Facial composites: A successful collaboration between technology and psychology

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SIBGRAPI 2016: WORKSHOP ON FACE PROCESSING APPLICATIONS: BIOMETRICS AND BEYOND

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University of Greenwich

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3

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  - Felicia Treml
    - University of Greenwich

Facial Composite System

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- Tool for creating a likeness to a suspect's face based on an eyewitness' description and memory
- Used by most UK police services and internationally
- Sometimes **only** tool available to locate suspect

Human Face Memory

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- Composites constructed by a witness/victim *unfamiliar* with the culprit
- Aim = Identification by a witness *familiar* with the suspect/culprit (often police officers)
- Unfamiliar and familiar faces processed by different cognitive and memorial mechanisms
  - Familiar face recognition based on "abstract" representation compiled from many views
  - Unfamiliar face recognition more image-based/episodic (Burton *et al.*, 2005)
  - Internal/external features
  - Neuroscience
  - Neuropsychology

Familiar Face – Image Variation

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Unfamiliar Face(s) – Image Variation

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Answer = 2 (Jenkins et al., 2011)

Witness Memory

- Stress
  - Weapon effect
  - Attention
- Cross-ethnicity effect
- View of culprit
  - Disguise
  - Lighting
- Alcohol
  - Drugs
- Repeat ID

Jennifer Thompson/Ronald Cotton (1984)

- Jennifer Thompson
  - Rape/burglary case
  - Victim "closely studied the culprit's face, determined to help the police later"
- **Facial Composite**

Jennifer Thompson/Ronald Cotton (1984)

Facial Composite

Photo line-up

Live Line-up

Ronald Cotton

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- 1985: Rape and burglary
  - Cotton: Life imprisonment
- 1987: Appeal - Defence – called Bobby Poole
  - Jennifer Thompson called as witness – failed to ID Poole
    - Cotton: Life + 54 years

- 1995: DNA proved Poole was perpetrator
  - Cotton exonerated

Innocence Project (2016)

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- USA 344 DNA exoneration cases
  - 75% Eyewitness misidentification
  - 30% Composite/sketch production
  - Newirth (2016)
    - "Creating a composite can essentially contaminate a witness' memory so that the witness can no longer discern - between their memory of the perpetrator and the likeness that they helped to create through the composite sketch process"
    - "Although composites have long been a tool of investigation, they should be avoided at all costs."

Rapist Manchester (2010)

- See Frowd (2015): EvoFIT


History

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Composite Systems

- Artist's Sketch
- Generation 1: Mechanical systems
  - Identikit and Photo-FIT
- Generation 2: Software feature-based systems
  - E-FIT, FACES, PROfit & Mac-A-Mug Pro
- Generation 3: Evolving holistic systems
  - EFIT-V (EFIT6), ID, EvoFIT

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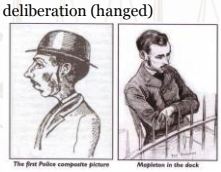
First Artist's Sketch

- Percy Lefroy Mapleton (1860-1881)
  - Issac Gold murdered on a train
    - Sussex, England
    - Artist's impression published in *The Daily Telegraph*
    - Located 10 days later
    - Sentenced to death after 10 min jury deliberation (hanged)



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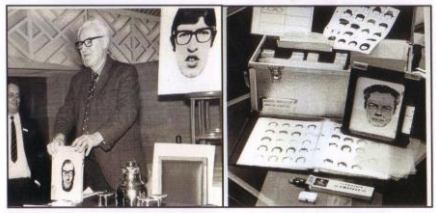
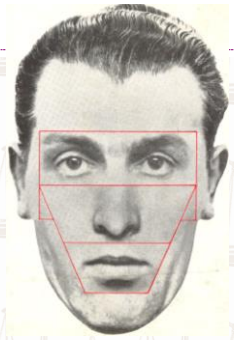
The Penry Facial Identification Technique (Photo-FIT)



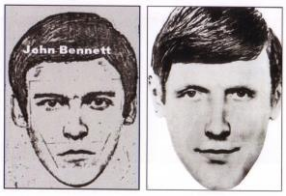
Jacques Henry demonstrating Photo-FIT An early Photo-FIT kit

- Manufactured by Waddington's (Monopoly)
  - Different ethnicities



1970: James Cameron

- First successful use of Photo-FIT in murder of Cameron in Islington, London
  - Broadcast on TV



Analysis of use in 'real' cases

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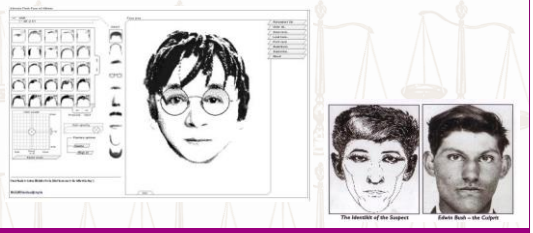
- 729 composites (Photo-FIT; Kitson *et al.*, 1978)
  - Of 140 cases 'solved'
    - 5% of cases: 'entirely responsible' for solving case
    - 17%: 'very useful'
    - 33%: 'useful'
    - 20%: 'not very useful'
    - 25%: 'no use at all'

Identi-KIT: 1961 (UK Case)

1. Developed USA, Los Angeles Police Department
2. Sketched facial features on transparencies overlaid to produce likeness



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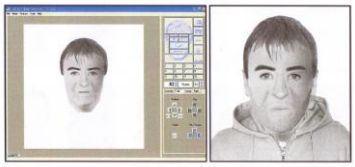
E-FIT (Electronic Facial Identification Technique, 1989)

- Metropolitan Police Service, London
  - Trial computerised system relying on witness describing and recognising 7 facial components
  - Allowed size rescaling, 'artistic' refinements
  - New developments still ongoing



Colin Ireland (1993)

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Feature-Based Composite Systems

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- Requires verbal recall of facial features to generate visual description
  - Hard to recall facial features in isolation
  - Hard to verbally describe facial features
  - Mismatch between psychological processing modes
    - Visual mode vs. verbal mode
  - Feature based approach not well suited to global transformations
    - (e.g., increasing perceived age; Perceived personality attributes)
  - Artistic skill required to add enhancements.
  - Faces processed holistically not feature-by-feature (Tanaka, 1993)
  - Recognition easier than recall

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Holistic Processing

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- Sometimes called configural processing
- Some models propose three stages
  1. Feature-based processing
  2. Configural processing
  3. Holistic processing

Composite Face Effect

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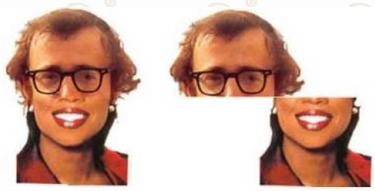
- Famous Faces
  - Woody Allen vs. Oprah Winfrey



Orientation

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- Yin (1969): Better at recognising upright faces than they are other objects.
  - Worse with inverted faces than for other inverted objects
  - Face recognition processes *qualitatively different* from object recognition?
  - *Holistic* processing disrupted

Margaret Thatcher

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- British Prime Minister (1979-1990)

Margaret Thatcher

33

- British Prime Minister (1979-1990)

Configural Processing Hypothesis

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- Bartlett & Searcy (1993):
  - Cannot determine the configuration of features when faces are inverted
  - Unaware of the odd configurations within inverted image
  - Holistic processes not operating when inverted

Features vs. Whole

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- Not possible to discern facial feature details
- Recognition still possible

Holistic Facial Composite systems

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- EFIT-V (EFIT6)
  - Used by the majority of UK police forces
  - 30 other countries worldwide
  - http://www.visionmetric.com/
  - Recognition of faces rather than recall of individual features
    - Other holistic systems: EvoFIT, ID

EFIT-V (EFIT6)

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- Training sample of images
  - Dimension reduction using principle component analysis (PCA)
  - Virtual faces generated by a Linear combination of numerical values
- Iterative search using evolutionary algorithm (Gibson, 2003)
  - Similar idea to DNA
    - Vector = genotype
      - Genotype is the set of genes in our DNA which is responsible for a particular trait.
    - Face image = phenotype
      - The phenotype is the physical expression, or characteristics, of that trait.
  - Select multiply mutate procedure
  - Photo-realistic faces: Implausible looking composites unlikely to occur
  - Parameters of the linear combination that results in a likeness to the perpetrator determined by witness selection

EFIT-V (EFIT6)

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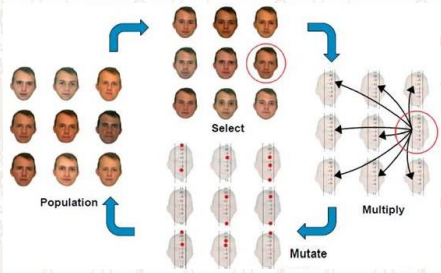

Procedure: 'Suspect'

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Procedure: Construction EFIT-V (EFIT6)

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Davis, Maigut, Jolliffe, Gibson, & Solomon (2015)

Final EFIT-V (EFIT6)

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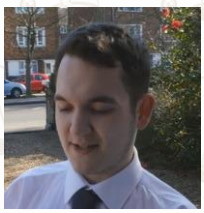

Identification rates

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- Solomon, Gibson, & Maylin (2012)
  - 18-month period – 1,000 composites constructed in police investigations revealed identification of suspects in 40% of cases

Improving Facial Composites

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Valentine, Davis *et al.* (2010)

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- Morphing study
  - Stage 1: Creation: Unfamiliar participant-witnesses
    - 2 min video: TV soap stars
    - Create four EFIT-Vs of target
- Stage 2: Morphing
  - Between-witness morphs
  - Within-witness morphs

Between-witness morph

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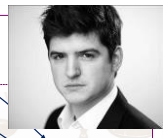

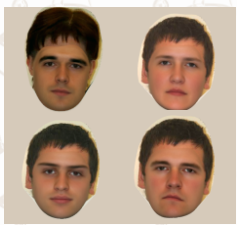

Witness A Witness B Witness C Witness D

25% 25% 25% 25%

Morphed from individual composites ranked 1st by each creator

Within-witness morph

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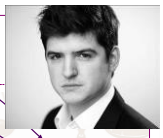
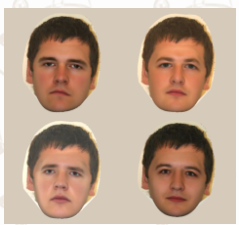
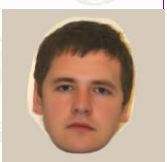
30% 40% 20% 10%







Stage 3: Naming task

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- *n* = 650 familiar with at least one soap opera
- Naming task
  - Un-manipulated original individual composites
  - Between-witness morphs
  - Within-witness morphs
  - Can you name the real photographs?

Dependent variable = Naming rate

Results

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- Best individual composite: 65.4%
- Best within-witness morph: 77.8%
- Best between-witness morph: 78.0%

Mean Results (10 composites)

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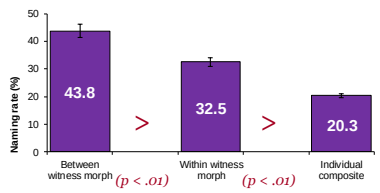

- ANOVA, $F(2, 647) = 58.55$, $p < .001$

Why?

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- Creating witnesses: Unfamiliar with culprit
- Recognising witnesses: Familiar with culprit
  - Familiar faces recognised better from internal features
  - Unfamiliar faces from external features (Ellis, Shepherd, & Davies 1979)
- Frowd *et al.* (2007)
  - Creating witnesses poor at replicating internal features of face
  - Morphing removes random errors in particular from internal features
  - Morphing less effective with external features as correlated

Experiment 2

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- 5 Novel Celebrities
  - n = 20 Unfamiliar creating-witnesses
- Design: 3 x 3 Repeated measures
  - Factor 1: Image type
    - Between-witness morphs
    - Within-witness morphs
    - Individual composites
  - Factor 2: Feature presentation
    - Whole faces
    - External features
    - Internal feature
- DV: Similarity task (315 images)
  - (mark out of 10)
  - n = 40 Familiar rating-witnesses

Similarity task (out of 10)

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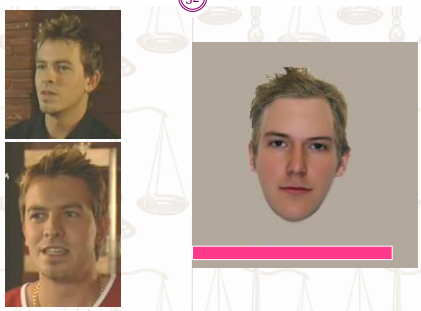

Mean Results

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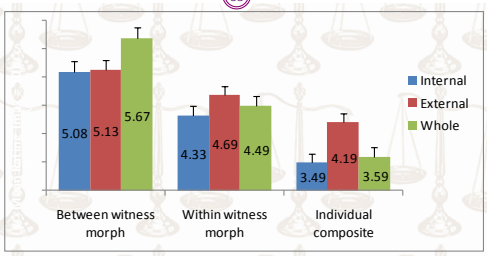

Main effect image type: $F(1.46, 57.05) = 189.27$, $p < .001$
Main effect feature presentation: $F(1.92, 74.74) = 7.76$, $p < .001$
Interaction: $F(2.65, 103.45) = 29.47$, $p < .001$

Summary

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- Witnesses less able to recreate internal features
  - Morphing improves internal configurations of composites by removing random errors
  - Less effective with external features as errors correlated
  - Errors in within-witness morphs may be correlated, meaning that morphing less effective
  - Using EFIT-V hairstyle is selected first and witnesses tend to select same hairstyle each time meaning external features correlated
- Davis, Sulley, Solomon & Gibson (2010): E-FIT; EFIT-V

Real Case of Rape

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Morphing applied

Suspect = 20 years in prison

Morphed EFIT-V and Rapist

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20 years in prison

Caricaturing

- Frowd et al. (2007)
  - E-FIT, Sketch & EvoFIT blended with an average face
- -50% Anticaricature
- +50% Caricature

Dynamic Caricatures

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- Frowd *et al.* (2007): EvoFIT; ProFIT
  - Madeleine McCann case: EFIT-Vs

Perceptual Backdrop Image

- Frowd *et al.* (2013) and (Davis *et al.*, 2015) – only one image required
  - Composite shown (to police staff and the public) accompanied by statement, "Viewing the composite sideways may help you to recognise the face"

Davis, Sulley, Simmons et al. (2015)

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- Within-witness morphs and Between-witness morphs rated and named more often than individual composites
- Perceptual sketch images rated as better than individual composites
  - Combining perceptual sketch and morphing confers no additional advantage
    - Suggests limit to the advantages of different 'averaging' techniques to improve composite naming likelihood

Prior-creation enhancement

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Holistic Interview

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- Verbal Overshadowing Effect (Schooler & Engstler-Schooler, 1990)
  - Describing a face can negatively influence subsequent face recognition and composite production (Frowd & Fields, 2010)
  - Relatively short term effect
  - Possibly shifts processing mode from holistic to feature-based mode prior to composite construction
- Holistic Cognitive Interview (H-CI)
  - "Think about perceived personality of offender"
    - Cues: Health, Masculinity, Pleasantness, Honesty, Distinctiveness, Intelligence, Likeability
  - Frowd *et al.* (2008)
    - Cued naming PRO-fit no H-CI: 9%
    - Cued naming following H-CI: 41%

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Influence of Composite Creation on Lineup Identification

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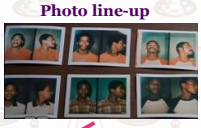
- Remember Jennifer Thompson/Ronald Cotton

Facial Composite

Photo line-up



Live Lineup

Video Line-up (UK)

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1 suspect, 8 foils – 15 seconds each: Play entire video twice....

Witness Final Selection

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Culprit/EFIT-V/Video Line-up

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Davis, Gibson & Solomon (2014)

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1. Does E-FIT or EFIT-V facial composite creation influence identification accuracy from a subsequent PROMAT video lineup?
   - E-FIT **feature-based system**
   - EFIT-V **holistic system**
2. Does the creation of more than one EFIT-V of the same target influence identification accuracy from a video lineup?
3. Davis, Thorniley, Gibson & Solomon (2016: Do children from 6-11 years-of-age possess the capacity to create an EFIT-V, and if so does this influence identification accuracy from a video lineup?

Davis *et al.* (2014): Experiment 1

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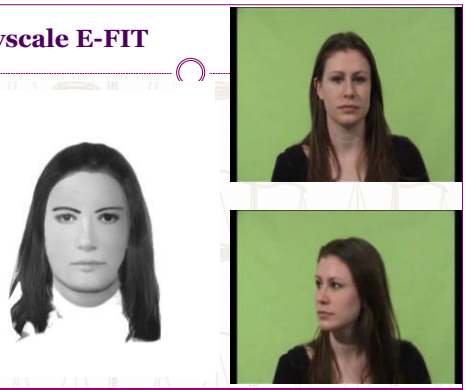
- Influence of E-FIT and EFIT-V composite creation on PROMAT video lineups
  - *n* = 385
- Stage 1: One Student actress unknown to all participants
  - 1 min 18 sec video
- Stage 2: Composite creation
  - Participant-witnesses created either an E-FIT or EFIT-V
  - Controls: No composite
- Stage 3: PROMAT video sequential lineup
  - Unbiased warning: "may or may not be present etc."
  - Target Presence: Culprit present vs. Culprit absent
  - System: E-FIT vs. EFIT-V
  - Role: Witness vs. Control

Greyscale E-FIT



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Colour EFIT-V

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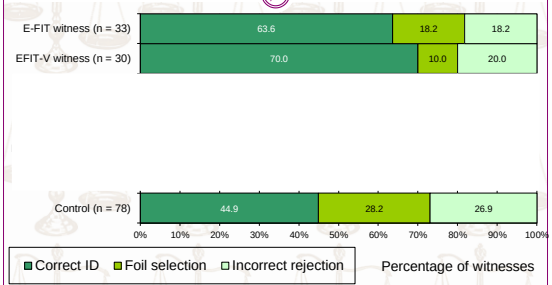
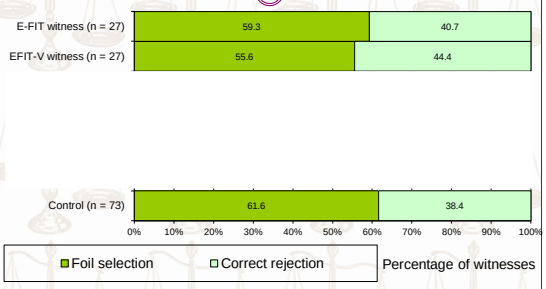
Target present video lineup

72



Target absent video lineup

73



Summary

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- Creating a facial composite improved memory for offender
- Criticism
  - Delay brief (2 hours from crime video to lineup)
  - Single actress
  - Student operators and witnesses

Davis *et al.* (2014): Experiment 2

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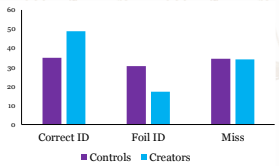
- Final component of police operator training
  - Stage 1
    - Controls (n = 157) view crime scene video (6 actors)
    - Creators (n = 41) view video and then construct up to 3 EFIT-Vs, each with a different police operator
  - Stage 2
    - Mean delay = 30 hours



Conclusions

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- Creation of one EFIT or EFIT-V improves lineup identifications
- Within-witness morphing improves EFIT-V composites
  - Increases likelihood of subsequent suspect ID

Davis, Thorniley, Gibson & Solomon (2016)

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- Examining influence of creating an EFIT-V on children's target present identification
  - Children (6-11 years)
  - Adults
  - Age-matched controls
- One operator
- Two videoed male targets

Best composites (familiar ratings)

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- *A: Adult composite (6.3 out of 10)*
- *B: PROMAT still of Actor B*
- *C: Child composite (5.0 out of 10)*

A B C

Mean Rating Data

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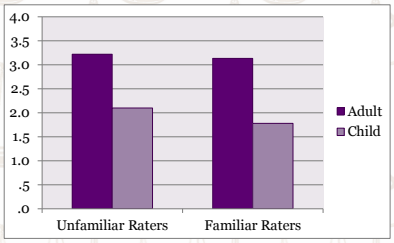

Target Present Lineups

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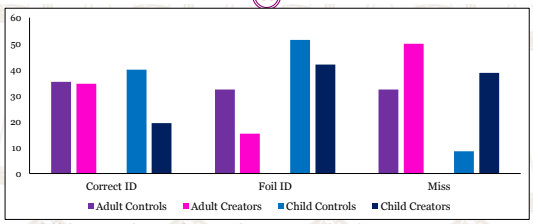

- Child controls tend to make more selections
  - Child creators make more misses
- Child witnesses significantly less likely to ID culprit
  - Accuracy related to composite quality

Recent Child EFIT-V

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- Sexual assault at Legoland, UK
  - The offender touched the two six-year-old girls
  - The offender, not known to the victims, is a white man, in his teens or early twenties, possibly under 5ft 8ins. He was wearing dark-coloured slim fitting trousers, a dark-coloured T-shirt, and trainers.

Jennifer Thompson/Ronald Cotton (1984)

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Facial Composite

Photo line-up

Live Line-up

Newirth (2016)

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- Newirth (2016) Innocence Project
  - "Although composites have long been a tool of investigation, they should be avoided at all costs"
  - Legal framework differs across jurisdictions
    - USA: Composite often created even if suspect apprehended
    - UK: Composite creation prohibited if there is a suspect in the case
  - USA – mainly feature-based composite systems
  - UK – mainly holistic composite systems
  - Composites can be the ONLY lead in a case

Lesson to Computer Scientists

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- I mentioned I was a psychologist to two delegates at SIBGRAPI (2016)
  - 'Shocked and stunned'
- Work with psychologists
  - Computer scientists develop excellent tools based on the design of the system
  - Sometimes the interface can be too complex for layperson use
  - Beneficial to work in collaboration to enhance design
  - Understanding human processing useful for computer processing
  - LASIE Project (www.lasie-project.eu)
    - 18 partner-collaboration across Europe
      - Computer vision and pattern recognition, psychology, police, legal/privacy and commercialisation experts

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Thank you!

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- Happy to e-mail slides