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Bloodstain pattern classification: Accuracy, effect of contextual information and the role of analyst characteristics

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ABSTRACT

It is becoming increasingly apparent that contextual information can exert a considerable influence on decisions about forensic evidence. Here, we explored accuracy and contextual influence in bloodstain pattern classification, and how these variables might relate to analyst characteristics. Thirty-nine bloodstain pattern analysts with varying degrees of experience each completed measures of compliance, decision-making style, and need for closure. Analysts then examined a bloodstain pattern without any additional contextual information, and allocated votes to listed pattern types according to favoured and less favoured classifications. Next, if they believed it would assist with their classification, analysts could request items of contextual information – from commonly encountered sources of information in bloodstain pattern analysis – and update their vote allocation. We calculated a shift score for each item of contextual information based on vote reallocation. Almost all forms of contextual information influenced decision-making, with medical findings leading to the highest shift scores. Although there was a small positive association between shift scores and the degree to which analysts displayed an intuitive decision-making style, shift scores did not vary meaningfully as a function of experience or the other characteristics measured. Almost all of the erroneous classifications were made by novice analysts.

1. Introduction

Forensic science is currently at a crossroads. The reliability of conclusions about forensic evidence, and the methods used to reach those conclusions, are firmly under the microscope. This juncture is largely due to the much talked about National Research Council (NRC) report [1] into the state of forensic science. This report highlighted the need for known error rates in forensic science, and recommended that forensic disciplines acknowledge the role of the examiner in the interpretation process. In particular, the report recognised the need for research into the effect of contextual information on the interpretation process [1]. Context effects in forensic science are commonly referred to as contextual bias—a term that typically describes the unconscious influence of irrelevant information on judgements.

Prior to the publication of the NRC report [1], research into the performance of forensic experts was sparse and had primarily focussed on fingerprint evidence [2,3]. This research highlighted a high degree of subjectivity in fingerprint interpretation, showing that fingerprint decisions are vulnerable to bias. Now, many other forensic disciplines have faced the same scrutiny, with investigations into contextual bias being carried out in forensic odontology [4,5], handwriting examination [6], forensic anthropology [7], shoeprint examination [8], bullet comparison [9], DNA interpretation [10], and bloodstain pattern analysis [11,12]. The general consensus from this research is that forensic interpretations are vulnerable to contextual bias—a finding that is not surprising to psychological scientists, who have long investigated these basic human decision-making processes [e.g.,13,14].

In response to this growing body of literature, forensic laboratories around the world are developing ways to minimise the potential for contextual bias [6,15,16]. In Australia, for example, the Victoria Police Forensic Services Department has introduced a system of contextual information management for handwriting examinations [6]. Here, a designated context manager removes all irrelevant contextual details before passing the document on to be examined. Consequently, there is minimal chance for irrelevant contextual details to cloud judgement. Implementing this type of bias-minimising procedure would also be relatively uncomplicated for many other forensic disciplines, such as fingerprint interpretation, shoeprint examination, and DNA interpretation. The interpretation of such evidence requires minimal to no additional contextual information, and most or all contextual details can be removed.

Not all forensic disciplines, however, are presented with such a straightforward solution to eliminating the negative effects of context.

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In bloodstain pattern analysis (BPA) for example, such an approach is more complex because much of the contextual information encountered seems both unavoidable and necessary for a complete analysis. BPA is largely a pattern recognition task in which interpretation of the size, shape, and distribution of bloodstains can provide valuable information in a crime scene investigation [17]. For example, features in a bloodstain pattern can indicate the mechanism for deposition, such as a blunt force impact or expiration from the mouth. This analysis can help to piece together the events of the crime and, in some cases, might help to distinguish between, for example, homicide and suicide, or self-defence and murder. In addition to classifying bloodstain patterns, analysts are sometimes required to reconstruct the crime events, in which case elements of the entire scene might contribute to their conclusions. So although context elimination might be recommended in other forensic disciplines, such an approach may not be possible in BPA.

Despite the complexities of managing contextual information in BPA, moves towards implementation seem prudent given the potential for bias to occur. In a recent study, experienced bloodstain pattern analysts made judgements about the classification of bloodstain patterns on ridged non-absorbent [11] and fabric surfaces [12]. Case scenarios presented alongside each bloodstain pattern were formulated to suggest how the bloodstaining occurred. This information either suggested the correct pattern type (positive biasing information), suggested the incorrect pattern type (negative biasing information), or was neutral. Relative to the neutral context, analysts were more often correct with the positive biasing information, and more often incorrect with the negative biasing information—findings consistent with confirmation bias [13].

To know more about the potential for bias in BPA, it is crucial that we understand how analysts use contextual information, and the degree to which this information influences their decision-making. Although Taylor et al.'s studies [11,12] are an important first step towards understanding context effects and reliability in BPA, there are still several unanswered questions. First, because each analyst was presented with different bloodstain pattern targets, we do not know if different analysts will reach the same conclusion when presented with the same pattern. Second, although the case scenarios in Taylor et al.'s studies contained information from various sources (e.g., medical findings, witness statements, police investigator's theory), it is not clear which of these sources exerted the greatest influence on analysts' decisions—data that would be crucial to the development of contextual information management systems in BPA. Finally, we do not know whether some analysts are more vulnerable to context effects than others, and whether or not training and experience in BPA plays a role in the degree to which context effects might emerge.

Dror [18,19] proposes that a cognitive profile representing cognitive abilities that underpin specific forensic tasks (e.g., visual attention, perceiving and comparing visual features) could help to identify forensic examiners who are the best suited to particular jobs. It is conceivable that such profiles could also consider a person's vulnerability to context effects, thereby enhancing endeavours to reduce the risk of contextual bias in forensic science. In the present study, we chose to assess three variables that could be associated with context effects in forensic decision-making: 1) need for closure (NFC; i.e., the extent to which people will be driven to reach any conclusion to avoid confusion and ambiguity [20]); 2) general decision-making style (GDMS; [21]); and 3) compliance (i.e., the extent to which people obey or conform with instructions when they would rather not [22]). These three variables were chosen based on their relevance to forensic decision-making and the availability of validated scales for their measurement.

2. Method

2.1. Participants

Study participants were attendees at a workshop titled “How do we reach conclusions about pattern classification in BPA?” at the International Association of Bloodstain Pattern Analysts (IABPA) Training Conference in San Diego, 2013. Participation in the workshop was voluntary and free of charge. The participants comprised analysts from Australasia (New Zealand and Australia), North America, Asia, and Europe. The participants were informed that, as part of the workshop, the researchers would be collecting data that may be published in a peer-reviewed journal. All 44 workshop attendees completed the experimental procedure. For data analysis, however, we excluded those participants who had no formal training in BPA ($n = 5$), giving us a final sample of 39 bloodstain pattern analysts. We considered the analysts who had advanced BPA training and experience presenting BPA testimony in court as experts ($n = 23$). The remaining analysts were considered as novices ($n = 16$).

2.2. Materials

2.2.1. Analyst characteristic measures

2.2.1.1. Need for closure (NFC) scale. We used a brief, 15-item version of the NFC scale [20], created and validated by Roets and Van Hiel [23]. This scale measures the respondents' NFC as it relates to five subscales: order, predictability, decisiveness, ambiguity, and closed-mindedness. The respondents are presented with statements such as “I don't like situations that are uncertain” and “I enjoy having a clear and structured mode of life,” and are required to indicate their agreement on a 6-point Likert Scale (1 = completely disagree, 6 = completely agree). Roets and Van Hiel [23] recommend that researchers use the abridged scale to calculate a total NFC score, rather than separate subscale scores.

2.2.1.2. General decision-making style (GDMS). We used a 25-item scale developed and validated by Scott and Bruce [21] to measure decision-making style as it relates to five constructs: rational, avoidant, intuitive, dependent, and spontaneous. The respondents are required to rate statements such as “I double-check my information sources to be sure I have the right facts before making decisions” and “I generally make decisions that feel right to me” on a 5-point Likert Scale (1 = strongly disagree, 5 = strongly agree).

2.2.1.3. Compliance scale. To measure compliance, we used a 20-item questionnaire, developed and validated by Gudjonsson [22]. The respondents answer “true” or “false” to statements such as “I give in easily when I am pressured” and “I try hard to do what is expected of me.” The scale also consists of reverse-score statements such as “I am not too concerned about what people think of me.” The total number of “true” responses to non-reverse-scored statements and the number of “false” responses to the reverse-scored statements are combined to give a total score.

2.2.2. Pattern classification task

2.2.2.1. Bloodstain pattern target. We used a bloodstain pattern presented in a colour photograph (22.5 cm × 25 cm) for the classification task. The photograph (Fig. 1) was obtained courtesy of Taylor et al. [11]. The pattern was cast-off spatter, created in the laboratory by swinging a blood-soaked wrench. The analysts were informed that the photograph was of a bloodstain found on a vertical section of wall, where the bottom of the wall was at floor level, indicating that the bloodstain was approximately 30 to 40 cm from the ground. A scale was provided within the photograph.

2.2.2.2. Contextual information. We compiled items of contextual information, said to relate to the bloodstain pattern target, from six commonly encountered information sources in BPA (see Table 1). Because the bloodstain pattern was created in the laboratory, all of the information was fictitious.

2.2.2.3. Response format. The analysts classified the pattern by allocating 10 points to the pattern type(s) which supported their opinion, giving