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The distribution of controlled drugs on banknotes via counting machines

James F. Carter[a,*], Richard Sleeman[b], Joanna Parry[a]

[a]*Organic and Biological Section, School of Chemistry, University of Bristol, Cantock's Close, Bristol BS8 1TS, UK*
[b]*Mass Spec Analytical Limited, Building 20F, Golf Course Lane, P.O. Box 77, Bristol BS99 7AR, UK*

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Abstract

Bundles of paper, similar to sterling banknotes, were counted in banks in England and Wales. Subsequent analysis showed that the counting process, both by machine and by hand, transferred nanogram amounts of cocaine to the paper. Crystalline material, similar to cocaine hydrochloride, could be observed on the surface of the paper following counting. The geographical distribution of contamination broadly followed Government statistics for cocaine usage within the UK. Diacetylmorphine, Δ^9-tetrahydrocannabinol (THC) and 3,4-methylenedioxymethylamphetamine (MDMA) were not detected during this study.

Keywords: Cocaine; Banknotes; Counting machines; Contamination

1. Introduction

A number of studies have shown that a significant proportion of banknotes in worldwide circulation are contaminated with cocaine and, to a lesser extent, other controlled substances [1–7]. Despite these findings and many other reports (e.g. Guardian, 15 November 1994; Sunday Times, 7 January 1996; New Scientist, 13 February 1999), the origin of this contamination has remained a matter for speculation.

Sterling banknotes are printed on a mixture of cotton fibre and linen rag [8]. After a period of use, the characteristics of the banknote fibres change [2,9], giving the appearance of cavities which might enclose small particles, including cocaine. This implies that the retention of controlled substances on banknotes is at least in part due to the physical entrapment of crystalline materials. Other authors have proposed that the retention of controlled substances is due to dissolution in surface inks or grease [10,11], or to chemical binding [5].

In a previous study, particulate material was collected from a large number of banknotes returned to The Bank of England [1] together with dust from a counting machine. Not only were the banknotes found to be contaminated with a range of controlled substances, the dust from the counting machine was also shown to contain significant amounts of cocaine [12]. Other authors have reported the presence of cocaine in counting machines at a bank in Basle, Switzerland [13]. This study demonstrated that counting machines could pass detectable amounts of cocaine from a heavily contaminated banknote to those subsequently counted. The conclusion was, however, that contamination within the counting machine did not account for the widespread occurrence of low levels of cocaine on banknotes.

In order to assess the extent to which counting machines are responsible for the widespread occurrence of controlled substances on banknotes, bundles of paper (with fibre characteristics similar to banknotes) were distributed to banks in England and Wales. The bundles of paper were counted as if they were banknotes and, upon return, analysed for the presence of controlled substances.

2. Materials and methods

A number of commercially available types of papers were examined by electron microscopy in order to find a similar

* Corresponding author. Tel.: +44-117-9546967; fax: +44-117-9298611.
E-mail address: jim.carter@bristol.ac.uk (J.F. Carter).

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fibre structure to sterling banknotes. Banknote and paper samples were attached to an aluminium stud using conductive carbon cement. The samples were placed under vacuum for 40 min and sputtered at 20 mA for 4 min to provide a 100 nm gold coating. The samples were observed at 500× magnification with a Hitachi S-2300 Scanning Electron Microscope (SEM) operated at an electron energy of 25 keV.

Conqueror Vellum Laid (100 g/m^2) paper (Arjo Wiggins) was cut into pieces the same size as five pound sterling banknotes (approximately 2.75 in. × 5.25 in.). Using disposable gloves and work surfaces covered with clean aluminium foil, bundles comprising 50 pieces of paper were counted and a small cross marked on one outer surface. These bundles were sealed in bags along with instruction for the bundles to be counted with the marked face on top. Using pseudorandom numbers, 60 branches of Lloyds Bank in England and Wales were selected from a register provided by Lloyds Bank head office. The bundles of paper were sent to these branches together with a request for them to be counted by the usual method employed. Each branch was also supplied with a form to be completed with details of the counting method, machine type (if used) and the number of notes recorded. In early 1998, samples were dispatched via Lloyds internal mail service and returned by Royal Mail. Off-cuts of paper were analysed for traces of illicit drugs to ensure that no traces were present on the paper prior to the counting process.

Paper samples were analysed for the presence of cocaine, diacetylmorphine, Δ^9-tetrahydrocannabinol (THC) and 3,4-methylenedioxymethylamphetamine (MDMA) using an Aromic 9100 triple quadrupole mass spectrometer (PE Sciex, Canada) specifically designed for sample introduction by thermal desorption [3]. Paper samples were analysed sequentially by inserting one half of each sheet between two heated metal plates (285 °C) for approximately 1 s. Volatile

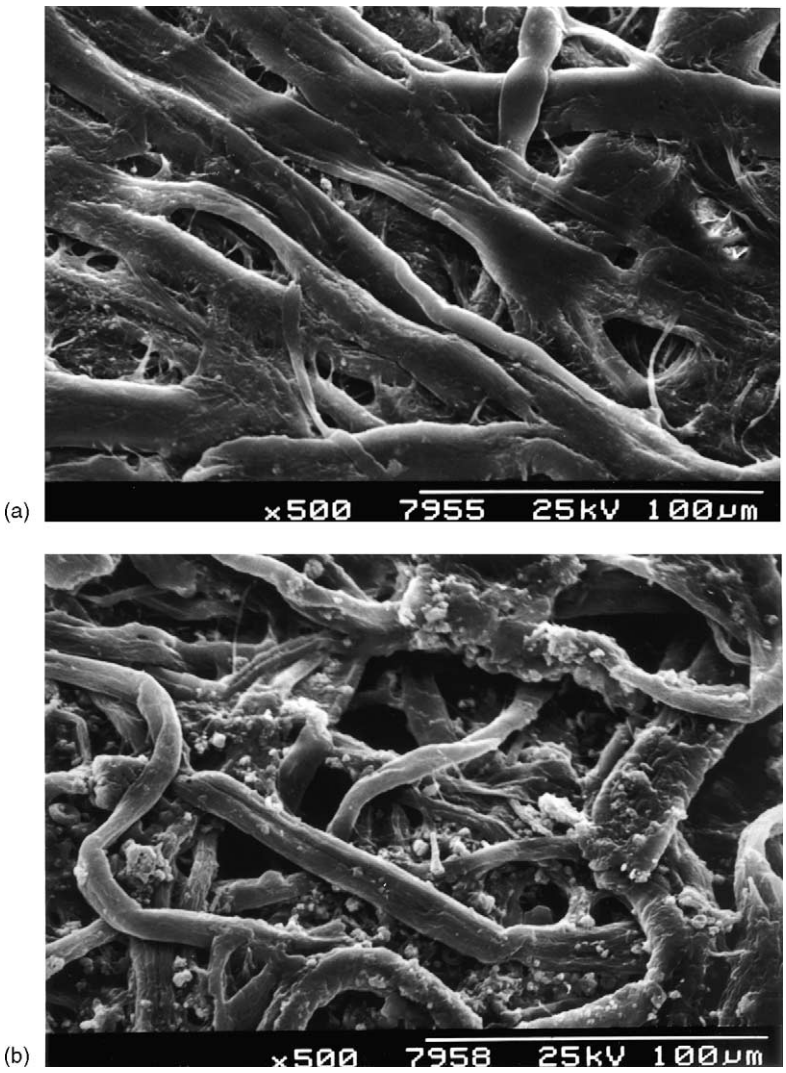

Fig. 1. (a) Sterling banknote surface 500×; (b) Vellum Laid surface 500×; (c) Vellum Laid surface 500× after machine counting.

(c)

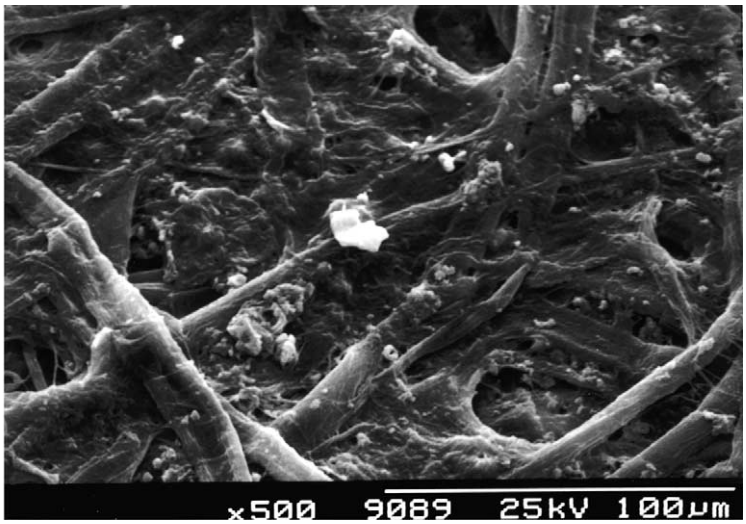

Fig. 1. (*Continued*).

components liberated by this process were drawn into the atmospheric pressure chemical ionisation (APCI) region of the mass spectrometer. The instrument was operated in selected reaction monitoring (SRM) mode, recording two gas phase ion transitions characteristic of each component [3]. Gas phase ion transitions were recorded sequentially for 20 ms, giving approximately 26 measurements for each compound per sample. The analysis of each paper bundle was preceded by a standard solution containing cocaine (1 ng), diacetylmorphine (10 ng), THC (2.5 ng) and 3,4-methylenedioxymethylamphetamine (1 ng). This was followed by the analysis of a paper off-cut.

3. Results

Observation of electron micrographs revealed that Conqueror Vellum Laid paper (Fig. 1b) showed the greatest resemblance to sterling banknotes (Fig. 1a) in terms of fibre structure and the size of cavities available for particles to occupy. It was judged that small surface particles, attributed to pigments, would not influence the retention of controlled substances.

An electron micrograph of the top face of a piece of paper from bundle #24 (opposite end to that analysed) counted in Knightsbridge, London, is shown in Fig. 1c. Particles present on the surface were of a type and size which had not originally been observed. These particles were of a similar size to cocaine hydrochloride crystals (count geometric mean diameter 1.4 µm, with a geometric standard deviation of 2.6 µm) [3]. Although no chemical analysis of individual particles was undertaken at this time, it has been proposed that Raman microscopy could provide a means of analysing single crystals present on the surface of banknotes [14].

Forty-three of the 60 paper bundles were returned following counting. Forty of these bundles had been machine counted, three by hand. A number of the banks reported jamming of the paper in automatic counting machines, presumably due to the paper being slightly thicker than banknotes. A number of these banks recounted the paper subsequently by hand (reported as M/H in Table 1).

Of the four controlled substances examined, only cocaine was detected on the paper bundles. The amount of cocaine present on bundles was qualitatively classified in three categories; ''high'' when responses were observed higher than the cocaine standard (i.e. higher than 1 ng per sheet), ''low'' when responses were observed lower than the cocaine standard (i.e. lower than 1 ng per sheet) and ''none'' where no controlled substances were deemed to be present. Table 1 summarises the amount of cocaine detected and the counting method employed at the 43 banks in this study. The authors have estimated that the response for cocaine desorbed from a paper surface is attenuated approximately 20-fold when compared to the injection of a standard solution.

Fig. 2 shows the response of the mass spectrometer to the gas phase transition m/z 304–105 (characteristic of cocaine) for a number of typical bundles analysed during this study. Fig. 2a shows a typical ''high'' assignment obtained from bundle #44 (counted in Fulham, London) and Fig. 2b shows a typical ''none'' assignment obtained from bundle #1 (counted in Peterborough).

A common pattern observed in both ''high'' and ''low'' contaminated bundles was an increase in the response for cocaine from each sheet throughout the bundle (Fig. 2c; counted in London). An unusual pattern of response for cocaine was recorded from bundles #9 and #39 (Fig. 2d; counted in Bristol) in which contamination was observed only on the outer sheets of the bundle.

Table 1
Location of banks returning bundles showing amount of cocaine detected and the counting method

Ref no.	Branch location	Amount	Method
1	Peterborough, PE1	None	M
4	London, NW11	High	M
7	Stockton-on-Tees, TS18	High	M
8	Edgeware, HA8	High	M/H
9	Camberley, GU15	Low	H
10	London, E1	High	M
11	Eastbourne, BN21	Low	M
12	Hanley, ST1	None	M
13	Christchurch, BH23	Low	M
14	Gosport, PO12	None	M
17	Barnstaple, EX31	None	M
18	North Walsham, NR28	None	M
19	Ivybridge, PL21	Low	M
20	Wells, BS5	Low	M/H
21	Birmingham, B10	None	M
22	Sutton Coldfield, B72	None	M
23	Weston-super-Mare, BS23	None	M
24	London, SW3	High	M
27	Lydney, GL15	None	M
29	Dorking, RH4	None	M
31	Luton, SY8	Low	M
32	Market Harborough, LE16	Low	M
33	Ealing, W5	Low	M
34	Wadebridge, PL27	None	M
36	Gloucester, GL1	Low	M
37	Altrincham, WA14	None	M
38	Cheltenham, GL50	Low	M
39	Bristol, BS8	Low	H
40	Llanelli, SA15	None	M/H
41	Cranbrook, TN17	Low	M
42	Oswestry, SY11	None	M
44	London, SW6	High	M
45	Ashbourne, DE6	None	M
46	London, SE3	Low	M
47	Warley, B66	None	H
48	West Midlands, CV1	None	M
49	Southampton, SO40	Low	M
51	Oxford, OX3	None	M
54	Wickham, NE16	None	M
55	Shotton, CH5	Low	M
57	Birmingham, B23	Low	M
58	Penzance, TR18	Low	M
60	Southampton, SO18	None	M

M: machine, H: hand.

Fig. 3 shows the geographical distribution of the banks in England and Wales which returned samples for this study.

4. Discussion

Cocaine was the only controlled substance detected, of the four sought, on the bundles of paper returned after counting. Using the classification described, 14% of the counted bundles were deemed to be highly contaminated, 46% of the bundles classified as showing some contamination and 40% no contamination.

Cocaine has an obvious connection with paper currency through the use of rolled banknotes as a means of ingestion. It is axiomatic that large amounts of cocaine present on a single banknote, through direct drug use, could be spread to a very large number of other banknotes in general circulation. This is consistent with empirical findings [13]. A number of controlled substances, other than cocaine, are commonly used in powder form, e.g. diacetylmorphine and amphetamines. These, however, occur as crystals much larger than cocaine [15,16] and may be less readily retained or distributed. In addition, diacetylmorphine and THC are known to be readily hydrolysed [17] which may explain the failure to detect these compounds. It is impossible, therefore, to state whether these compounds were not present in the counting machines or were degraded on the paper surfaces prior to analysis. MDMA is a more stable molecule and should not degrade as rapidly as diacetylmorphine or THC. Both MDMA and THC are, however, used in compressed (tablet or resin) forms which are less likely to yield particulate material which may be retained by banknotes.

A common pattern observed was an increase in the response for cocaine recorded on each sheet throughout a bundle (Fig. 2c), the sheets having passed through the counting machines in the reverse order to which they were analysed. This is attributed to cocaine contamination on components of the counting machine being passed to the paper and diminishing through abrasion during the counting process. The occurrence of crystalline material on bundle #24 (Fig. 1c) was coincident with black marks on the surface of the paper sheets which are assumed to originate from components of the counting machine.

Bundles of paper which had been counted by hand in Bristol (#39, Fig. 2d) and Camberley (#9) showed detectable amounts of cocaine on the outer sheets of the bundles but no discernibly contaminated sheets in the middle of the bundles. Previous studies have concluded that cocaine could not be detected on the hands of bank staff after many hours of handling banknotes [18]. These findings would imply, therefore, that the cocaine detected on hand counted bundles was transferred from working surfaces within the bank.

Although participating banks were selected at random, certain geographical regions were represented more than others. It is assumed that the occurrence of Lloyds banks mirrors population density. The majority of the bundles containing "high" contamination and a significant number of the bundles containing "low" contamination were returned from the London area. Only one bundle returned from a London bank remained uncontaminated. This finding is consistent with UK Government statistics [19] which found that in 2000 London had a significantly higher rate of cocaine usage than other regions of the UK. In general, the use of cocaine and other Class A drugs was highest in affluent urban areas and amongst the richest income

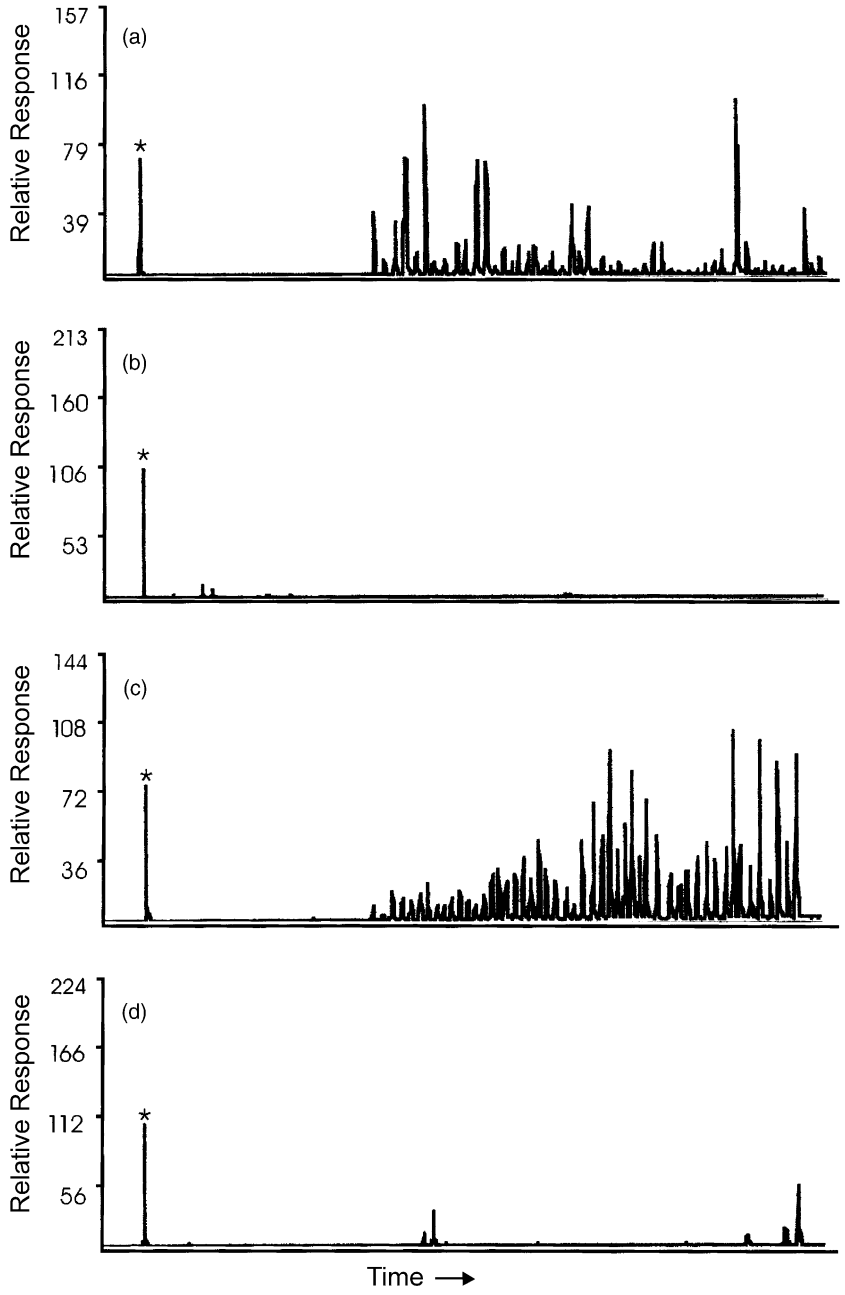

Fig. 2. Mass spectrometer response (*m/z* 304–105) for bundles of paper: (a) #44; (b) #1; (c) #24; and (d) #39. Traces are scaled to 2,000,000 ion counts, (*) indicates response to 1 ng of cocaine standard.

categories. Bundles returned from major population centres in the North and Midland regions of the UK (Liverpool, Birmingham and Manchester) showed little or no contamination, confirming the correlation with cocaine use.

Contaminated bundles returned during this study appear to reflect regional patterns of cocaine usage rather than the frequency of drug seizures (per million population for 1999) [19]. Customs typically seize larger quantities than local police forces and operate at, or soon after, the point of importation [20]. Hence, seizure rates do not reflect the amount of cocaine which may come into contact with banknotes via trading or ingestion. Uncontaminated bundles were returned from both South Wales (#40) and the North East of England (#54) which are areas with a high number of drug seizures [20] but a low level of cocaine usage [19].

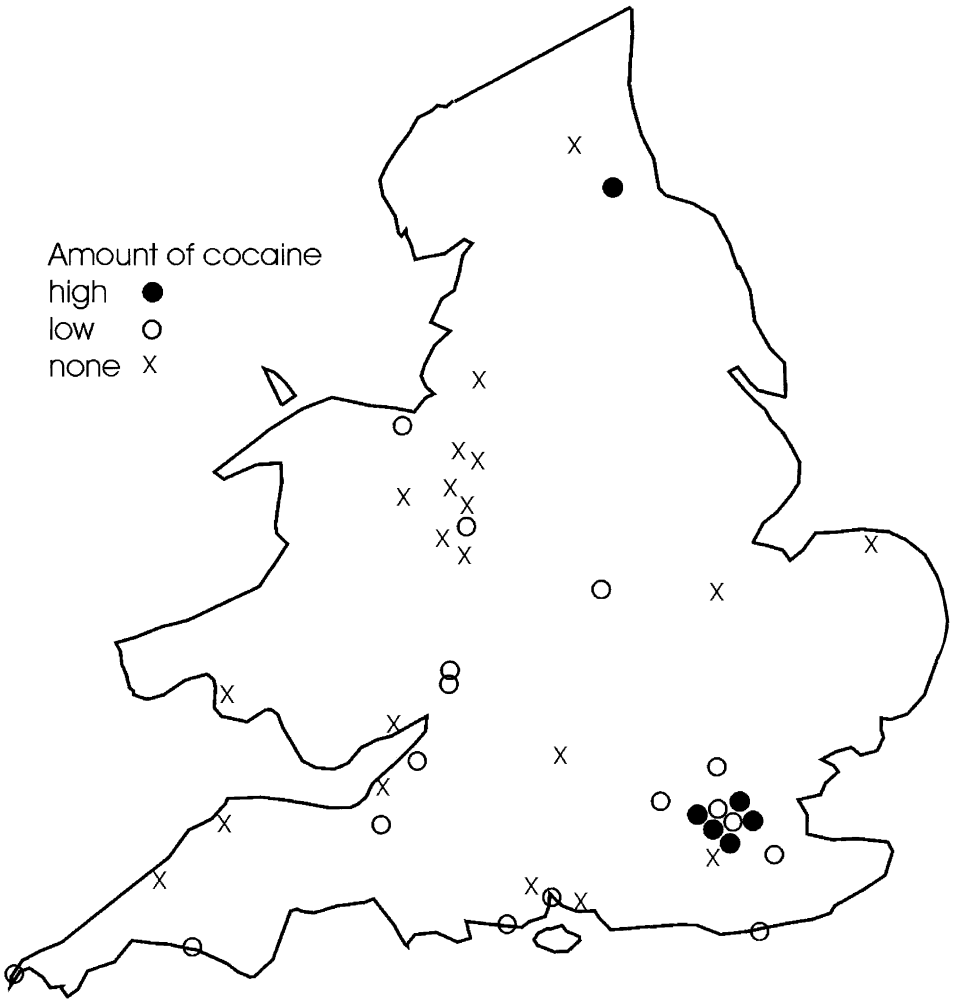

Fig. 3. Locations of participating banks within England and Wales.

The sole contradiction to this pattern was returned from Stockton-on-Tees (#7) which was the only bundle containing "high" contamination returned from outside the London area. This is an area with moderate drug seizures and limited cocaine usage. The bundle returned from nearby Wickham (#54), which has a higher rate of drug seizures and comparable cocaine usage, showed no detectable contamination.

5. Conclusion

This study has shown that the widespread occurrence of nanogram amounts of cocaine on banknotes is, at least in part, due to transfer by counting machines. To a lesser degree, cocaine may be transferred by hand counting. The extent of cocaine contamination on notes broadly reflected known trends in cocaine usage rather than regional patterns of drug seizures. The presence of large amounts of cocaine or other controlled substances on banknotes is unlikely to be accounted for by this transfer mechanism and may still be viewed as evidence of close contact with a controlled substance.

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