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Anthropology

Assessing the effect of facial disguises on forensic facial comparison by morphological analysis

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Abstract

Disguises are commonly used to mask a person's facial appearance in areas under closed-circuit television (CCTV) surveillance. While many studies attempted to understand the effects of disguises, such as hats and glasses, on facial recognition, limited studies have looked at disguises in forensic facial comparison. The aim of this study was to compare the outcomes of forensic facial comparison by morphological analysis (MA) in a CCTV sample with sunglasses and brimmed caps. The sample was obtained from the Wits Face Database and organized into 81 face pools of one target facial image wearing a disguise (cap or sunglasses) and 10 potential matching images. MA was conducted across face pools, and confusion matrices were used to assess the outcomes. Surprisingly, sunglasses had limited effect on MA performance both in accuracy (90.4%) and in reliability (κ = 0.798), while caps markedly decreased both accuracy (68.1%) and reliability (κ = 0.639). Error rates were associated primarily with false negatives in both samples (caps: 42.4%; sunglasses: 16.1%) despite the sample distribution favoring false-positive errors, which were very low (caps: 0.6%; sunglasses: 0%). Similarly to other studies, hats and caps were more harmful to correct identification when compared to sunglasses, which actually resulted in better accuracy than regular CCTV recordings. The effect of brimmed caps on accuracy was attributed to the overall loss of facial information caused. On training analysts, it may be helpful to instruct purposefully avoiding overreliance on easily disguised facial features, as other regions of the face also contain substantial feature information.

KEYWORDS
caps, CCTV, disguise, facial identification, forensic facial comparison, glasses, morphological analysis

Highlights

- The effects of facial disguises are understudied in forensic facial comparison.
- This is the first study to test morphological analysis on disguised faces in a CCTV setting.
- Brimmed caps were found to hide more facial information than sunglasses and decrease accuracy most.
- Sunglasses were found to have minimal effects on feature-based facial comparison.

Any opinions, findings, and conclusions or recommendations expressed in this study are those of the authors, and therefore, the NRF and University of the Witwatersrand, Johannesburg, do not accept any liability in regard thereto.

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1 | INTRODUCTION

Closed-circuit television (CCTV) surveillance is common in both public and private areas [1–3]. CCTV recordings and images extracted from these recordings are often used for facial identification purposes [4], particularly in criminal proceedings. Unfamiliar face identification is widely considered a complex task [5–7],with experts performing relatively better than the general public [8]. As a result, many prosecutors rely on expert assessments and testimony for facial comparison cases [9,10].

Despite the many studies investigating human cognitive ability to correctly identify individuals' facial images (e.g., [11–14]), few take into consideration external confounding factors such as disguises [14–17]. It has long been accepted that various forms of disguises hamper the ability to identify faces [18], despite the occasional inconsistent findings of their effects on identification [19]. Disguises, in the form of sunglasses and hats, are often worn by criminals and are widely considered effective in obscuring facial appearance and maintaining anonymity [10,20]. However, these effects are relatively disregarded in facial comparison research and have not been investigated extensively in forensic facial comparison.

Eyeglasses or sunglasses and hats or caps are some of the most commonly used disguises affecting facial recognition and identification (e.g., [15,21,22]). The majority of studies investigating disguises do so in relation to some form of facial memory, often in the context of eyewitness identification (e.g., [19,23,24]), hence looking at faces with a level of familiarity. In a setting where CCTV evidence is analyzed by a facial comparison expert, faces are predominantly unfamiliar to the analyst performing the comparison, which relies on a different cognitive approach [12,25]. In fact, many studies suggest that when attempting familiar face recognition, priority is given to internal facial features, such as the eyes and nose, as opposed to peripheral features, such as face contour shape and ear morphology [25,26]. Others have suggested that familiar faces are recognized based on an average of the variations in their appearance [27], with further postulation that familiarization creates an understanding of the truly invariable features of each face [28]. Nonetheless, understanding which facial features are prioritized in unfamiliar face recognition is particularly relevant when disguises are involved, as it means that a further limitation on available features for facial comparison is imposed.

When conducting facial comparison, a systematic approach is recommended, particularly with the use of a facial feature list as it has been shown to improve accuracy [29–32]. Facial comparison in the forensic context is usually conducted under the recommendations proposed by the Facial Identification Scientific Working Group (FISWG), which has established policies and guidelines for practice and research in facial identification and facial recognition [33]. According to FISWG [31] and research in the field of facial identification (e.g., [8,10,34,35]), the recommended method for forensic facial comparison is considered to be morphological analysis with the aid of feature lists or instructions [29,30,36]. The most recent and extensive feature list developed for this purpose was put forward by FISWG in 2018 [37]. This feature list includes detailed descriptors regarding each individual anatomical facial feature to provide a thorough guide during analysis. This FISWG feature list has recently been tested and was found reliable in both photographic- and CCTV-derived images of relatively good quality [32]. Although multiple studies have looked at disguises in general face recognition (e.g., [14–17]), to date, feature list-based facial comparison has not been tested in the context of disguised faces, and it has been recommended that further research is required in suboptimal conditions [38]. Conducting thorough testing of methodologies is particularly relevant in the field of facial comparisons as its admissibility has been questioned due to lack of testing and validation [39].

The aim of this study was, hence, to test the effectiveness of facial comparison by morphological analysis using the most extensive available feature list [37] in CCTV footage with individuals wearing face obscuring accessories, namely brimmed caps and sunglasses. The study hypothesized that both caps and sunglasses would negatively impact the ability to identify faces using morphological analysis.

2 | MATERIALS AND METHODS

This study made use of standardized (ST) photographs and CCTV recordings originating from the Wits Face Database [40,41]. See Bacci et al. [41] for further details on database composition, design, and image data acquisition. Still images from the recordings and standardized photographs were used to compile face pools from a total of 86 consenting, known individual, young male adults of black South African descent. From this database, face pools were composed which included one still target image and 10 prospective matches/foils from the ST photographs. Of the 10 prospective matches, nine were incorrect matches in most of the face pools; however, a few face pools included 10 incorrect prospective matches so that the analyst did not feel obliged/subjectively pressurized to make a match in every analysis (Table 1). These face pools were compiled by someone other than the primary analyst to ensure blinding during analysis. Across all face pools, the maximum number of repetitions

TABLE 1 Analysis trials face pools: cohort subsample breakdown

Analysis cohort	Test trials	No-match trials	Analysis trials	Repeat trials	Total trials
Cap CCTV to ST photographs	33	4	37	5	42
Sunglasses CCTV to ST photographs	31	3	34	5	39

Abbreviations: CCTV, closed-circuit television; ST, standard.

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12. Megreya AM, Burton AM. Unfamiliar faces are not faces: evidence from a matching task. Mem Cognit. 2006;34(4):865–76. https://doi.org/10.3758/BF03193433.
13. Megreya AM, Sandford A, Burton AM. Matching face images taken on the same day or months apart: the limitations of photo ID. Appl Cogn Psychol. 2013;27(6):700–6. https://doi.org/10.1002/acp.2965.
14. Lee W-L, Wilkinson C, Memon A, Houston K. Matching unfamiliar faces from poor quality closed-circuit television (CCTV) footage: an evaluation of the effect of training on facial identification ability. AXIS Online J Cent Anat Hum Identif. 2009;1(1):19–28.
15. Henderson Z, Bruce V, Burton AM. Matching the faces of robbers captured on video. Appl Cogn Psychol. 2001;15(4):445–64. https://doi.org/10.1002/acp.718.
16. Megreya AM, Memon A, Havard C. The headscarf effect: direct evidence from the eyewitness identification paradigm. Appl Cogn Psychol. 2012;26(2):308–15. https://doi.org/10.1002/acp.1826.
17. Righi G, Peissig JJ, Tarr MJ. Recognizing disguised faces. Vis Cogn. 2012;20(2):143–69. https://doi.org/10.1080/13506285.2012.654624.
18. Patterson KE, Baddeley AD. When face recognition fails. J Exp Psychol Hum Learn Mem. 1977;3(4):406–17. https://doi.org/10.1037/0278-7393.3.4.406.
19. O'Rourke TE, Penrod SD, Cutler BL, Stuve TE. The external validity of eyewitness identification research: generalizing across subject populations. Law Hum Behav. 1989;13(4):385–95. https://doi.org/10.1007/BF01056410.
20. Ryder H, Smith HMJ, Flowe HD. Estimator variables and memory for faces. In: Valentine T, Davis JP, editors. Forensic facial identification: theory and practice of identification from eyewitnesses, composites and CCTV. Hoboken, NJ: John Wiley & Sons, Ltd.; 2015. p. 159–83.
21. Terry RL. How wearing eyeglasses affects facial recognition. Curr Psychol. 1993;12(2):151–62. https://doi.org/10.1007/BF02686820.
22. Davis JP, Tamonyte D. Masters of disguise: Super-recognisers' superior memory for concealed unfamiliar faces. In Proceedings of the Seventh International Conference on Emerging Security Technologies (EST); 2017 Sept 6–8; Canterbury, U.K. Piscataway, NJ: IEEE; 2017. p. 44–9. https://doi.org/10.1109/est.2017.8090397.
23. Mansour JK, Beaudry JL, Bertrand MI, Kalmet N, Melsom EI, Lindsay RCL. Impact of disguise on identification decisions and confidence with simultaneous and sequential lineups. Law Hum Behav. 2012;36(6):513–26. https://doi.org/10.1037/h0093937.
24. Cutler BL, Penrod SD. Improving the reliability of eyewitness identification: lineup construction and presentation. J Appl Psychol. 1988;73(2):281–90. https://doi.org/10.1037/0021-9010.73.2.281.
25. Ellis HD, Shepherd JW, Davies GM. Identification of familiar and unfamiliar faces from internal and external features: some implications for theories of face recognition. Perception. 1979;8(4):431–9. https://doi.org/10.1068/p080431.
26. Kramer RSS, Manesi Z, Towler A, Reynolds MG, Burton AM. Familiarity and within-person facial variability: the importance of the internal and external features. Perception. 2018;47(1):3–15. https://doi.org/10.1177/0301006617725242.
27. Jenkins R, Burton AM. Stable face representations. Philos Trans R Soc B Biol Sci. 2011;366(1571):1671–83. https://doi.org/10.1098/rstb.2010.0379.
28. Burton AM, Kramer RSS, Ritchie KL, Jenkins R. Identity from variation: representations of faces derived from multiple instances. Cogn Sci. 2016;40(1):202–23. https://doi.org/10.1111/cogs.12231.
29. Megreya AM. Feature-by-feature comparison and holistic processing in unfamiliar face matching. PeerJ. 2018;6:e4437. https://doi.org/10.7717/peerj.4437.
30. Towler A, White D, Kemp RI. Evaluating the feature comparison strategy for forensic face identification. J Exp Psychol Appl. 2017;23(1):47–58. https://doi.org/10.1037/xap0000108.
31. Facial Identification Scientific Working Group. Facial comparison overview and methodology guidelines. 2019. Version 1.0 2019.10.25. https://fiswg.org/fiswg_facial_comparison_overview_and_methodology_guidelines_V1.0_20191025.pdf. Accessed 21 Jan 2021.
32. Bacci N, Houlton TMR, Briers N, Steyn M. Validation of forensic facial comparison by morphological analysis in photographic and CCTV samples. Int J Legal Med. 2021. https://doi.org/10.1007/s00414-021-02512-3
33. Facial Identification Scientific Working Group. Facial Identification Scientific Working Group (FISWG) overview. 2018. Version: 2.0 2018.09.19. https://fiswg.org/FISWG_overview_v2.0_2018_09_19.pdf. Accessed 21 Jan 2021.
34. Evison M. Forensic facial analysis. In: Bruinsma G, Weisburd D, editors. Encyclopedia of criminology and criminal justice. New York, NY: Springer; 2014. p. 1713–29.
35. Houlton TMR, Steyn M. Finding Makhubu: a morphological forensic facial comparison. Forensic Sci Int. 2018;285:13–20. https://doi.org/10.1016/j.forsciint.2018.01.022.
36. Megreya AM, Bindemann M. Feature instructions improve face-matching accuracy. PLoS One 2018;13(3):e0193455. https://doi.org/10.1371/journal.pone.0193455.
37. Facial Identification Scientific Working Group. Facial image comparison feature list for morphological analysis. 2018. Version: 2.0 2018.09.11. https://fiswg.org/FISWG_Morph_Analysis_Feature_List_v2.0_20180911.pdf. Accessed 21 Jan 2021.
38. Ritz-Timme S, Gabriel P, Obertovà Z, Boguslawski M, Mayer F, Drabik A, et al. A new atlas for the evaluation of facial features: advantages, limits, and applicability. Int J Legal Med. 2011;125(2):301–6. https://doi.org/10.1007/s00414-010-0446-4.
39. Mallett X, Evison MP. Forensic facial comparison: issues of admissibility in the development of novel analytical technique. J Forensic Sci. 2013;58(4):859–65. https://doi.org/10.1111/1556-4029.12127.
40. Bacci N, Davimes J, Steyn M, Briers N. Wits Face Database. Wits Institutional Repository Environment on Dspace. 2020. https://hdl.handle.net/10539/29924. Accessed 18 Mar 2021.
41. Bacci N, Davimes J, Steyn M, Briers N. Development of the Wits Face Database: an African database of high-resolution facial photographs and multimodal closed-circuit television (CCTV) recordings. F1000Res. 2021;10:131.
42. Speckeis C. Can ACE-V be validated? J Forensic Identif. 2011;61(3):201–9.
43. Steyn M, Pretorius M, Briers N, Bacci N, Johnson A, Houlton TMR. Forensic facial comparison in South Africa: state of the science. Forensic Sci Int. 2018; 287:190–4. https://doi.org/10.1016/j.forsciint.2018.04.006.
44. R Core Team. R: A language and environment for statistical computing [computer program]. MS Windows version: 3.6.3. Vienna, Austria: R Foundation for Statistical Computing; 2020. https://www.r-project.org. Accessed 18 Mar 2021.
45. Gamer M, Fellows I, Singh P, Lemon J. irr: Various coefficients of interrater reliability and agreement R package. [computer program package]. MS Windows version 0.84.1. 2019. https://cran.r-project.org/package=irr. Accessed 18 Mar 2021.
46. Kuhn M. Building predictive models in R using the caret package. J Stat Softw. 2008; 28(5):1–26. https://doi.org/10.18637/jss.v028.i05.
47. Kuhn M. Caret: classification and regression training R package. [computer program package]. MS Windows version: 6.0-86. 2020. https://CRAN.R-project.org/package=caret. Accessed 18 Mar 2021.

48. Watson PF, Petrie A. Method agreement analysis: a review of correct methodology. Theriogenology 2010;73(9):1167–79. https://doi.org/10.1016/j.theriogenology.2010.01.003.
49. Dietterich TG. Approximate statistical tests for comparing supervised classification learning algorithms. Neural Comput. 1998;10(7):1895–923. https://doi.org/10.1162/089976698300017197.
50. Davis JP, Valentine T. CCTV on trial: matching video images with the defendant in the dock. Appl Cogn Psychol. 2009;23(4):482–505. https://doi.org/10.1002/acp.1490.
51. Meissner CA, Susa KJ, Ross AB. Can I see your passport please? Perceptual discrimination of own- and other-race faces. Vis Cogn. 2013;21(9–10):1287–305. https://doi.org/10.1080/13506285.2013.832451.
52. Terry RL. Effects of facial transformations on accuracy of recognition. J Soc Psychol. 1994;134(4):483–92. https://doi.org/10.1080/00224545.1994.9712199.
53. Noyes E, Jenkins R. Deliberate disguise in face identification. J Exp Psychol Appl. 2019;25(2):280–90. https://doi.org/10.1037/xap0000213.
54. Kemp RI, Caon A, Howard M, Brooks KR. Improving unfamiliar face matching by masking the external facial features. Appl Cogn Psychol. 2016;30(4):622–7. https://doi.org/10.1002/acp.3239.
55. Valentine T, Davis JP. Forensic facial identification: Theory and practice of identification from eyewitnesses, composites and CCTV. Chichester, U.K.: John Wiley & Sons, Ltd, 2015.
56. Beaudry JL, Bullard CL, Dolin JR. Estimator variables and eyewitness identification. In: Bruinsma G, Weisburd D, editors. Encyclopedia of criminology and criminal justice. New York, NY: Springer; 2014. p. 1384–94.
57. Abudarham N, Yovel G. Reverse engineering the face space: discovering the critical features for face identification. J Vis. 2016;16(3):40. https://doi.org/10.1167/16.3.40.
58. Abudarham N, Shkiller L, Yovel G. Critical features for face recognition. Cognition 2019;182:73–83. https://doi.org/10.1016/j.cognition.2018.09.002.
59. Farley R. Homicide trends in the United States. Demography 1980;17(2):177–88.
60. Maluleke R. Crime statistics series volume V: Crime against women in South Africa. 2018. Report No.: 03-40-05. http://www.statssa.gov.za/publications/Report-03-40-05/Report-03-40-05June2018.pdf. Accessed 18 Mar 2021.
61. White D, Dunn JD, Schmid AC, Kemp RI. Error rates in users of automatic face recognition software. PLoS One 2015;10(10):e0139827. https://doi.org/10.1371/journal.pone.0139827.
62. Zorin A, Abramov N. Disguised face detection. In: Kim KJ, Kim H-Y, editors. Information science and applications. Singapore: Springer; 2020. p. 509–17.
63. Kumaar S, Vishwanath RM, Omkar SN, Majeedi A, Dogra A. Disguised facial recognition using neural networks. In Proceedings of the 3rd International Conference on Signal and Image Processing (ICSIP); 2018 July 13-15; Shenzhen, China. Piscataway, NJ: IEEE; 2018. p. 28–32.
64. Yoshino M, Noguchi K, Atsuchi M, Kubota S, Imaizumi K, Thomas CL, et al. Individual identification of disguised faces by morphometrical matching. Forensic Sci Int. 2002;127(1–2):97–103. https://doi.org/10.1016/S0379-0738(02)00115-9.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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