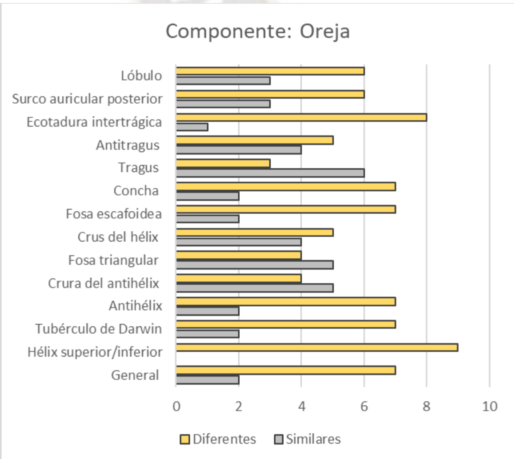

Figure 13: Ear

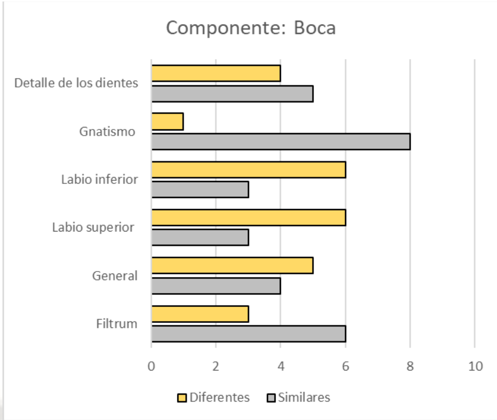

Figure 14: Mouth

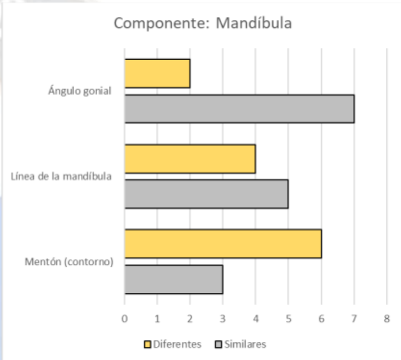

Figure 15: Jaw

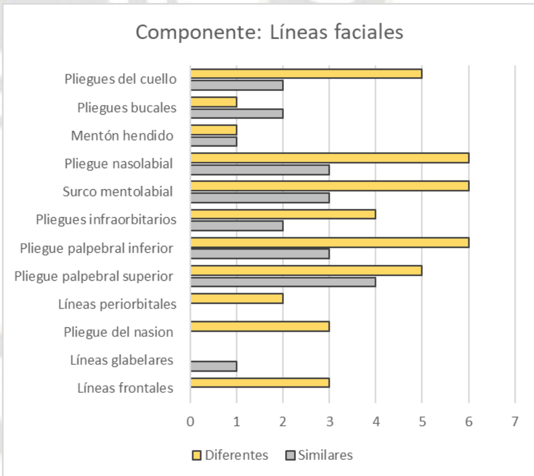

Figure 16: Facial Lines

Analysis of variance on similar traits

The total number of similar features (n=220) were distributed among the 10 facial components evaluated. Subsequently, the facial components were compared with each other by means of an analysis of variance, which showed a statistically significant difference between the medians of the components (Kruskal-Wallis; H = 28.69; GL = 9; p = 0.001). The post-hoc test (Dunn's test) indicated that the facial component called "eyes" presented a statistically significant difference with respect to the other

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components (p=0.0001), presenting the highest median (Fig. 12).

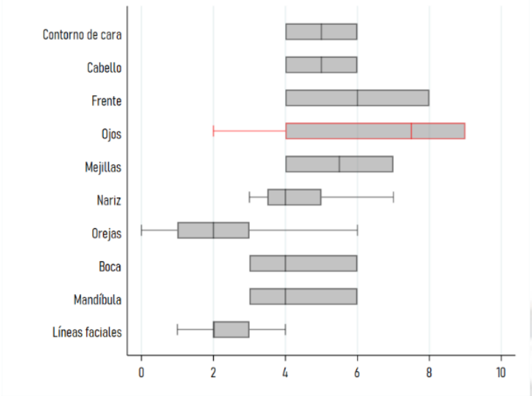

Figure 17: Comparison of medians between components (grouping similar facial features) using analysis of variance (Kruskal-Wallis H).

Analysis of variance on different traits

The total number of different features (n=126) were distributed among the 10 facial components. Next, the facial components were compared with each other using an analysis of variance, which showed that there is a statistically significant difference between the medians of the components (Kruskal-Wallis; H = 13.23; GL = 9; p = 0.015). The post-hoc test (Dunn's test) identified that the facial component called "ears" presented a statistically significant difference with respect to the other components (p=0.001), presenting the highest median (Fig. 13).

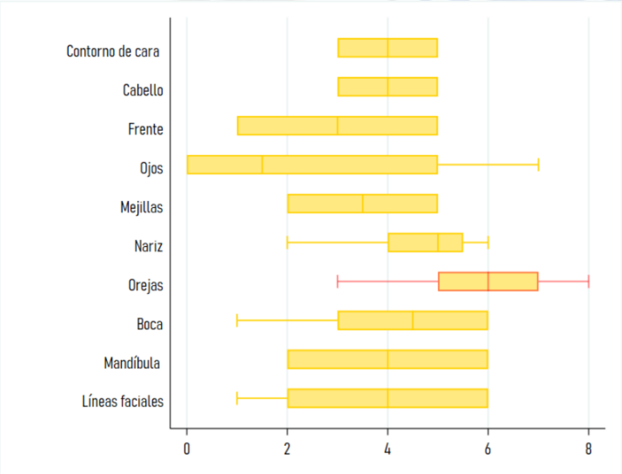

Figure 18: Comparison of medians between components (grouping different facial features) using analysis of variance (Kruskal-Wallis H).

III. DISCUSSION

The present study aimed to explore the ability of facial morphological analysis to differentiate identical twins, as well as to identify which facial features were most useful in achieving this goal.

The results showed that all pairs of twins had some different facial features. However, the frequencies of these differences were highly variable in each facial component (Fig. 6-15). Analysis of variance of similarities and differences indicated that the ear was the most useful facial component for differentiating identical twins in this sample.

In that sense, this exploratory study suggests that facial morphological comparison has the potential to differentiate identical twins as long as the most discriminating facial components and features are employed. For example, while the ear was the most discriminating facial component in this sample, more specific elements of the ear such as the helix or the intertragic notch were the most useful features in differentiating twins. It should be noted that facial scars and marks were the most discriminating components, allowing the twins to be differentiated in all cases.

The implications of these findings for the forensic field of facial identification by morphological comparison suggest that the differentiation of identical twins would only be possible if the images present an optimal resolution that allows the details of the most discriminating components and characteristics to be evaluated. Another practical implication of these results is related to the finding of differences in facial components between twins. This begs the question: if we find facial morphological differences in identical twins, could we expect these frequencies to be higher among unrelated people?
On the other hand, the results presented and the published literature suggest that the differentiation of twins without a doubt can be achieved by observing facial scars and marks. However, these are not always present in all faces, for this reason it is highly important to know which facial components are most useful for the differentiation of calves.
Due to the limited number of participants, some results may be refuted or validated in a larger sample. In this sense, at this exploratory stage the conclusions should not be extrapolated to the general population.

However, this study is important because it provides significant evidence suggesting that the method of facial identification by morphological comparison proposed by the FISWG has the potential to differentiate people, even though they are identical twins.

Future research needs to expand the number of participants to corroborate the results presented. In addition, a larger sample will allow participants to be segregated by age groups, thus exploring the effect of age on the components that interact most with the environment, such as facial folds or hair.

IV. CONCLUSIONS

The present work is a contribution to forensic investigation, as an element of inclusive or exclusive conviction in the identification and individualization of identical twins, which serves as a basis for future facial identification investigations to include or exclude people in forensic investigation.

The morphological method has been shown to have the ability to differentiate identical twins by systematically comparing facial components. However, evidence would indicate that not all facial components and features have the same utility in distinguishing between identical twins. Due to the limited number of participants, the results presented cannot be generalized to a wider population of identical twins. However, it would set important guidelines for future research as well as practical considerations on this problematic topic of facial identification.

V. GRATITUDE

A todos los participantes de este estudio, sin ellos no hubiera sido posible esta publicación.

VI. CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

VII. FUNDING SOURCE

Financed.

REFERENCES

[1] Spaun N. A., 2009 Facial comparisons by subject matter experts: Their role in biometrics and their training. In M. Tistarelli, & M. S. Nixon (Eds.), Advances in Biometrics (pp. 161-168). Heidelberg: Springer-Verlag.

[2] Burton, A. M., Wilson, S., Cowan, M., & Bruce, V. (1999). Face recognition in poor-quality video: Evidence from security surveillance. Psychological Science, 10(3), 243-248.

[3] Atsuchi, M., Tsuji, A., Usumoto, Y., Yoshino, M., & Ikeda, N. (2013). Assessment of some problematic factors in facial image identification using a 2D/3D superimposition technique. Legal Medicine, 15(5), 244–248.

[4] Yoshino M, Kubota S, Matsuda H, Imaizumi K, Miyasaka S, Seta S. Face-to-face video superimposition using three-dimensional physiognomic analysis. Jpn J Sci Tech Iden 1996;1:11–20.

[5] Davis, J.P., Valentine, T. and Davis, R.E., 2010. Computer assisted photo-anthropometric analyses of full-face and profile facial images. Forensic Science International, 200(1), pp.165-76.

[6] Kleinberg, K.F., Vanezis, P., Burton, A.M., 2007. Failure of anthropometry as a facial identification technique using high-quality photographs, Journal of Forensic Science, 52, 779-83.

[7] Moreton, R. and Morley, J., 2011. Investigation into the use of photoanthropometry in facial image comparison. Forensic Science International, 212, 231-7.

[8] Houlton, T. M. R., & Steyn, M. (2018). Finding Makhubu: A morphological forensic facial comparison. Forensic Science International, 285, 13–20.

[9] Steyn, M., Pretorius, M., Briers, N., Bacci, N., Johnson, A., & Houlton, T. M. R. (2018). Forensic facial comparison in South Africa: State of the science. Forensic Science International, 287, 190–194.

[10] FISWG, 2013, Facial Image comparison Feature List for Morphological Analysis, version 1.0, https://fiswg.org/FISWG_1to1_Checklist_v1.0_2013_11_22.pdf [Accessed on 13 December 2020].

[11] FISWG, Guidelines for Facial Comparison Methods, (2012) www.fiswg.org (Accessed 13 December 2020).

[12] [12] İşcan, M.Y., Steyn, M. 2013. The Human Skeleton in Forensic Medicine. Springfield: Charles C. Thomas.

[13] Stephan, C. N., Caple, J. M., Guyomarc'h, P., & Claes, P. (2018). An overview of the latest developments in facial imaging. Forensic Sciences Research, 1–19.

[14] Biswas, S., Bowyer, K. W., & Flynn, P. J. (2011). A study of face recognition of identical twins by humans. 2011 IEEE International Workshop on Information Forensics and Security.

[15] Sun, Z., Paulino, A. A., Feng, J., Chai, Z., Tan, T., & Jain, A. K. (2010). A study of multibiometric traits of identical twins. Biometric Technology for Human Identification VII.

[16] Bowyer, K. W., & Flynn, P. J. (2016). Biometric identification of identical twins: A survey. 2016 IEEE 8th International Conference on Biometrics Theory, Applications and Systems (BTAS).

[17] Phillips, P. J., Flynn, P. J., Bowyer, K. W., Bruegge, R. W. V., Grother, P. J., Quinn, G. W., & Pruitt, M. (2011). Distinguishing identical twins by face recognition. Face and Gesture 2011.

[18] Klare, B., Paulino, A. A., & Jain, A. K. (2011). Analysis of facial features in identical twins. 2011 International Joint Conference on Biometrics (IJCB).