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When Emotions Get the Better of Us: The Effect of Contextual Top-down Processing on Matching Fingerprints

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SUMMARY

Twenty-seven participants made a total of 2,484 judgments whether a pair of fingerprints matched or not. A quarter of the trials acted as a control condition. The rest of the trials included top-down influences aimed at biasing the participants to find a match. These manipulations included emotional background stories of crimes and explicitly disturbing photographs from crime scenes, as well as subliminal messages. The data revealed that participants were affected by the top-down manipulations and as a result were more likely to make match judgments. However, the increased likelihood of making match judgments was limited to ambiguous fingerprints. The top-down manipulations were not able to contradict clear non-matching fingerprints. Hence, such contextual information actively biases the ways gaps are filled, but was not sufficient to override clear bottom-up information. Copyright © 2005 John Wiley & Sons, Ltd.

The need to identify people accurately is widespread and is on a sharp rise. With advances in science and technology a variety of tools are now available for identifying people. Nevertheless, fingerprints continue to be the major method used for identification in forensic and other domains (Alam, Akhteruzzaman, & Cherri, 2004). Fingerprints are quite easy to find, collect, and process; and they are also relatively non-intrusive and cost effective. With the development and increased use of computer technology in searching very large amounts of fingerprints held in databases, fingerprints are likely to continue to be the major method for biometric identification, and we can perhaps even expect its use to increase further.

The strength of fingerprint identification also derives from perceived reliability. The use of fingerprints has evolved over a long period of time and for over 100 years fingerprints have been used quite successfully as a means of identification. The reliability of fingerprint evidence stems from applied scientific knowledge of the uniqueness of friction ridge skin within the fields of biology, embryology, and genetics. During all this time there has not been a single reported case of two people having identical fingerprints (even identical twins have differentiated fingerprints). Fingerprint identification seems to have withstood the test of time and proven itself as a sound and authoritative tool. Consistent with the above,

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research has shown that fingerprint evidence affects the perceived innocence or guilt of defendants (Bregman & McAllister, 1987).

However, in recent years the reliability of fingerprint identification has come into question and is under close scrutiny (Cole, 1999; Dror, Charlton, & Péron, 2004; Moenssens, 2003). A publicly exposed erroneous identification has highlighted a shortfall of fingerprint identification. In this case an individual was wrongly linked to the Madrid bombing based on a fingerprint match found by the Latent Print Unit (LPU) of the Federal Bureau of Investigation (FBI) in the United States. A number of experts, including an independent examiner appointed by the court upon the request of the defendant, all confirmed the initial finding of a match. However, a few weeks after arresting the suspect, this match was proved to be false and he was released (for more details, see full report on this erroneous identification, Stacey, 2004). This is only one of a handful of cases that has been publicly exposed and acknowledged. Such cases are only found and acknowledged under extremely unique and rare circumstances, and it is unreasonable to believe that other erroneous identifications have not occurred.

The research reported here attempts to examine some of the processes involved in fingerprint identification and factors that may interfere with these processes. Fingerprint identification involves a decision making process. This requires making a decision as to whether or not a pair of fingerprints match (for example, whether a fingerprint lifted off a crime scene matches that of a potential suspect). Such decisions, as with many other cognitive processes, are composed from two main components: First, the bottom-up component which is purely data driven (see for example, Ashworth & Dror, 2000); and the second is the top-down component in which contextual effects mediate how the input is processed, evaluated, and a final decision is derived (see for example, Dror, Busemeyer, & Basola, 1999; Levy, Ashman, & Dror, 2000).

As per the bottom-up component, each fingerprint is composed of a pattern which is believed to be individually unique. A close examination at three different levels can help decide if fingerprints match or not. The first level examines the overall pattern of friction ridges; the second level examines the characteristics of specific ridges; and the third level zooms in to examine things such as locations and distribution of sweat pores, individual ridge topology, and other uniquely identifiable features.

The examination of such bottom-up information means that if a decision can be made, it would constitute compelling identification evidence (or lack thereof). In an ideal world, such decisions would seem to be rather simple and relatively easy to make: either there is, or there is not, a match. However, in the real world many fingerprints are far from perfect. They are often degraded and partially missing and are often distorted by the substrate upon which the latent print was deposited as well as the constituents that make up the essence of the latent print, such as sweat, oil, grease, and other contaminants.

In fact—even in an ideal world—should an individual provide many sets of fingerprints one after the other, even then they would not be 100% identical (the varying pressure on the skin's elasticity, among other things, would produce slightly different prints). Since no pair of fingerprints are 100% identical, one needs to decide if they are similar enough to determine that they originated from the same individual. In many cases the information contained in the prints (especially those collected at a crime scene) is not enough to enable a sound decision (Ashbaugh, 1999). Although fingerprint matching is a complex and challenging pattern recognition problem, it is important, if not imperative, that decisions are accurate. This becomes an even more monumental task when you take into account top-down processes involved in pattern recognition.

The other component involved in deciding whether there is a fingerprint match is top-down processing. A top-down component occurs when the processing of incoming bottom-up information is mediated by a variety of factors, such as prior experience and knowledge, as well as the person's expectations and emotional state. Top-down processing can facilitate the processing of information by making it more efficient and faster (for example, help direct attention to important features in object recognition, e.g. Dror & Kosslyn, 1998). It can also help interpret ambiguous information (Selfridge, 1955) or fill in missing information (for example, the phoneme restoration effect e.g. Warren, 1970).

However, in some cases top-down influences are so pronounced that they can even override the 'objective' information coming in as input from the bottom-up component (for example, different top-down information leads to contradicting judgments on the same bottom-up data, e.g. Darley & Gross, 1983). Thus, top-down components can interfere and distort the 'objective' processing and evaluation of incoming data. Top-down is a term that encompasses a very wide range of phenomena, such as expectation, hope, context, knowledge, emotional state, and mind set, to name but a few. Indeed, 'mind set' has been identified as one of the main contributors to the FBI erroneous identification (Stacey, 2004).

A large body of research demonstrates that the emotional state of the individual plays a critical role in how they interpret information, and specifically that their interpretations correspond to their emotional state (Byrne & Eysenck, 1993; Eysenck, Macleod, & Mathews, 1987; Halberstadt, Niedenthal, & Kushner, 1995; Niedenthal, Halberstadt, & Setterlund, 1997; Pincus, Pearce, & Perrott, 1996; Richards, Reynolds, & French, 1993). Many of these studies involved looking at lexical ambiguity and revealed that both state anxiety and trait anxiety were linked with increased tendencies to adopt negative interpretations (Byrne & Eysenck, 1993; Richards et al., 1993; Russo, Patterson, Roberson, Stevenson, & Upward, 1996). In addition to verbal stimuli, similar findings linking emotional states to associated interpretations of stimuli have been found using facial expressions (Niedenthal, Halberstadt, Margolin, & Innes-Ker, 2000; Richards et al. 2002), interpersonal situations (Hirsch & Matthews, 1997), and even physical sensations (Calvo & Eysenck, 1998).

Given that fingerprint matching occurs frequently within a highly emotional context of forensic evidence associated with finding those who committed crimes, it is important to examine how emotional states may affect fingerprint identification. There has not been any research examining top-down influences on fingerprint matching. However, research has shown that presenting gruesome evidence does influence the verdicts of mock jurors (e.g. Bright & Goodman-Delahunty, 2004).

In the research reported here we examined people's decisions on matching fingerprints. We observed if and how their decisions were influenced by top-down information. We manipulated their emotional state and motivation to find a fingerprint match by providing background information and by subliminal priming. We were interested to see if such top-down manipulations can affect their decisions, and to what extent.

We manipulated both the level of top-down influence and the actual difficulty of the task. The main manipulation of the top-down component was achieved by introducing information about the background of the crime, where the fingerprint was collected and by including explicit and emotionally provoking photographs. To further strengthen our top-down effect we also introduced subliminal priming by flashing the words 'guilty' and 'same'. This was to examine the general vulnerability of the matching process to top-down external influences. Our task difficulty was manipulated to examine the possible strength

of the top-down component. As the match becomes more difficult, more room was available for the top-down process to make an impact. Hence we included varying levels of ambiguity in the bottom-up information that was provided to the decision makers.

METHOD

Participants

The participants in this study were 27 university student volunteers, with a mean age of 23 (nine were males and 18 were females).

Materials and apparatus

Fingerprints

Ninety-six pairs of fingerprints were selected from a large fingerprint database (Maltoni, Maio, Jain, & Prabhakar, 2003). This database enabled us to use an established set of stimuli to construct our experimental conditions: half of the stimuli (48 pairs of the fingerprints) provided clear and detailed bottom-up information and hence were relatively easy to decide; 24 of them presented a perfect match whereas in the other 24 pairs of fingerprints it was clear that they did not match (see Figure 1 for examples). The other half of the stimuli (the remaining 48 pairs of fingerprints) was not as complete and detailed and hence did not provide sufficient bottom-up information to make a clear decision (see

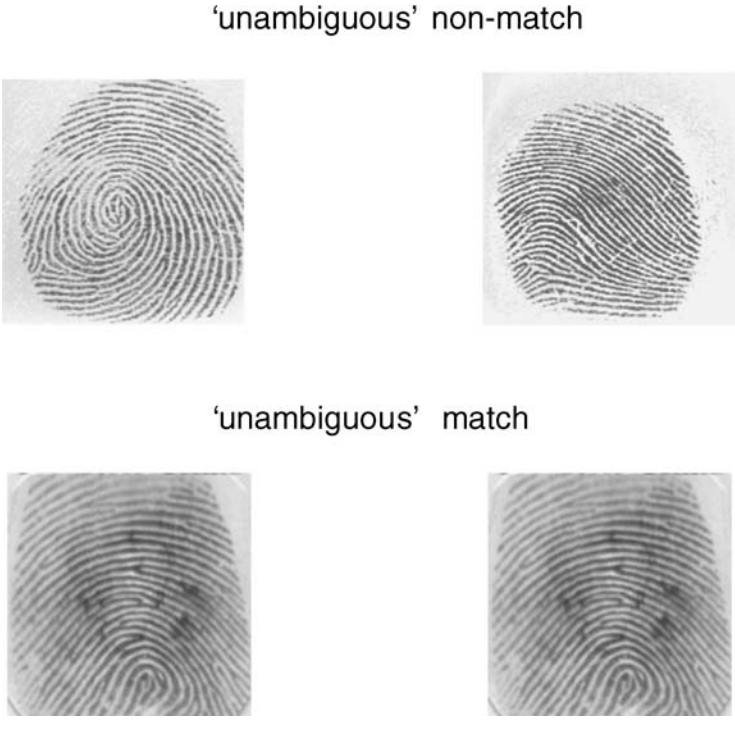

Figure 1. Example of 'Unambiguous' pairs of fingerprints

Figure 2 for an example). We included these ambiguous pairs of fingerprints for two main reasons. First, it was for ecological validity; many fingerprints in real world applied settings are far from perfect. Second, weakening the bottom-up information may allow the top-down component more room to influence the process.

Figure 2. Example of an ambiguous pair

Background information

We invoked two emotional states (low and high) by exposing the participants to background stories and photographs. The background for the low emotional state included stories about bicycle theft, burglary, and other relatively common crimes that do not include physical harm to a person. The high emotional evoking stories included a variety of crimes, such as murder, personal attacks, and other cases where there is a victim who is seriously hurt. To further induce the emotional state we included photographs from the crime scene. For the low emotional state there were photos of the items that were stolen. For the high emotional states we included highly emotional photographs of victims (see Figure 3 for examples). The photographs were obtained from a standardized set of photos (the Affective Photographic Gallery (Lang, Bradley, & Cuthbert, 1997)). These photos have been widely used in research and have been established as evoking emotional states.

Subliminal

To further increase the strength of our top-down bias to find a match we included subliminal messages. Following established paradigms (Levy, Ashman, & Dror, 2000) we made 'guilty' and 'same' messages to present to participants to try and induce them to find a match to convict a suspect.

Apparatus

The experiment was programmed using the experimental software Cedrus Superlab Pro. Participants were tested on an IBM computer with a 17 inch monitor.

Design

All participants were tested in all conditions. There were two levels of stimuli difficulty (ambiguous vs. unambiguous) and four levels of top-down influence (a control with no emotional influence, low emotion stories and photographs, high emotion stories and photographs, and the highest level of top-down influence that includes the high emotion

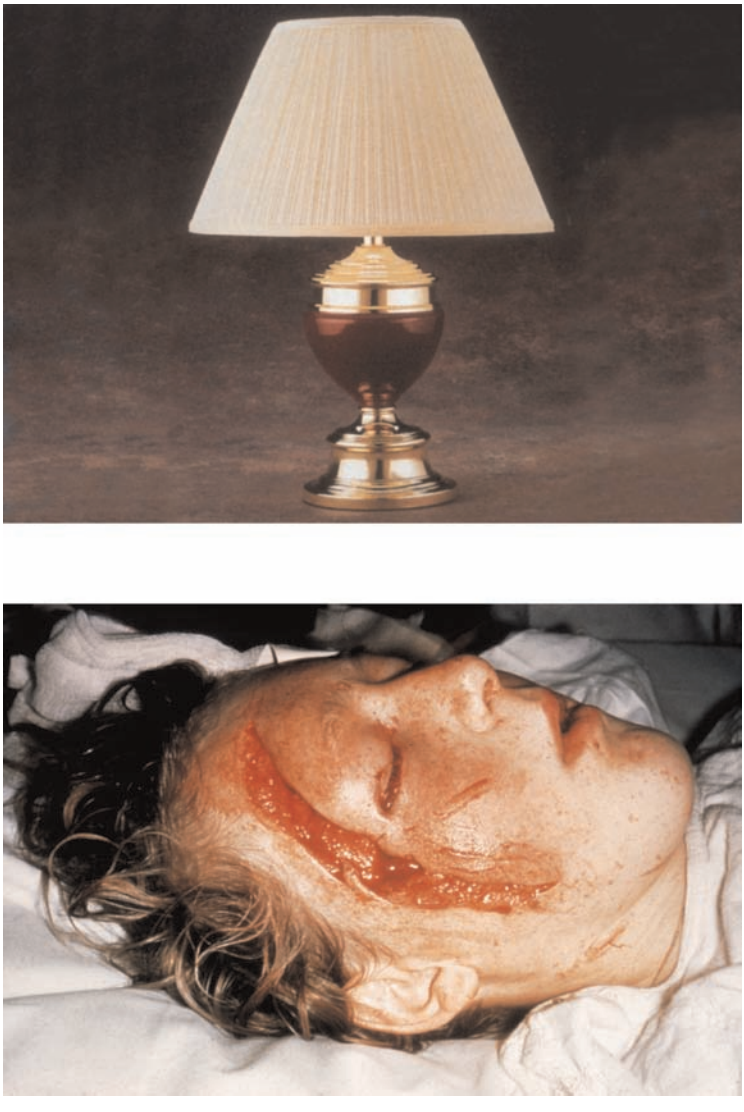

Figure 3. Examples of low emotion (top panel) and high emotion (bottom panel) provoking photographs

stories and photographs as well as subliminal messages in addition). The dependent variables were the number of matches made in each condition (i.e. number of times the participant made a 'same' decision).

Procedure

Each participant was tested individually and was presented with 96 trials. Each trial contained a pair of fingerprints. For the blocks of trials that included the top-down manipulations, participants were presented with the stories and photographs prior to

showing them the pair of fingerprints. For the trials that included subliminal priming, the words 'guilty' and 'same' were flashed on the screen for 88 ms after the emotional stories and photographs were presented and right before the fingerprints were presented.

For each pair of fingerprints, the participants were asked to decide if the fingerprints in the pair were the same or different, and to respond as quickly as possible. The participants responded by pressing the appropriate keys on the computer keyboard (either the 'b' key which was labelled 'same' or the 'n' key which was labelled 'different'). Each pair of fingerprints was presented simultaneously, and remained on the computer screen until the participant made a 'same' or 'different' decision, at which point the next trial appeared on screen.

Initially participants were given practice trials consisting of six pairs of fingerprints, and asked to decide if the prints in the pair were the 'same' or 'different.' Once the participants responded to a practice trial, the correct answer (i.e. 'same' or 'different') would appear on the screen before the next pair was displayed.

After the practice trials, the participants began the actual experiment. No feedback was given during the actual experiment. The 96 pairs of fingerprints were divided to four blocks of trials. Each block contained 12 unambiguous pairs (six were a 'match' and six were a 'no match') and 12 ambiguous pairs of fingerprints. Within each block, the fingerprints were presented in random order. The experimental blocks themselves were not randomized, to avoid emotions crossing between trials where by highly emotional states will transfer and affect low emotional states and control trials. Thus, it was unwarranted to randomize the order of the blocks, but the trials within the blocks were randomized. To summarize, the first block of 24 trials included all the control decisions that had no top-down component. Then the second block of 24 trials included the low emotional manipulation of top-down influence, followed by the third block of 24 trials with the high emotional manipulation. Then finally we presented the fourth block of 24 trials which included the high emotional manipulation along with the subliminal messages of 'guilty' and 'same'.

RESULTS

A two-way analysis of variance (ANOVA) was carried out with Stimuli Type (ambiguous vs. non-ambiguous) and Top-Down Manipulation (control, low emotion, high emotion, and high emotion + subliminal) as within variables. Of main interest was a significant interaction we found between Stimuli Type and Top-Down Manipulation ($F(3, 78) = 8.172$, $p < 0.001$). This interaction reflected that the Top-Down Manipulation affected decisions on matching fingerprints, but that this effect varied with the different Stimuli Type. There were no significant main effects for Stimuli Type and Top-Down Manipulation ($p > 0.05$) by themselves.

In order to understand better the source of the interaction, we subjected each one of the Stimuli Type to a separate ANOVA. The analysis of the unambiguous fingerprints revealed that participants found matches in 50%, 54%, 51%, and 46% of the time, respectively for the control, low emotion, high emotion, and high emotion + subliminal Top-Down Manipulations (and identifying the non-matching pairs in the remaining trials, respectively). Thus participants correctly distinguished between the match and non-match fingerprints. Furthermore, the unambiguous data did not differ across these experimental manipulations, and hence was of no further interest by itself.

When we examined the ambiguous Stimuli Type, where there was no objectively correct response, a different picture emerged. We found a significant effect ($F(3, 78) = 6.247$, $p < 0.001$), with matches differing across the experimental manipulations. Participants found a match in 47%, 49%, 58%, and 66% of the trials, respectively for the control, low emotion, high emotion, and high emotion + subliminal Top-Down Manipulations. These analyses together reflected the source of the interaction we found in our overall analysis; namely, that decisions only varied with the Top-Down Manipulation when judgments were made on the ambiguous Stimuli Type.

In order to determine the nature of the significant differences within the ambiguous Stimuli Type, repeated *t*-tests were carried out across the four Top-Down Manipulation conditions. The *t*-tests revealed that the low emotion condition did not affect decisions, as we found no significant difference between decisions made in the control condition and those made in the low emotion Top-Down condition, $p > 0.05$ (47% was comparable to 49%). However, there was a significant difference between the control condition and the high emotion condition ($t = -2.057$, $df = 26$, two-tailed = 0.050), reflecting that participants were more likely to find a match when subjected to the high emotion Top-Down Manipulation (47% vs. 58%). Furthermore, the addition of subliminal messages to the high emotion condition produced even higher levels of matches (66%), which was also reflected in the focused *t*-test, ($t = -2.687$, $df = 26$, two-tailed = 0.012).

DISCUSSION

The aim of the current study was to investigate the possible effects of top-down processing in interfering with bottom-up identification of fingerprints. We focused on emotion and subliminal messages as our top-down manipulations for three reasons.

First, both are present in many of the applied real world forensic settings where fingerprints are matched. In these settings background information is available to the decision makers. This information may have emotional impact (such as the nature of the crime and the victims) and may also include subliminal messages (such as non-verbal biases communicated by colleagues and superiors, as well as additional evidence that points towards the suspect).

Second, past cognitive research has shown that both of our manipulations may affect decision making. Emotion-congruent effects and subliminal messages have shown in a number of domains (but not in the context of fingerprint matching) that they can alter how we process information, what we see, and our decision making process (e.g. Byrne & Eysenck, 1993; Darley & Gross, 1983; Hirsch & Mathews, 1997; Murphy & Zajonc, 1993).

Third, they are relatively easy to control, quantify, and administer in a laboratory condition. Hence, our manipulations of emotion and subliminal messages as our top-down conditions seemed to capture a number of important applied, theoretical, and practical considerations.

Using our top-down manipulations we wanted to examine whether they can affect decisions in matching fingerprints. Furthermore, if they are able to make such an impact, we were interested to see the potential strength and scope of this affect.

The results of this study demonstrated that emotion and subliminal messages did influence decision making. Specifically that top-down influences can interfere with people's decisions in matching fingerprints. However, our findings show that this top-

down effect is limited in scope and strength. When the fingerprints were a clear match (or no match) then the top-down component was not able to override the bottom-up input information (see Pylyshyn, 1984, for a full discussion of cognitive penetrability).

Our findings did show that when the fingerprints to be matched were ambiguous, the top-down component had effects on the decisions being made. Thus, the top-down component was able to bias how gaps are filled but did not have the power to override clear bottom-up incoming information. Top-down components may well be able to override and contradict clear bottom-up information, but this may only occur under very specific circumstances.

With the growing use of technology in fingerprint identification, some claim that such human biases and weakness will be reduced, if not eliminated altogether. Although technology is an important ally in fingerprint matching, the issues addressed in this study, as well as other psychological/cognitive issues, will continue to exist and even increase. In the foreseeable future computers will be able to judge whether a pair of fingerprints match or not. But computers will only be able to make good judgments with confident high levels of accuracy when both prints are of high quality and in very good condition. Human experts will continue to be needed in the foreseeable future to deal with prints that are partial, distorted, not clear, contaminated, or not-ideal in any respect.

Furthermore, the growing use of computer technology in fingerprint matching gives rise to giant databases that contain larger and larger samples of fingerprints (e.g. approaching 10 million in the UK system and 100 million in the USA system). With such large samples, the relative similarity (and hence difficulty in matching fingerprints) will increase (Ashworth & Dror, 2000). The data reported in this study demonstrate that with greater difficulty in the bottom-up matching of the prints, greater opportunity and vulnerability are created for the top-down contextual components to influence and interfere.

Our study is the first step in examining how top-down influences may interfere with (or enhance) fingerprint matching. Once these influences are understood, then better ways to avoid them (or utilize them) can be developed. If we deny their existence, rather than acknowledge and study them, then we will not be able to deal with or manage them appropriately. In our study we first wanted to establish that top-down processing can indeed influence decisions about fingerprint identification. Now that this has been demonstrated further research will need to address two main lines of research.

First, a more careful scrutiny of the interaction between top-down and bottom-up information in the domain of fingerprint identification is required. In our study we included the more extreme manipulations and design to see if such influences have any effect on how fingerprints are matched. For example, we combined subliminal messages with emotional state, without scrutinizing the possible effects of subliminal messages on their own.

In this study we did not give the participants an option to respond 'cannot decide,' they had to state either a 'match' or a 'no match'. This, of course, may underlie our findings and have important implications to real world forensic fingerprint matching. What we have done in this study is to demonstrate the existence of an effect in which top-down components interfere with fingerprint identification and future research is needed to further elucidate this effect.

Second, our findings need to be examined within the context of routine everyday work of fingerprint experts. The training, experience, and work procedures of fingerprint experts may play an interesting and crucial role in if and how top-down components play a role in fingerprint identification. On the one hand, fingerprint experts may be less susceptible to

top-down interference, perhaps even immune, to such effects. Given their highly specialized skills, they may be able to focus solely on the bottom-up component and be data driven without the external influences that we have observed in the research reported here. On the other hand, and in contrast, fingerprint experts may be even more susceptible to such top-down components. Their vast knowledge and experience may provide them with extra degrees of freedom to rationalize and justify what they are biased to find by the top-down components. Research has demonstrated that professional police officers are susceptible to attentional biases caused by top-down influences as much as novices (Eberhardt, Goff, Purdie, & Davis, 2004). Further research can address these theoretical and applied issues.

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