KİMLİKLENDİRME İÇİN
KULAK KEPÇESİ MORFOLOJİSİNİN KULLANILABİLİRLİK SINIRLARININ TANIMLANMASI

DETERMINATION OF THE USABILITY
LIMITS OF AURICLE MORPHOLOGY FOR IDENTIFICATION

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ÖZET
Amaç:

Bu çalışmada, pozitif ve negatif kimliklendirme için kulağın morfolojik görünümünün kullanılabilirliğinin değerlendirilmesi ve deneyimli gönüllüler tarafından çıplak gözle tespit kullanılarak kulak kimliklendirmesinde doğruluk oranlarının belirlenmesi amaçlandı.

Yöntemler:

Bu çalışma üç aşamada uygulandı: 30 erkek ve 30 kadın gönüllünün (18-26 yaş arasında) 120 kulak görüntüsünün (60 sağ ve 60 sol) toplanması, kimliklendirme deneyimi olan 20 gönüllünün yorumları ve SPSS-11 İstatistik Programı ile istatistiksel analiz.

Bulgular:

Doğru cevap oranları orantısal hesaplama ile % 86,5 ve olasılık hesaplamasıyla %99,73 olarak bulundu. Yanlış cevapların toplam oranı erkek gönüllülerde orantısal hesaplama ile % 12,5, olasılık hesaplamasıyla % 0,25 iken, kadın gönüllülerde sırasıyla orantısal hesaplama ile % 14,5, olasılık hesaplamasıyla % 0,29 idi (p→0,05). Yanlış cevapların toplam oranı sol kulakta, sağ kulaktan iki kattan daha fazlaydı.

Sonuç:

Çıplak gözle kulak görüntülerinin bire bir karşılaştırması, şüpheli kişiler arasında suçun fail(ler)inin ayırt edilmesi için, polis memurları tarafından uygulanan ilk elemenin bir bölümü olarak kullanılabilir.

Anahtar Kelimeler: kimliklendirme, kulak görünümleri, kulak kepçesi morfolojisi, adli bilimler.

ABSTRACT
Objective:

In the present study, it was aimed to evaluate the usability of morphological appearance of ears for positive and negative identification and to define the accuracy rates in ear identification using naked-eye detection by experienced volunteers.

Methods:

This study was performed in three stages: the gathering of 120 ear images (60 rights and 60 lefts) of 30 male and 30 female volunteers (between 18-26 ages), the observation by 20 volunteers experienced on the identification, and the statistical analysis with SPSS-11 Statistics Program.

Results:

The rates of correct responses were 86.5 % by proportional calculation and 99.73 % by probability calculation. Whilst the total rates of wrong responses were 12.5 % by proportional calculation and 0.25 % by probability calculation in male volunteers, they were 14.5 % by proportional calculation and 0.29 % by probability calculation in female volunteers (p>0.05) respectively. The total rates of wrong responses were more than twice in left ears than right ears.

Conclusion:

One-to-one matching of ear images with naked eyes can be used as a part of first elimination carried out by police officers in order to differentiate the perpetrator(s) of a crime among suspicious persons.

Key words: *personal identification, ear images, auricle, morphology, forensic sciences.*

INTRODUCTION

Identification which is nourished by and interrelated with a large number of medical specialties and related sciences, is a fundamental aspect of legal and forensic medicine. In daily practice, the forensic scientists come across identification cases of living subjects, recently deceased bodies and human remains, and in each case use the technique or techniques most suitable for the material under study [1].

It is suggested that the shape of the ear and the structure of the cartilaginous tissue of the pinna are important and unrecognized defining features of the face [2, 3] opposing to some authors' opinion: "The features of an ear are not expected to be very distinctive in establishing the identity of an individual" [4]. The shape of the ear gives information about age and sex, which is clear. But, still has difficulties in characterizing it [2-6]. The size of the human auricle increases between 0 and 18 ages [7], and its size continues to increase even after the body development finishes [5-6]. Also, the size of auricle is usually larger in males than in females [2, 3].

In the 18th century, Lavater (1741-1801) wrote reports about the individual design of the ear [8]. More systematic papers on the auricle or the pinna appeared in the last part of the 19th and early part of the 20th centuries [9]. Bertillón (1852-1914) was probably the first scientist to use the ear for identification. Under the category of anthropometric measurements, he made several measurements of the head, one of which was the length of the right ear. In the descriptive category, amongst the morphological characteristics, he continued the analysis of the right ear, including its edges, lobe, folds, general shape, separation and particularities. Due to its proportional ratio and the shape, the ear had the most important characteristics within the descriptive category on being considered immutable [1]. The awakening of forensic interest in the description of earprints and in identification by means of earprinting is relatively recent [9]. The first earprint identification of a criminal was made in Switzerland in 1965 [1]. In the last part of the 20th and the beginning of the 21st century, earology or otomorphology was a field developed amongst anthropologists, criminologists and forensic doctors. It makes use of the fact that auricles of every individual are different, even among identical twins, and that earprints may be compared with fingerprints in their highly personal characteristics. Earology makes use of identification through photographs, through systematized descriptions of auricles and through ear-prints [9]. Besides, number of studies about using earprints with aim of forensic expertise increased and described important features of earprints in the last decade [10-12]. Concurrent with the development in the use of earprints for forensic identification, a substantial number of cases involving evidence based on earprints and some isolated cases involving video images of ears have appeared in courts and some of them were accepted as evidence in the Netherlands, the United Kingdom, the West Germany, Austria and the United States [13]. In 2006, it was reported that there were more than 200 judicial cases of earprint identification in Holland and more than 20 in Spain [1].

In several forensic events, a few of the most important problems in personal identification for forensic scientists were presence of only the profiling images of perpetrators among images of surveillance cameras and the presence of mask covering the face regions of perpetrators except ears [13]. Thus, the use of advanced technologies became significant for ear identification. Ruty et al illustrated the concept of potential for the development of a computerized earprint identification system [14]. Distance measurements were taken for both left and right ears of 700 individuals and superimposition technique was applied on the randomly selected ear images by Purkait & Singh [15]. Ventura et al analyzed the video clip of a bank robbery by a computer and emphasized that the features of the ear were comparable to fingerprints in their ability to identify an individual [16]. Yan et al and Yoshino et al described the ear identification in 3D ear shapes [17, 18].

Purkait and Singh emphasized in their study in 2000 that no ears were found to be exactly same in morphology to its counterpart and left and right digital impressions

of ears for any individual were found different, [15]; contrary to the report of Pellnitz which was denying the differences between left and right ears, in 1958 [19].

In this study, it was aimed to evaluate the usability of morphological appearance of ears with naked eyes for positive and negative identification, and to define the accuracy rates in the ear identification using naked-eye detection by experienced volunteers.

MATERIALS AND METHODS

In this study, we aimed to determine the limits in the one-to-one matching of ear photographs including well-resolution.

This study was performed by permission of the Presidency of Scientific Ethic Board of Celal Bayar University (Date of approval: February 02, 2009; no. of approval: 0042) and performed in three stages.

First stage:

Authors had interviews with 60 volunteers (30 male, 30 female), between 18 to 26 years old, including university students and residents, informed them about the study and received their written consents to be included in the study. The volunteers with operated ears were eliminated from study, but volunteers having nevus, congenital signs, acnes, earring pricks or ear hairs were not eliminated because these features were accepted as parts of identification. Then, photographs from 38 cm distance of the right and left ears of volunteers by using "Nikon Digital Camera were taken after covering the face of volunteers by a cartoon plaque.

Two lists as "A list" and "B list" were prepared by obtained ear images.

"A list" was composed of 100 images. Fifty images of right ears (25 male+25 female) and fifty images of left ears (25 male+25 female) were randomly selected among totally 120 ear images of 60 volunteers (30 male, 30 female). The images in "A list" were labeled by numbers **(Figure-1).**

"B list" was composed of 20 images (10 males: 5 right, 5 left ear images + 10 female: 5 right, 5 left ear images), first 10 images (3 male left ears + 2 female left ears + 2 male right ears + 3 female right ears) were randomly selec-

Figure 2: *"20 ear images in the "B list"*

ted among the "A list" and second 10 images (2 male left ears + 3 female left ears + 3 male right ears +2 female right ears) were randomly selected among ear images which were not present in the "A list". The images in "B list" were labeled by letters **(Figure-2).**

Second stage:

Authors had interviews with 20 volunteer observers experienced on the forensic personal identification. They compared the ear images in "B list" with the ear images in "A list". Then, they checked on the form including paired or not paired images.

Third stage:

The results of observers were evaluated as follows: a) if an image from the B list present in the A list couldn't be selected, it was defined as "false negative result"; b) if an image from the B list which was not present in the A list matched with a wrong image, it was defined as "false positive result"; c) if an image present in both lists matched with a wrong image, it was defined as "false pairing - matching result"; d) the total of all these mistakes mentioned above were named as "wrong response"; e) the other results provided the "correct response" in this study.

The results obtained from 20 observers were statistically analyzed on SPSS-11 Statistic Program. Statistical analyses were performed with Chi-square test. In the statistical assessment, p value was accepted to be statistically significant when it was ≤ 0.05.

RESULTS

In this study 20 forensic scientists experienced in forensic identification and individualization were volunteer observers. Fifteen of them were males and five were females. The mean age of them was 41.9 years (SD: 6.4; range: 30-51 years) and their mean experience on the forensic personal identification was 9.8 years (SD: 7.1; range: 2-21 years). However, none of them had performed a duty in the field of ear or ear-print identification.

Each of 20 observers paired 20 images in "B list" with images in "A list" according to proportional calculation. Thus, totally 400 pairings (20x20) occurred. Fifty four pairings (13.5 %; SD: 12.47 %) were wrong and 346 pairings were correct out of 400 pairings. Among 54 wrong responses, there were 36 false positive results (9 %; SD: 9.95 %), 10 false negative results (2.5 %; SD: 4.44 %) and 8 false pairing results (2% SD: 3.77%), respectively. The number of false positive results was higher than the total number of false negative results and false pairing results (p < 0.001). Thus, the rate of correct responses was calculated to be 86.5 % (SD: 12.47%).

According to another point of view which developed on the basis of probability calculations, each observer matched with 10 right ear images in the "B list" among 50 right ear images in the "A list" and 10 left ear images in the "B list" among 50 left ear images in the "A list". Thus, according to probability calculation, each observer carried out totally 1.000 matchings ([10x50] + [10x50] = 1,000) and 20 observers carried out totally 20.000 matchings in order to be able to find the correct response . In this case, the wrong responses were at the level of 0.27 % (SD: 0.25 %), while the rate of correct responses had increased to the level of 99.73 % (SD: 0.25 %). Besides, the rate of false positive results was 0.18 % (SD: 0.2 %), the rate of false negative results was 0.05 % (SD: 0.09 %) and the rate of false matching results was 0.04 % (SD: 0.08 %) in the calculation performed by taking into consideration the possibility.

The numbers of wrong responses were zero in 5 observers, 1 in 3 observers, 2 in 2 observers, 3 in 5 observers, 6 in 4 observers, 8 in only one observer respectively (p<0.01). The numbers of "false negative results", "false positive results", and "false pairing - matching results" for each observer were shown in **Figure-3.**

When the rates of wrong responses for each images in the "B list" were assessed, it was seen that the numbers of wrong responses were zero in 5 images, 1 in 3 images, 2 in 4 images, 3 in 2 images, 5 in 2 images, 6 in 2 images, 7 in 1 image and 8 in 1 image, respectively (p<0.001). The numbers of "false negative results", "false positive results", and "false pairing - matching results" for each image in "B list" were shown in **Figure-4.**

Most of the false negative results occurred during the matching of "L" image in "B list" with 5 wrong responses, followed by "O" image with 2 wrong responses, "D" image and "M" image with 1 wrong response for each.

Most of the false positive results occurred during the matching of "K" and "A" images in "B list" with 8 and 7 wrong responses, followed by "S" image with 6 wrong responses, "P" image with 5 wrong responses, "J" image with 3 wrong responses, "B", "E" and "U" images with 2 wrong responses, and "N" image with 1 wrong response. Five observers wrongly matched "K" image in "B list" with "100th" image in "A list", five observers wrongly matched "A" image in "B list" with "33rd" image in "A list", four observers wrongly matched "P" image in "B list" with "80th" image in "A list", four observers wrongly matched "S" image in "B list" with "81st" image in "A list", and others wrongly matched several images in "B list" with several images in "A list", although none of them was absent in "A list".

All of the false matches occurred during the matching of "M" and "T" images in "B list" with 5 and 3 wrong responses, respectively. Three observers wrongly matched "M image" in "B list" with "62nd" image in "A list", although it was "92nd" image in "A list". Two observers wrongly matched "T image" in "B list" with "53rd" image in "A list", although it was "99th" image in "A list". The other false matches were differing from another.

Whilst the total rates of wrong responses were found to be 12.5 % (n=25) by proportional calculation and 0.25 % by probability calculation according to matching of images in male volunteers; they were found to be 14.5 % (n=29) by proportional calculation and 0.29 % by probability calculation according to matching of images in female volunteers (p>0.05). The rates of "false negative results", "false positive results", and "false pairing or matching results" for ear images of male and female volunteers were shown in **Table-1.**

Besides, the total rates of wrong responses were found to be more than twice in left ears (19 % according to proportional calculation; 0.38 % according to probability calculation; n=38) than right ears (8 % according to proportional calculation; 0.16 % according to probability calculation; n=16) (p<0.05). The rates of "false negative results", "false positive results", and "false pairing or matching results" for left and right ear images were shown in **Table-2.**

DISCUSSION

According to a very hard but not impossible hypothesis, forensic identification from ears is based on uniqueness, same as other biometric identification issues such as fingerprinting, facial recognition and DNA [13]. On the basis of this hypothesis, few scientists carried out some studies related with using ears in personal identification. Most of these studies concentrated on the earprints. In one of these studies, Alberink et al reported a study about repeatability and reproducibility of the earprint acquisition and they suggested that different operators might acquire prints of differing

quality, with error rates of the matching system ranging from 9 % to 19 % [10]. In another study performed by Alberink et al, error rates were significantly increased from 20 % to 30 % when different operators looked at earprints [11].

The reliability of ear-print evidence has recently been challenged in the Courts and the trial resulted in rejection of the earmark evidence in the State v. Kunze case in the United States and calling for a retrial in the Regina v. Mark Dallagher case in the United Kingdom [20-22].

In 16th December 1994, an intruder entered the Clark County home of James McCann. McCann was asleep in the master bedroom. His son Tyler, age 13, was asleep in another bedroom. The intruder bludgeoned McCann in the head with a blunt object, causing his death. The intruder also bludgeoned Tyler in the head, causing a fractured skull. David Wayne Kunze appealing his convictions for aggravated murder and other crimes, discovered a partial latent earprint on the hallway-side surface of McCann's bedroom door. In his trial, the validity of earprints as an evidence was discussed among famous forensic scientists [23].

In 1998, Mark Dallagher was convicted by Leeds Crown Court for the murder of 94-year-old Dorothy Wood in Huddersfield in the UK. Cornelis van der Lugt, an expert on ear prints from the Netherlands, stated he was 'absolutely convinced' an ear print

from Dallagher matched that on the window. A re-trial was ordered because a low copy number DNA profile consisting of a single allele was produced from a swab taken from an earprint found on a window at the crime scene. This single allele was not consistent with the DNA profile of the suspect Mark Dallagher. The weight of this DNA evidence was enough to overrule the comparably unreviewed technique of earprint examination and Mr Dallagher was acquitted on 25th July 2002. Based on this finding, in January 2004, the prosecution decided to drop the charges against Dallagher, who was the first man to be convicted of murder on earprint evidence. Even though it was not clear whether the DNA material, or the earprint for that matter, bear any relation to the crime, it might look as though several other convictions involving ear print evidence would be presented for review in the wake of this decision. However, ear prints have not been used since then in the UK and are unlikely to be allowed unless there is extensive research to support their reintroduction [24-26].

Hoogstrate et al evaluated the possibility of identification by ear from surveillance in a small experiment, with forensically trained persons and laymen; they concluded that the whole 65 % of possible matches were identified and especially the forensically trained respondents were able to determine whether they had sufficient information for identification, without any false positives [13].

In 2005, Hurley et al defined that out of 252 trials, 250 resulted in correct classification which corresponded to a classification rate of 99.2 % by developing a technique including ear biometrics [20]. In 2007, Alberink et al described that comparing lab quality prints to one another, the resulting matching system had an equal error rate of 4 %, and starting from databases containing two prints per ear, hit list behaviour was that in 90 % of all query searches the best found hit was in the top 0.1 % of the list in their study.

We were not able to find a study based on one-to-one matching principle in the literature. In the present study, the rate of wrong responses was found to be 13.5 % (SD: 12.89) by proportional calculation and 0.27 % (SD: 0.25%) by probability calculation. Also, the rates of correct responses in ear identification using naked-eye detection by experienced observers were found to be 86.5 % (SD: 12.47) by proportional calculation and 99.73 % (SD: 0.25%) by probability calculation.

Whilst all responses of 5 observers were correct, the highest number of wrong responses was 8 in one observer. Also, there were 8 wrong responses in one image while there was not any wrong response for 5 images.

Despite the relatively low rate of correct responses obtained by proportion calculation, the responses to relatively high-qualified images of this study in comparison to surveillance camera ima-
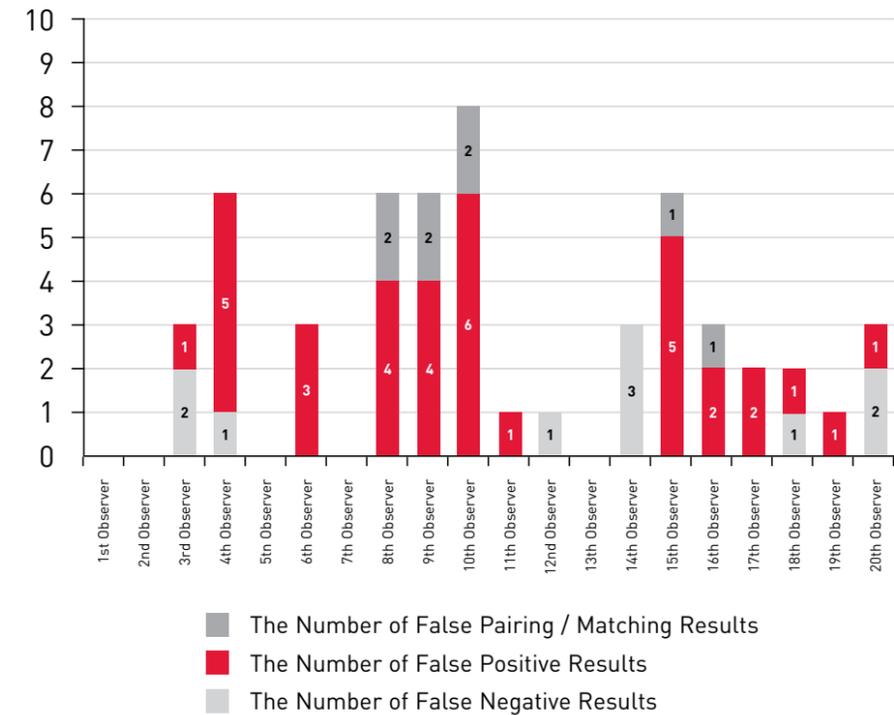

Figure 3: The numbers of false positive, false negative and false pairing - matching results of 20 observers
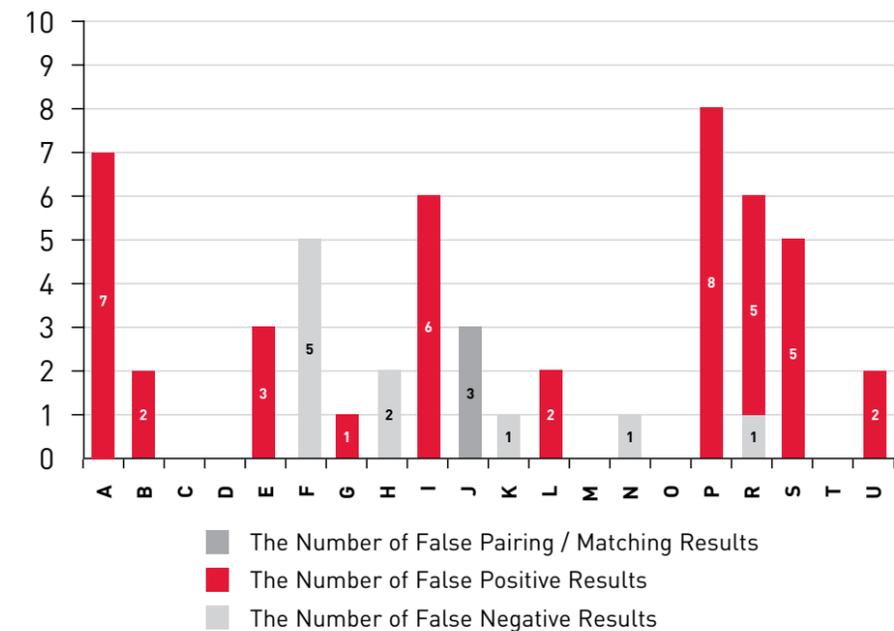

Figure 4: The numbers of false positive, false negative and false pairing - matching results for each image in the "B list"

ges needs a cautious approach. Besides, the high rate of correct responses obtained by probability calculation, at the same time, 100 % correct responses achieved in five images and for 5 observers were encouraging.

One of the two interesting results of the present study was the significant increase in the rate of wrong responses given as a result of left ear image evaluations in comparison to right ear image evaluations, although, to carry an earring, often only at the left auricle, has been a very old tradition [9]. These results were considered to be compatible with the results of the study of Purkait and Singh [15].The second interesting result was the rate of wrong responses'- given as a result of female ear image evaluations- being higher than the wrong responses in the evaluation of male ear images. In fact, the overall nature of differences in ear shapes exhibits a greater tendency for the female ear shapes to be more alike than the male counterpart [15]. However, when compared with male ear shape variations, female ear shape variations' being to a lesser degree has been accepted as a factor for the higher error rate in the identification of female ears.

Before this study, we were thinking that, only shape of ears might not provide enough clues to observers for making effective decision, but descriptive features, such as nevus, congenital signs, acnes, earring pricks, ear hairs played a role in the identification. In the present study, the rate of wrong responses were higher in evaluation of female and left ear images, despite the presence of a descriptive feature: earring pricks. These results implicated us that right and male ears were having more distinctive features than left and female ears.

CONCLUSION

The potential use of earprints and ear images obtained through surveillance for personal identification has continued to be a controversial issue within the forensic arena. Each step on these subjects will broaden forensic scientists' horizons.

This study includes one-to-one matching of ear images, with relatively high accuracy rates, especially in proportional calculation. These results may be considered for development of personal identification from ear images even though the results of this study is a minor step and needs a cautious approach. After all, long walks begin with minor steps.

We think that, neither the results of the present study nor the results of recent studies is enough to use ear images as evidence in trial phage yet, but, morphological appearance of ears can be used as a part of first elimination carried out by police officers in order to differentiate the perpetrator(s) of a crime among suspicious persons. The usability as an evidence of ear morphology for personal identification in the routine in courts needs more efforts with more images and more observers, and maybe some computerized programs on this subject for minimization possible errors caused by observers.

Table 1: *The rates of "false negative results", "false positive results", and "false pairing or matching results" for ear images of male and female volunteers*

TABLE-1	Females			Males			Total		
	n	%1	%2	n	%1	%2	n	%1	%2
False Negative Results	7	3.5	0.07	3	1.5	0.03	10	2.5	0.05
False Positive Results	19	9.5	0.19	17	8.5	0.17	36	9.0	0.18
False Pairing/Matching Results	3	1.5	0.03	5	2.5	0.05	8	2.0	0.04
Wrong Responses	29	14.5	0.29	25	12.5	0.25	54	13.5	0.27
(%1): According to proportional calculation; (%2): according to probability calculation									

Table 2: *The rates of "false negative results", "false positive results", and "false pairing or matching results" for left and right ear images*

TABLE-2	Right Ears			Left Ears			Total		
	n	%1	%2	n	%1	%2	n	%1	%2
False Negative Results	2	1	0.02	8	4	0.08	10	2.5	0.05
False Positive Results	14	7	0.14	22	11	0.22	36	9.0	0.18
False Pairing/Matching Results	0	0	0	8	4	0.08	8	2.0	0.04
Wrong Responses	16	8	0.16	38	19	0.38	54	13.5	0.27
(%1): According to proportional calculation; (%2): according to probability calculation									

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