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Factors influencing the contamination of UK banknotes with drugs of abuse

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Abstract

Bank of England banknotes sampled from different locations in the UK have been analysed for the presence of cocaine, diamorphine (DAM), Δ^9-tetrahydrocannabinol (THC) and 3,4-methylenedioxymethamphetamine (MDMA). A database of the contamination detected is routinely used as a benchmark against which the contamination detected on seized banknotes can be compared. Evidence presented at court details how banknotes seized from a suspect may differ from banknotes in general circulation in terms of their contamination with controlled drugs. A question arising from such evidence is whether seized banknotes could have become contaminated through being in circulation in drug "hot spots". In order to address this issue, a Plackett–Burman experimental design was used to investigate the influence of source location and other factors on banknote contamination with drugs of abuse.

Banknotes were drawn from banks in eight regions throughout the UK. Each location could be described by a unique combination of the factors under investigation, namely whether the location was rural or urban, in the North or South of the UK, and whether it was a port of entry. The socio-economic class and the proportion of drug offenders in the area and the denomination of the banknotes were also considered as potentially influential factors. Indices were calculated to describe the degree to which samples were contaminated with different drugs, and normal probability plots were used to identify the factors that could account for the contamination observed. Whilst some factors were more influential than others, it was shown that, at the 95% confidence level, none of the proposed factors were significant influences on the contamination.

Cocaine contamination on banknotes has been shown to follow a log-normal distribution. It was, therefore, possible to calculate *F*- and *t*-statistics to compare the cocaine contamination on the entire sample set with that detected on a second sample set consisting of banknotes all drawn from a single bank branch. It was shown that both inter-bank samples and intra-bank samples had similar variance and similar contamination levels at the 95% confidence level. This suggests that there are no significant regional trends in the contamination of banknotes with drugs of abuse across the UK.

Keywords: Banknotes; Drugs of abuse; Experimental design; Contamination trends

1. Introduction

The presence of drugs of abuse on Bank of England banknotes in general circulation is well established [1–3] and various techniques to detect or quantify the contamination have been described previously in the literature [4–9]. One approach [3] used to assess the contamination of individual banknotes in a bundle involves using a triple-quadrupole mass spectrometer with a custom-built thermal desorption inlet to detect traces of drugs; commonly cocaine, diamorphine (DAM), 3,4-methylenedioxymethylamphetamine (MDMA or "ecstasy") and Δ^9-tetrahydrocannabinol (THC). The ability to detect contamination on individual banknotes in a short timeframe, and without damaging the notes, has proven to be of forensic value in relation to the Proceeds of Crime Act and money laundering investigations [10]. It is possible to distinguish patterns of contamination on batches of notes seized from defendants, from those of notes in general circulation [3,4,9,11]. Circumstantial evidence to this effect is routinely presented in Courts of Law throughout the UK in support of the proposition that the seized notes became contaminated through illegitimate involvement with controlled drugs.

A database was constructed, consisting of samples of notes withdrawn over the counter from banks in various locations

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within the UK, against which comparisons of the pattern of contamination of the seized notes could be made. This was considered to be representative of notes in general circulation. Since these were convenience samples [12], a significant proportion were from Bristol (approximately 20%), where the analyses were undertaken. With approximately two billion Bank of England banknotes currently in circulation [13], and a growing database of approximately 46,000 banknotes (approximately 0.002% of the UK banknotes in circulation), the suitability of the background database for comparison with casework has been criticised. This approach emerged from the Court of Appeal as being fit for purpose, although during the court proceedings there was expressed an ''uncertainty as to whether the same conditions of drug use could be expected in every part of the country'' [14]. This suggested that patterns of contamination may have regional trends and that seized banknotes should only be compared with general circulation notes obtained from the same region. A counter-argument is that the daily movement of banknotes between regions would dilute the effect of drug ''hot spots'' and that banknotes sampled from general circulation anywhere in the UK might not be expected to mirror regional drug trends.

This paper addresses the significance of factors that potentially influence variation in contamination patterns, by sampling notes from banks in different regions of the UK. Samples were taken from eight carefully selected regions. Each bank was selected from a location broadly characterised by five factors, namely whether rural or urban, the socio-economic class, the proportion of offenders, whether a port of entry (close proximity to a port or international airport), and whether North or South. All North samples were collected in Scotland; hence, this factor can also be considered as Scotland/England. In addition, a combination of £10 and £20 notes were collected to assess the significance of denomination. A number of indices for drug contamination of each sample were then determined and the significance of any relationship between contamination patterns and each of the factors was studied. This was placed in context by comparison with equivalent samples taken from a single branch.

2. Experimental

2.1. Sampling design

In order to address the effect a sampling region could have on the amount of drug contamination observed on banknotes from the region, a Plackett–Burman design was used for sampling [15]. Plackett and Burman's 1946 paper [16] originated from the need for war-time testing of components in equipment manufacture. A large number of factors influenced the quality of these components and efficient procedures were required for screening. They proposed a number of two level factorial designs, where the number of experiments is a multiple of four and the number of factors is one less than the number of experiments. These designs minimise the number of experiments required to allow exploratory study of a large number of factors to see whether these have a significant effect on the response.

In this study, the influence of six factors (Table 1) on drug contamination patterns was investigated. The state of each factor was coded +1 or −1 and experiments were performed at several specific combinations of factor levels. Factor three described the socio-economic make-up of an area in terms of credit rating determined using a commercial website [17]. The latter is a classification from one of a number of databases that record, among other data, the affluence, the stage in life, qualifications and housing of the local population at a particular postcode in the UK. Factor four, was derived for UK Government drug seizure and offender statistics [18]. A seventh control or ''dummy'' factor, was that the person obtaining the samples was instructed to wear a wristwatch on either their left or right hand, a factor which can reasonably assumed to have no bearing on the extent of drug contamination on the banknotes collected.

Table 1
Factors employed in the experimental design

	Factor	+1	−1
1	Settlement	Rural area	Urban area
2	Denomination	£20 banknotes	£10 banknotes
3	Socio-economic	'Low'	'High'
4	Offenders	'Many offenders'	'Few offenders'
5	Port of entry	Port of entry	Non-port of entry
6	Region	Northern UK	Southern UK
7	Dummy factor	Wristwatch on right	Wristwatch on left

The Plackett–Burman experimental design for seven factors requires eight experiments. The experiments are designed so that each factor is orthogonal, and there are only certain specific combinations of factor levels that obey these criteria. The choice of bank branches for sampling was, therefore, tightly controlled by the design of the experiment. The locations of the bank branches from which samples were obtained, and the associated factors, are listed in Table 2.

Samples, consisting of 100 used banknotes from general circulation, were drawn over the counter at eight different branches of banks throughout England, Scotland and Wales over a 3 day period in March 2004. Cash withdrawn over the counter tends to have been paid in by local businesses. In contrast, automated teller machines (ATMs) use banknotes received from regional counting centres, which are less likely to be representative of a single locality. Withdrawls were made by prior arrangement and banknotes were stored in tamper evident bags pending analysis.

2.2. Banknote analysis

All banknotes in this study were analysed for the presence of four drugs of abuse: cocaine, DAM, MDMA and THC. The analytical instrument used was an API365 triple-quadrupole mass spectrometer (MDS SCIEX, Concorde, ON, Canada). The mass spectrometer was modified for the thermal desorption of substances on banknotes [3].

All samples were analysed within a 2 day period. Data, for 100 notes, were acquired over periods (runs) of 20 min. At the beginning and end of every run, five 3 μL injections of a standard solution were introduced, each containing 1 ng μL^{-1} of cocaine, DAM, MDMA and THC in methanol. At the start of each run, a banknote-sized piece of paper was introduced between the heated metal plates at the front end of the instrument for approximately 1 s. The real-time response, displayed on screen, indicated whether the paper was free from drug contamination. Paper shown to be free from drug contamination was used to swab the analyst's gloves and a clean aluminium foil work surface before re-analysing. In this manner, contamination of the sample by the laboratory surfaces could be excluded prior to opening the tamper evident bag.

Drug-free paper swabs were used to test the outer and inner surfaces of a tamper evident bag containing a sample, as well as any other packaging. Banknotes were then analysed individually by sequentially introducing one end of the notes between the hot blocks for approximately 1 s. Each banknote typically produced a response for cocaine, which was allowed to fall to the baseline before introduction of the next note. After the right-hand end (or portrait end) of each banknote in a sample had been analysed, the other end of each banknote was analysed. For convenience during data handling, the packaging, and different ends of the banknotes were analysed on different runs.

The presence of a peak for cocaine was used as a time-marker to locate responses for any other target drug desorbed from a given banknote, as nearly all banknotes contain a detectable amount of cocaine [2]. Various indices were calculated and their relationship to the factors employed in the design was modelled.