Face Familiarity in Deep Convolutional Neural Networks

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Introduction

State-of-the-art Deep Convolutional Neural Networks (DCNNs) perform with
- high accuracy on face identification tasks (e.g. Taigman et al. 2014).
- good generalization across viewpoint, illumination, and ***appearance***.

To date, DCNN performance tested only with 'cooperative' images.
DCNN performance for disguised faces is unknown.

Here we test identification performance of a state-of-the art DCNN on disguised face images (Sankaranarayanan et al. 2016).

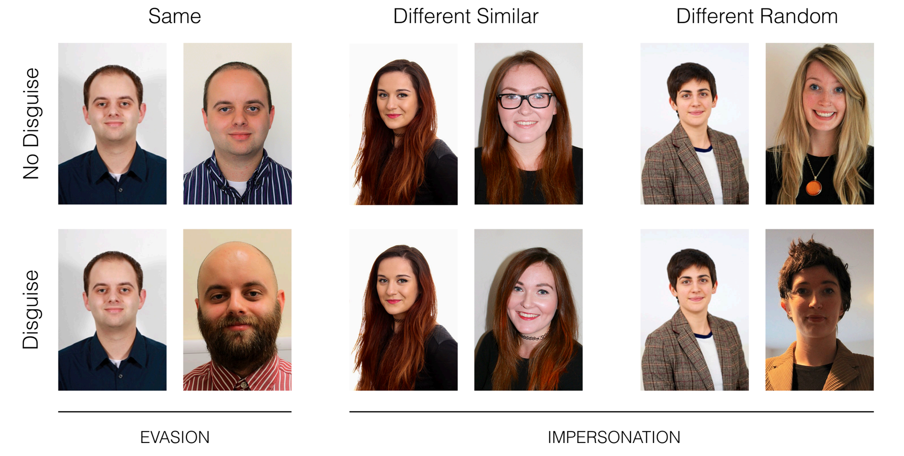
DCNNs – *are they impaired by evasion and impersonation disguise?*
Humans are strongly impaired by evasion disguise; less impaired by impersonation (Noyes & Jenkins, submitted)

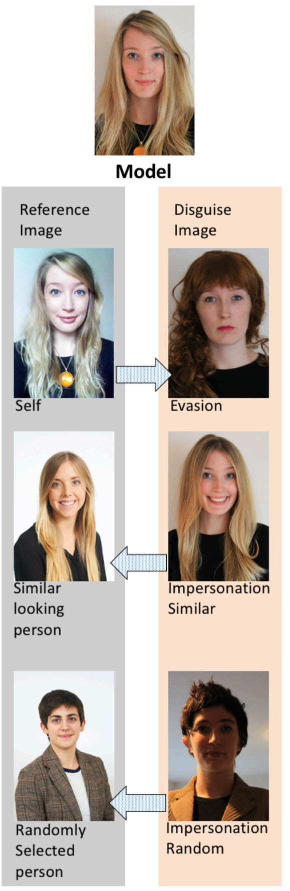
DCNN performance for disguised faces – do they improve with identity **familiarization**?
Humans -> more accurate for **familiar** disguised faces (Noyes & Jenkins, submitted).

Stimuli

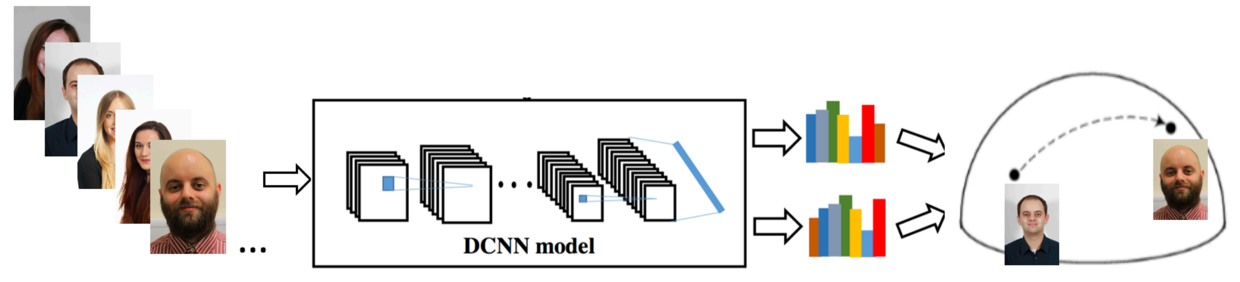
- Stimuli - FAÇADE image dataset (26 models)
- Conditions - No Disguise and 3 Disguise types

Evasion: model photographed to look unlike self.
Impersonation Similar: model photographed to look like a 'similar' person.
Impersonation Random: model photographed to look like a 'random' person.





DCNN Similarity Procedure



1. FAÇADE images input to algorithm
2. Processed…
3. 'Feature vectors' generated for each image
4. Similarity scores computed

(Sankaranarayanan et al. 2016)

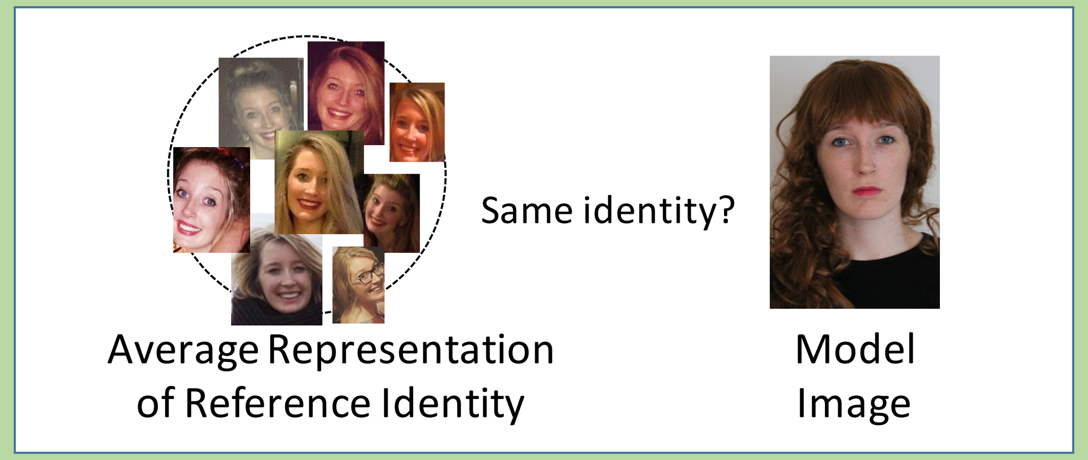
If similarity scores > criterion = same identity, if not = different identity

Human & Machine: Face Matching

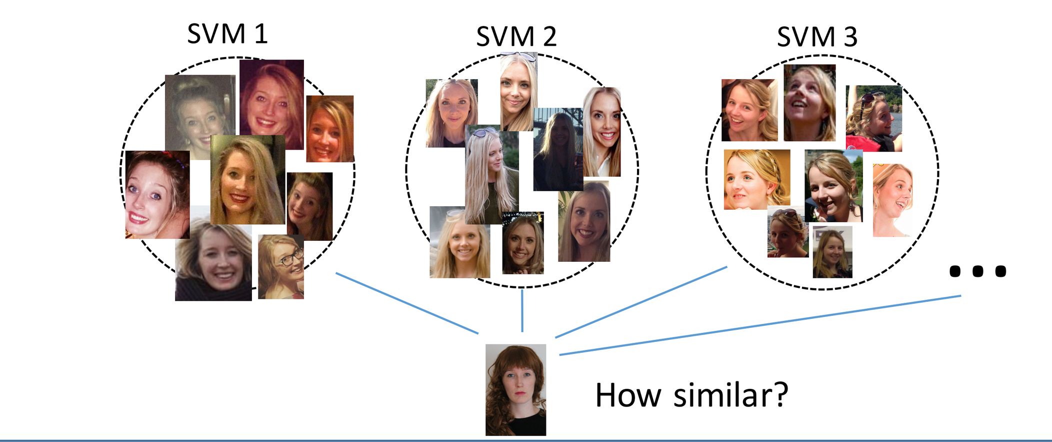
(Noyes & Jenkins, submitted; Noyes et al. 2017)

2 Methods of Familiarity

Averaging Method of Familiarity



Contrast Method of Familiarity



Methods

Human & Machine: Face Matching

- Paired matching task on humans (Noyes & Jenkins, submitted).
- DCNN matching performance computed by calculating similarity score between **Reference Image** and **Model Image** for each image pair.
- Similarity score compared against criterion to determine same/different identity response.

Averaging Method of Familiarity

- When people learn a face, they may create an average image-based representation for multiple images of the face (Kramer, Ritchie & Burton, 2016).
- **Alternative model**: Average ***DCNN face representation***:
  - Varied number (N= 0-100) of no disguise images of each model submitted to DCNN.
  - Similarity score calculated by comparing **Average Representation** with **Model Image.**

Contrast Method of Familiarity

- Familiarity depends on learning ***within-identity variation*** and ***between-identity contrasts***.
- Trained SVM classifiers for each identity. DCNN learned many images of each identity, and how each identity differed from all other identities.
- All images compared to SVMs. Dot product for each image pair calculated to produce similarity score.

Results

Human & Machine: Face Matching

% of correct responses

	Unfamiliar Human Participants		Familiar Human Participants		DCNN		
	No Disguise	Disguise	No Disguise	Disguise	No Disguise	Disguise	
Same	96	60	98	87	100	50	Evasion
Different Similar	92	82	99	98	100	96	Imp. Sim.
Different Random	98	89	100	98	100	92	Imp. Rand.

Averaging Method of Familiarity

% of correct responses

	No Images	3 Images	5 Images	10 Images	20 Images	All Images
Same No Disguise	100.0	100.0	100.0	100.0	100.0	100.0
Same Disguise	50.0	46.9	52.3	64.6	65.4	69.2
Different Similar No Disguise	100.0	99.2	98.5	96.2	96.2	96.2
Different Similar Disguise	96.2	95.4	87.7	85.4	87.7	84.6
Different Random No Disguise	100.0	100.0	100.0	100.0	100.0	100.0
Different Random Disguise	92.3	96.2	95.4	95.4	96.2	96.2

Contrast Method of Familiarity

% of correct responses

	3 images	5 images	10 images	20 Images	All Images
Same No Disguise	99.2	99.2	100.0	100.0	96.0
Same Disguise	40.0	43.9	44.6	46.2	57.6
Different Similar No Disguise	99.2	100.0	100.0	100.0	100.0
Different Similar Disguise	99.2	100.0	100.0	100.0	100.0
Different Random No Disguise	100.0	100.0	100.0	100.0	100.0
Different Random Disguise	99.2	100.0	100.0	100.0	96.0

Main Premise

Unfamiliar
- Humans : No Disguise > Impersonation >>> Evasion
- DCNN : No Disguise > Impersonation >>> Evasion

Familiar
- Humans : No Disguise > Impersonation > Evasion
- DCNN : ????

'Averaging' Method Results:
- Increased performance on Evasion trials
- But… ***decreased*** performance on different-identity face pairs

'Contrast' Method Results:
- Increased performance on Evasion trials
- Maintained high performance on different-identity face pairs

Conclusions

- DCNN (and human) identification performance impaired by Evasion Disguise.
- Averaging Method improved Evasion Disguise but reduced performance on different-identity trials.
- Contrast Method improved Evasion Disguise and maintained high performance of different identity trials. ✔

References

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