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Holistic facial composite systems: Are they compatible with witness recall?

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Facial composite systems offer a particular challenge to human-computer interaction as they must facilitate several cognitively complex tasks and also aid communication between the operator and the witness. This paper presents the findings from a survey conducted with UK police composite operators that explored some of the issues involved in composite construction. A particular emphasis was placed on the information that witnesses report and its compatibility with both the composite system interface and the underlying construction method used by the system.

Keywords: composite; facial memory; witness; holistic; PCA-based composite system

The purpose of a facial composite is to capture a likeness of a person's face and in police work it is used to generate a suspect in a criminal investigation. Police artists sometimes work with a witness to draw a likeness, but more commonly a composite system is used. Different generations of such systems can be identified, and psychological research has helped to inform the development of the later systems. Producing a facial composite is a cognitively difficult task (Brace, Pike, Allen, & Kemp, 2006) as it requires the witness to recall an unfamiliar face (maybe only seen briefly) and describe it accurately to the police operator. The operator must then take this verbal description and use the system to produce a likely looking face, which is then modified further on the basis of comments made by the witness. As the image being produced is an important element in a criminal investigation, it is critical that all possible information about the appearance of the perpetrator is elicited and that this information is accurately represented by the composite system. The construction process therefore places considerable demands both on the witness and on the software involved, particularly the rather unusual demand that the system be operated by one person at the direction of a second.

As with most technology, facial composite systems have largely been a product of the hardware available at the time of development. The earliest systems, which predate the advent of personal computers, comprised component facial features arranged in books, which witnesses would look through to select each component feature. The first system appeared in 1959 (Identikit I) and used line-

drawn features and accessories. In the 1970s two similar systems emerged (Identikit II and Photo-FIT) which both used monochrome photographed features and permitted artistic enhancement via a transparent overlay. Research undertaken by psychologists highlighted a range of problems which were thought to limit the quality of the composites produced with these systems. The two key problems were with the databases employed, which had only a limited range of features available, and the interface used to construct the image, which relied on a piecemeal technique where the face was constructed by working on one feature in isolation at a time (e.g. Shepherd & Ellis, 1996). This latter is a particular problem given the findings of research which has demonstrated the importance of viewing faces 'holistically' (e.g. Hole, George, & Dunsmore, 1999) and of the configuration of the features (e.g. Hole, 1994). However, research also showed that the quality of the composites constructed was influenced by the expertise of the operator and by the use of artistic enhancement (Gibling & Bennett, 1994).

A range of computer-driven composite systems emerged in the 1980s and 1990s. Mac-A-Mug Pro retained some of the limitations of the earlier systems in that it relied on witnesses selecting each feature to build a likeness. However software-based artistic enhancement was possible and as well as making changes to the features, operators could also change the configuration of the features. Two systems that sought to develop a new user interface not reliant on working individually on features in the database were E-FIT and PRO-fit, and, at the time of writing this paper, they

are still the dominant systems used in the UK as well as being used widely around the world. Both systems involve the operator first interviewing the witness to derive a full verbal description of the perpetrator's face. From this the operator constructs an initial 'first' face and the witness then works with the operator to alter this image. Global and configural changes can be made to the image and there is greater flexibility in the placement of and blending between different facial features. The systems also have larger, improved databases and permit artistic enhancement via sophisticated paint or drawing packages – though both generally use relatively low resolution, greyscale images.

A key point about both the E-FIT and PRO-fit interface is that the witness works on a 'whole' face and manipulates configural information. A considerable amount of research has shown that humans appear to differentiate between faces not just by attending to facial features but by considering the relational arrangements between facial features or the internal spacing of the facial features. Further, recognition of individual features seems to be more accurate when those features are presented within the context of a face. For example, Tanaka and Farah (1993) showed that participants were significantly better at identifying a target feature (such as the nose) when it formed part of a normal whole face than when seen in isolation. However, it was worth noting that the construction process employed by E-FIT and PRO-fit does still largely proceed through changes to individual facial features.

The focus of psychological research investigating these contemporary computerised systems has been to determine whether they produce more accurate facial-images than their predecessors. A variety of quality assessment methods have been utilized, including rating or ranking composites in terms of similarity to a photograph of the person depicted, sorting tasks which involve matching composites to a photograph, and naming tasks in which someone familiar with the person depicted in the composite attempts to identify them. Unfortunately, analysis of naming data typically indicates that composites are of low quality, although sorting tasks and similarity judgements provide a more positive picture. For example, Cutler, Stocklein and Penrod (1988) found participants could match composites produced by an experienced operator using the Mac-A-Mug Pro system to a photograph with a success rate ranging from 58% to 80%. However, using the same system, Kovera, Penrod, Pappas and Thill (1997) found that students were unable to identify a familiar person depicted in a composite image, even though these were of other students or faculty members known to them.

More recently, research has been conducted with a new generation of computerised systems which are currently in development and Frowd et al. (2007) reported promising results, finding higher naming rates for one such new system, EvoFIT, compared with PRO-fit. This new generation, often referred to as holistic systems, take advantage of the statistical technique of Principal Component Analysis (PCA) which incorporates the image properties of whole faces and hence captures facial information that is intrinsically holistic. PCA is applied to a training set of face images to produce 'eigenfaces' (the image equivalent of an eigenvalue) which can be combined to form any face within the 'face-space' of the original training set. Two such systems being developed in the UK are EvoFIT and EFIT-V (the prototype of which was known as EigenFIT). As well as a database based on eigenfaces rather than piecemeal features, both systems have developed interfaces which enable the witness to make more use of 'recognition' and less of 'recall' and which also do not require the witness to focus on separate facial features. This interface typically involves showing an array of faces, from which the witness decides which face is most like the perpetrator. Using genetic algorithms, this selection is used to construct a second array in which the faces share some characteristics with the selected face. The witness again chooses the best likeness and a third array is constructed, and so on until the witness decides that the best likeness in the present array is the best likeness that they can produce. The variation between the faces in each array decreases each time an array is generated, so that the images in each successive array tend to look more and more similar to one another (and, if the process is successful, to the perpetrator).

The use of such an interface means that the composite construction process does not require the witness to provide a verbal description. This is a potentially important development given that verbally describing a face is a cognitively difficult task prone to generalities and inaccuracies. In addition, research using the verbal overshadowing paradigm has suggested that describing a face can interfere with later recognition of that face (e.g. Schooler & Engstler-Schooler, 1990). Although some studies have failed to replicate the verbal overshadowing effect (e.g. Yu & Geiselman, 1993), a meta-analysis of research in the area, conducted by Meissner and Brigham (2001), found the effect to be statistically significant, if small. However, Meissner and Brigham also reported a verbal *facilitation* effect, based on analysis of studies excluded from the main meta-analysis, either because they presented multiple target faces to each participant or used alternative identification procedures. Although these analyses are certainly relevant to composite

construction, where a verbal description is required, the process of constructing a composite is far more complex than simply providing a description and then identifying a face. In particular, composite construction involves a substantial visual component as well as requiring both recall and recognition. Meissner and Brigham (2001) note this distinction and indeed conducted a separate meta-analysis of 8 studies that had included both a composite construction and later identification task. This analysis revealed that composite construction tended to facilitate, rather than overshadow, identification. Indeed, participants who constructed a composite were 1.56 times more likely to make an accurate identification than participants in a 'no-description' control condition. In contrast to this, a more recent study conducted by Wells, Charman and Olson (2005) reported that composite construction reduced the likelihood that the target would be selected from a target-present lineup, although interestingly did not increase false-positive selections from target-absent lineups.

The verbal overshadowing paradigm is particularly relevant to composite construction in terms of demonstrating whether, and how, construction affects later identification of the target. However, the interfaces used with traditional, feature-based composite systems necessitate a construction process that requires both verbal descriptions and recognition. It is therefore possible that verbal overshadowing and/or facilitation effects could operate within the construction process itself. As well as the impact on composite accuracy of traditional methods of construction, there is a particular need to consider whether the new interfaces developed for use with PCA-based systems offer more, or indeed less, opportunity for either facilitation or overshadowing.

In addition to how they interact with witness cognition, the interfaces developed for the new generation of systems represent a radical departure from those used currently and historically, thus raising a number of questions regarding how effectively they could be used in real investigations and by real police operators. One particular question that arises with these new systems is whether police operators should adapt the way witnesses are interviewed to better suit the new interface. Frowd et al. (2007) described a holistic interview which centres on a series of personality judgements rather than eliciting information on individual facial features. They first asked the witness to describe in their own words the personality of the target face, and then to assign a rating to each of seven personality traits (honesty, intelligence, friendliness, kindness, excitability, selfishness and arrogance). However, so far holistic interviewing and, more recently, Holistic-Cognitive Interviewing (Frowd,

Bruce, Smith, & Hancock, 2008), have only been shown to improve the quality of composites constructed using the PRO-fit system, and not the new generation of systems such as EvoFIT.

It is clear that the design of existing composite systems, such as E-FIT and PRO-fit, was informed by psychological research conducted specifically on facial composites as well as more general research on human face perception and memory. Their development has also been informed by the needs of their police users and the demands of relevant policing legislation and guidelines. For newer systems, such as EFIT-V and EvoFIT, to offer a real-world improvement in performance it is crucial that their development therefore takes account of both psychological relevant research and the needs of potential users. The aim of the current paper is to report the results of a survey that was conducted with experienced police composite operators and which explored their experiences of working with real witnesses, in particular the type of information witnesses tend to recall about the face of the perpetrator. This survey was administered during the initial phase of developing the EFIT-V system (indeed to inform the design of the prototype EigenFIT). The survey also sought the opinions of police users on a variety of possible interfaces that can potentially be used with the new generation of composite systems. As well as informing the design and development of the system itself, the results of the survey are also of importance when considering whether, and how, to adapt witness interviewing techniques in order to make better use of the new generation of composite systems.

Method

Survey instrument

A questionnaire was constructed with multiple sections. The first asked about the experience of the operator with different composite systems and the training they had received. The second section asked operators to reflect upon their experience regarding the verbal descriptions that witnesses provide just before composite construction commences. The third section was directed at the composite construction process and the type of requests for changes to the composite that witnesses make during construction. The final section asked operators for their views on new array-based systems and possible types of interface. Where possible, questions asked for a response on a five point Likert-type scale.

Sample and Procedure

A questionnaire was sent out to 200 UK E-FIT and PRO-fit operators by post. The operators were identified using existing user-group lists; these being the most complete and inclusive record of police

operators that was available at the time. A covering letter explained that as a research group we were involved in developing new facial compositing techniques and systems, and felt it was vital to gain the opinions of those using compositing systems with real witnesses. Contact details were supplied in case of queries and anonymity was assured. Operators were not offered payment for their participation. Seventy-six police composite operators completed and returned the questionnaire, giving a response rate of 38%. As is always the case with surveys including an opt-in element, there is the possibility that pre-selection effects mean that the respondents were not representative of the broader population being sampled. However, although it is important to bear this factor in mind when interpreting the results, analysis of the respondents did show them to cover a broad range of experience, roles and geographical locations, suggesting that the respondents were not limited to any particular sub-group of police operators and were generally representative in terms of these factors.

Respondents

Of the 76 UK police composite operators who returned the questionnaire, 50 were male and 26 female. Two were former sketch artists and 6 still worked as sketch artists. Their job titles varied and police ranks represented included constable, detective constable and detective sergeant, as well as a small number of civilian operators. All were familiar with E-FIT, 2 were also familiar with PRO-fit, 6 with CD-FIT, 4 with 3D-FIT, 9 with Photo-FIT and 3 with Identikit. Approximately 17% had up to and including 1 year's experience as a composite operator, 55% over 1 and up to and including 5 year's experience, 15% over 5 and up to and including 10 year's experience and 13% over ten year's experience. Almost 90% had received formal training with 10% reporting that they had received guidance from another user.

Results and Discussion

The two main computerised systems that are in the UK and also in many other countries, E-FIT and PRO-fit, rely on witnesses giving a full verbal description of the perpetrator's face in a pre-construction interview. This description then allows the operator to create a 'first' composite image that witnesses can then work on to amend with the operator. One of the first questions asked was "In general, how difficult do witnesses find providing a verbal description of the face?". Only 2 respondents reported that witnesses do not find it difficult to provide such a verbal description. Just under 15% reported that this was a slightly difficult task and just under 58% a fairly difficult task with the remainder,

21%, that this was a very or extremely difficult task. The questionnaire explored whether witnesses provided information suited to a holistic-type interview and composite system, and their responses are reported in the following sections.

Recall of holistic information in pre-construction interview

Currently, UK composite operators are trained to conduct a full Cognitive Interview (CI) (see, for example, Fisher & Geiselman, 1992) before starting composite construction. This commences with a free recall stage, thus first requiring witnesses to recall all the information they can about the perpetrator, their physical appearance and voice attributes. Then the operator will use the CI mnemonic strategies, including the instruction to form a mental image, to elicit further information. The aim is to obtain as full a description of the perpetrator as possible. When asked about the description the witnesses provided during this interview, operators reported that descriptions would often include information about the more 'holistic' aspects of the face. This type of information is not easily incorporated into the facial composites when using traditional feature-based systems such as E-FIT and PRO-fit, however they do form dimensions that PCA-based systems could include. Table 1 below shows how operators responded when asked about the witness' description of certain facial dimensions in the pre-construction interview. They were asked about the frequency with which witnesses described the face in terms of facial expression (e.g. startled or menacing), character (e.g. a friendly or mean face), gender (e.g. masculine or feminine), ethnicity (e.g. Caucasian or Asian-looking), attractiveness (e.g. handsome or ugly), distinctiveness (e.g. very average or odd-looking) and age (e.g. younger, older, middle-aged).

Table 1: Percent of respondents reporting how often witnesses mention specific types of holistic information in pre-construction interviews

	Always	Often	Some times	Rarely	Never
Expression	1.3	25.0	38.2	30.3	3.9
Character	6.6	40.8	34.2	14.5	1.3
Gender	26.3	15.8	14.5	28.9	13.2
Ethnicity	21.1	22.4	34.2	14.5	5.3
Attractiveness	3.9	31.6	31.6	26.3	3.9
Distinctiveness	7.9	51.3	27.6	10.5	1.3
Age	27.6	46.1	19.7	5.3	-

Table 1 shows that nearly three quarters of operators reported that witnesses 'often' or 'always' included information about age. Over half said they 'often' or 'always' included information about

distinctiveness, and between 42% and 47% that they ‘often’ or ‘always’ included terms relating to character, gender and ethnicity. Only 26% reported that witnesses ‘often’ or ‘always’ mentioned information regarding facial expression. It appears that, even in the type of interview currently conducted by composite operators, useful holistic information is volunteered by witnesses and that cueing for such information could be beneficial if the composite system itself allows operators to manipulate such dimensions.

Recall of holistic information during composite construction

The information gained in the pre-construction interview is used by operators to construct an ‘initial’ facial composite. The witness is then shown this ‘initial’ image and works with the operator to modify it to improve its resemblance to the perpetrator. The questionnaire asked composite operators to comment on the sorts of instructions that witnesses gave to operators during the composite construction stage, when amending this ‘initial’ image. Table 2 below shows how operators responded when asked about the holistic aspects of the face.

Table 2. Percent of respondents reporting how often witnesses mention specific types of holistic information during composite construction

	Always	Often	Some times	Rarely	Never
Expression	-	26.3	31.6	31.6	7.9
Character	-	28.9	35.5	26.3	6.6
Gender	5.3	13.2	27.6	35.5	15.8
Ethnicity	5.3	9.2	36.8	35.5	9.2
Attractiveness	2.6	15.8	40.8	31.6	7.9
Distinctiveness	2.6	21.1	43.4	22.4	7.9
Age	11.8	65.8	19.7	1.3	-

Table 2 shows that even though the operators worked with a composite system where witnesses made changes to the type, size and placement of facial features, some reported that witnesses often or always mentioned holistic information. Whilst over three-quarters responded that witnesses often or always mentioned age-related terms, fewer (between 15% and 29%) indicated that witnesses referred to other holistic dimensions. Allowing age to be manipulated as a dimension would therefore be beneficial to composite construction.

Operators’ views on manipulating holistic dimensions

When asked if they would like to be able to manipulate directly certain holistic characteristics, many operators responded positively. Table 3 shows

the percentage of respondents who reported how useful they thought it would be if they could manipulate directly certain holistic dimensions within the composite system.

Table 3. Percent of respondents reporting how useful it would be to manipulate holistic information during composite construction

	Extremely useful	Very useful	Of little use	Not at all useful	Harmful
Expression	14.5	61.8	17.1	1.3	-
Character	11.8	43.4	35.5	2.6	1.3
Gender	15.8	28.9	32.9	9.2	1.3
Ethnicity	13.2	42.1	34.2	2.6	1.3
Attractiveness	9.2	32.9	38.2	7.9	1.3
Distinctiveness	15.8	40.8	30.3	5.3	1.3
Age	44.7	47.4	1.3	-	-

Table 3 shows that over three-quarters of respondents would find it extremely or very useful to manipulate ‘age’ and ‘expression’ during composite construction. Less than 10% responded that such manipulations would not be useful, and only one responded that in some cases they thought such a manipulation might be ‘harmful’.

Recall of skin-related information in pre-construction interview

The feature-based computerised systems that are currently used require operators to use paint package software to add aspects of the skin such as freckles and wrinkles. This is both time-consuming and requires considerable skill on the part of the operator to ensure a realistic appearance. A holistic system has the capacity for some aspects to be more easily manipulated, in particular freckles and wrinkles. A section of the questionnaire was therefore designed to ask about the extent to which witnesses recalled this type of information in the initial interview. Respondents were asked whether the descriptions witnesses provided in the pre-construction interview contained terms describing aspects of skin type (e.g. clear or freckled complexion), skin texture (e.g. wrinkled, smooth) and skin blemishes (e.g. moles, scars, acne) and terms describing male characteristics (e.g. 5 o’clock shadow) and female characteristics (e.g. make-up). Their responses are shown in Table 4 below.

As Table 4 shows, between one third and nearly half of the respondents reported that witnesses often or always mentioned something about the skin and/or about male characteristics. Less frequent was information about female characteristics. Less than 8%

reported that they would rarely hear information relevant to skin type, blemishes and male characteristics. The responses as a whole suggest that a system that permits this information to more easily manipulated might aid in improving the quality of the composites constructed.

Table 4. Percent of respondents reporting how often witnesses mention skin-related information in pre-construction interviews

	Always	Often	Sometimes	Rarely	Never
Skin type	7.9	39.5	40.8	7.9	-
Skin texture	2.6	36.8	38.2	21.1	-
Skin blemishes	5.3	40.8	43.4	7.9	-
Male Characteristics	7.9	42.1	40.8	7.9	-
Female characteristics	3.9	14.5	35.5	32.9	9.2

Operators’ views on manipulating skin-related dimensions

Table 5 below shows the percentage of respondents who reported how useful it would be to be able to manipulate directly aspects of skin within the composite system.

Table 5 shows a consensus among operators. The majority reported that it would be beneficial to be able to manipulate directly certain aspects of the skin. This is reflected in their responses regarding their own experience of adding skin type/texture to achieve an accurate likeness of the perpetrator. When asked ‘How often, in your experience, have you felt that the addition of skin type and/or texture was important for creating an accurate likeness’, approximately 40% reported that this was sometimes important, 38% often important and 5% that it was always important, with the remainder (17%) indicating ‘rarely’ or ‘never’.

Table 5. Percent of respondents reporting how useful it would be to manipulate skin-related information during composite construction

	Extremely useful	Very useful	Of little use	Not at all useful	Harmful
Skin type	18.4	53.9	19.7	2.6	-
Skin texture	19.7	60.5	9.2	2.6	-
Skin blemishes	26.3	53.9	7.9	2.6	1.3
Male characteristics	13.2	43.4	28.9	6.6	1.3
Female characteristics	11.8	43.4	32.9	3.9	1.3

Operators’ views on holistic composite systems

The final section of the questionnaire asked operators to provide their views on the new generation of composite systems. Obviously this section had limited value compared to earlier questions as the operators would have had no experience of such systems at the time. However, operators do obviously have experience of the practical demands of working with witnesses on real cases, so the questions in this section were of potential interest because of what they could reveal about any perceived, real world difficulties associated with new approaches to composite construction.

First, the nature of such systems was briefly explained to them. Operators were then asked whether they felt witnesses could use an array-based system effectively. Respondents were fairly evenly divided between those who felt witnesses could use an array-based system (25% felt they either definitely or probably could) and those who felt they could not (26% felt they either probably or definitely could not). However, almost half (46%) were ‘not sure’ whether witnesses could use such a system, demonstrating the limited value of asking operators questions falling outside their existing experience.

As holistic PCA-based composite systems work by presenting a series of arrays containing multiple facial images, further questions were directed at different selection methods that would allow witnesses to progress through the arrays. These included: choosing a single face from the array that they thought looked most like the perpetrator; choosing two or three faces that they thought looked most like the perpetrator; and providing a score out of ten for each face in the array that indicated how good a match it was to the perpetrator. Overall, nearly half of the responses to all three questions were positive, with approximately one quarter undecided and less than 20% responding negatively. Composite operators were also asked if they thought witnesses would be able to provide specific feedback, such as “it’s like Face 4, but the eyes are bigger and the nose is more like that from Face 7”. Nearly 65% responded that witnesses ‘probably’ or ‘definitely’ could provide such feedback.

When asked if the witness would be able to interact directly with the computer, should the array-face selection method be relatively simple and user-friendly, 40% of operators responded that they did not feel that witnesses would be able to do so. A further 33% were undecided and only 17% provided positive

responses. When asked whether it would still be necessary to have a trained operator to assist the witness, even if the system were simple and user-friendly, 57% responded 'definitely' and a further 21% 'probably'. A number of reasons were provided, including the witness not being computer literate or being elderly, vulnerable, confused or traumatised and hence needing support. Some operators also pointed to legal requirements around evidence or to the extra statements that are collected during the composite construction process.

LIMITATIONS AND FUTURE DIRECTIONS

Several limitations of the current research have already been described, such as the 38% response rate and the fact that the final section of the questionnaire asked operators for opinions (albeit necessarily) outside of their existing experience. Other limitations include possible bias on behalf of the operators, who may have given responses in defence of their current practice or indeed to justify the continued role of police composite operator. For example, many operators indicated that witnesses should not work directly with a composite system and that an operator would always be required. Although such bias cannot be ruled out, it is common practice within UK police services to rotate personnel through different roles on a regular basis, meaning that for many operators there would be no advantage to answering in a fashion designed to perpetuate the continuation of a specific role.

The findings reported here suggest that a substantial number of witnesses, when first interviewed, describe holistic aspects of the appearance of the perpetrator, such as their age, ethnicity, character and distinctiveness. Such findings provide support for considering a move towards the type of holistic interview suggested by Frowd et al. (2007). Research is, therefore, now needed to study whether holistic, or other novel interviewing techniques, will improve the quality of composites constructed using the new generation of systems such as EvoFIT or EFIT-V.

The results of the questionnaire were used to inform the development of the EFIT-V system. Over three-quarters of the composite operators felt that it would be useful to be able to manipulate directly age and expression, and over half that it would be useful to manipulate distinctiveness, character and ethnicity. The development of EFIT-V was informed by this finding and the system does allow age, gender and ethnicity to be manipulated. The results also influenced the design

of a series of experiments aimed at determining the most effective methods of witness/system interaction. (The results of these experiments have been presented to user groups and are being prepared for publication.) For example, analysis of the questionnaire showed that 65% of operators felt that witnesses probably could provide specific, accurate information about facial features. Although providing verbalised details about individual features is in some respects antithetical to composite systems employing array-based interfaces, experiments conducted as a result of this element of the questionnaire found that allowing, but not requiring, participant-witnesses to provide and make use of feature based information did appear to be advantageous to the construction process.

EvoFIT and EFIT-V are now being used in police work, and it will be important for future studies to include a follow-up survey of operators now that they are gaining experience of using the new generation of composite systems. The inclusion of the final section about operators' views on holistic composite systems in the present questionnaire will enable some interesting comparisons to be made with any such follow-up survey that examines operators' views once they have used the new system.

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