The prevalence of two 'commonly' encountered synthetic target fibres within a large urban environment.

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Abstract

A target fibre study was carried out to assess the random prevalence of two ostensibly commonly encountered synthetic fibre types; blue acrylic and blue polyester. The study was performed in an environment which maximized the number of random contacts between textile garments and specific surfaces, namely; seating relating to buses, public houses and cinemas found within a large urban conurbation.

Surface debris was collected from a sample of bus seats (30), pub seats (54) and cinema seats (53). Using low power stereomicroscopy, a total of 114 and 68 fibres, superficially similar to the respective black acrylic and blue polyester target fibres, were recovered from these tapings. The full range of comparative microscopical and instrumental analysis used in operational forensic laboratories was performed on the recovered fibres.

No matches were found with either of the target fibres.

These findings are in accordance with similar studies which show that the probability of an 'adventitious' match with a particular fibre type/ colour combination is extremely low. In addition, the findings demonstrate that the current techniques and instrumentation employed by operational forensic laboratories are fit for purpose.

Importantly, the findings demonstrate that databases and surveys (e.g. fibre population studies) which do not consider the analytical/ comparison processes, must not be used in isolation when evaluating evidence fibre evidence at source level.

Introduction

Fibre evidence is often considered as having poor probative value in forensic investigations due to the perception that unlike DNA evidence, there is a lack of robust frequency data which renders source level determinations problematic [1, 2].

Seasonal, fashion, and economic factors (to name a few) create a state of flux within the textile industry which means that it is virtual impossible to create a reliable database providing frequency data for every possible fibre type/ dye combination. The fundamental difference between DNA evidence and fibre evidence is therefore that; data relating to the prevalence of the former is (by and large) fixed in time, whilst the latter is not.

This difference means that (as far as source level evaluations are concerned) they must be treated with different evaluative methods. The use of a single database may be appropriate for DNA profile frequency data (since it is underpinned by established genetic models), however, attempting to apply a similar approach to other evidence types may not be appropriate [3]. Perceived difficulties and misconceptions regarding the availability and use of relevant data for fibre evidence are discussed by Houck [2] who described these problems as arising from; '[limiting] *a discipline by requiring it to fit into a preordained [mathematical] model. One size does not fit all*."

In the absence of 'fixed' data such as allelic frequencies used in the calculation of DNA match probabilities, the following types of studies are extremely useful in forming an evaluative opinion as to the significance of source level fibre evidence;

- Fibre population studies: which provide estimates of the relative frequencies of different fibre type/ colour combinations, at the generic level, on particular surfaces/ substrates e.g. car seats [4], skin [5].
- Colour block studies: provide information on the ability of a scheme of analysis to discriminate between ostensibly similar fibres of a given generic fibre/ colour combination [6-13].
- Target fibre studies: provide estimates of the probability of finding significant numbers of a specific fibre type, morphology and colour combination, on a random surface [13-22].

It is important that the distinction between these studies is understood. Fibre evidence is often dismissed because population studies show a particular fibre type/ colour to be 'common'. To use an analogy; whilst stating that '*blue cars are common*' is ostensibly true, not all blue cars are the same (as anyone who has attempted to repair car panels will know).

Evaluating source level evidence purely on the relative frequency of a fibre at the *generic level*, without consideration of the ability of instrumentation to discriminate between apparently similar fibres (colour block studies and target fibre studies), is likely to lead to important evidence being woefully understated or wrongly dismissed as irrelevant.

Target fibre studies published over the past 28 years, have consistently demonstrated that the chances of finding significant numbers of a particular fibre type/ colour combination on a random surface are very small. It therefore follows that the chances of finding more than one particular target (e.g. in a cross transfer situation) are even smaller. These studies are therefore extremely useful in addressing source level propositions, particularly when a Bayesian framework is employed.

Despite the high value of these studies, only 10 such studies have been published over the past 28 years. To put this into perspective, a target fibre study which incorporated a review of the results of previous such studies was published in 2004 [21]. Since this work was published, only 2 target fibre studies [13, 22] have been carried out during the intervening decade. The list of published target fibres to date, is shown in *Table 1*.

Aims

The aim of the present study was to investigate the degree of prevalence of synthetic fibre targets which are (*at the generic level*) commonly encountered in forensic casework on surfaces within a large urban environment which were likely to be subjected to enumerable contacts with textile garments worn by the populace. Since the number of random contacts between clothing and a particular surface are likely to influence the chances of encountering an adventitious match with a given target fibre, the purpose of this approach was to obtain a 'worse case' estimate.

Experimental

Target fibre data

Constituent and shed control samples were taken from each target garment to establish the degree of intra sample variability under reflected light, for use in initial tape searching using a *Leica M60*^{TM} low power stereomicroscope, as well as for subsequent high power comparison microscopy using a *Nikon Ortholux*^{TM} Polarising light microscope, and a *Leica DMR*^{TM} comparison microscope equipped with fluorescence filters.

Black acrylic

The target garment chosen for the black acrylic fibres was a pair of black 'HANDY magic' gloves. Manufactured by the 'Handy Glove Co', this product is widely available in high street shops and markets as well as numerous internet mail order sites. Whilst the product label cited the composition as 85% acrylic, 10% nylon and 5% spandex, shedding tests demonstrated that virtually all of the transferred fibres were from the acrylic component.

Although appearing black to the naked eye, the acrylic target fibres were found to have a dark green appearance when viewed using high power transmission microscopy. The cross section of the fibres was found to be 'bean' shaped, approximately 20 microns in diameter and was delustred (dull). There was minimal intra-sample variation in dye uptake.

Blue polyester

The target garment chosen for the blue polyester fibres was a dark blue fleece style top donated by a member of staff. Other than a label stating "Originals", details of its manufacture were unknown. The target fibres were blue in colour (in reflectance and transmission) with a round cross section, approximately 12 microns in diameter, and delustred (dull). There was minimal intra-sample variation in dye uptake.

Tape lift sources

Surface debris was collected from seats relating to cinemas, public buses and public houses within the Newcastle upon Tyne conurbation. The surface debris from the seats were collected using surface debris tapings. The back and squab surfaces of random seats were sampled using the 'press and rub' method using 2 inch wide strips of '*J-Lar*^{TM}'.The tapes were then secured for subsequent searching by pressing the adhesive side down onto a clear acetate sheet.

Table 2 shows the source and the number of seats sampled and tape lifted.

Tape lift searching

The tapings were searched manually using low power microscopy and any fibres which appeared similar to the target fibre controls were marked using a marker pen. Once searching was complete, any marked fibres were recovered from the tape by cutting a window in the tape around the fibre and using '*Sticky Stuff Remover™*' to remove the fibre for mounting onto a microscope slide in *phytohistol* under a glass cover slip.

Comparison

The mounted recovered fibres were then initially compared with the target fibres using a high power comparison microscopy (brightfield, polarized light and fluorescence). Any recovered fibres which appeared indistinguishable from the target fibres, were then compared using a *J & M TIDAS MSP 800*™ (UV-Vis) microspectrophotometer, initially in the visible range, analysis in the UV-visible range only being employed for the acrylic target in the event no discrimination made (polyesters fibres being opaque to UV light). The resultant spectra were compared visually.

Results

The results of the searching/ recovery and comparison for each of the target fibres are as follows;

Black Acrylic

The results relating to the black acrylic target fibre are shown in Table 3.

Blue Polyester

The results relating to the black acrylic target fibre are shown in Table 4.

Unlike cotton fibres reported in colour block studies [9, 11], this study has demonstrated that the use of comparison microscopy has high discrimination for synthetic target fibres, due to the high degree of variation in their visual morphology.

Discussion

The purpose of target fibre studies is to assist in addressing source level issues by providing *estimations* of the probability that a particular analyte has originated from a source other than that in question. The Bayesian framework is particularly suited for this purpose as it caters for both the calculation of a probability based on empirical data as well as the *assignation* of a probability based upon data, such as that obtained from target fibre studies [23].

Whilst the use of car seats and clothing in target fibre studies (see *Table 1*) do provide useful data in this respect, these are fairly limited in terms of encompassing potential contact with the huge number and variation of textiles in the population.

The surface debris obtained in this study was sampled from surfaces which would be expected to have been subjected to innumerable contacts with textile garments from the population of a large urban environment and as such, it would not be unreasonable to expect a greater chance of finding adventitious matches with the target fibres, compared to surfaces such as garments and car seats used in other studies (see *Table 1*).

To illustrate this, data obtained from two of the three cinemas showed that approximately 18000 tickets were sold in cinema 1 and 850000 tickets were sold in cinema 2. This translates to approximately 900 *potential* contacts per seat for cinema 1 and 300 *potential* contacts for each seat in cinema 2. Whilst these figures would of course assume that all of the seat contacts were evenly distributed and that all tickets sold were actually used, it nevertheless serves to illustrate that the surfaces sampled are likely to have been subjected to a large number of random contacts with a large variety of garments in the population.

The bus service from which the seats were sampled, ran daily between Newcastle city centre to Easington in county Durham (with 10 stops in between). The service is run approximately 70 times a day, with an average of 1500 people using the service. As with the cinema seats, it can be seen that there is a large number of potential contacts between clothing of the populace and the recipient surfaces (it may however be argued that the range of bus seat contacts is less random than that of cinema seats).

In addition, both target fibres types are commonly encountered (in the *generic* sense) in casework and have been shown to be the most frequently encountered synthetic fibres in fibre population studies [4, 24, 25].

Despite this, no fibres matching the either of the two target fibres were found on any of the seats sampled.

The results show that for the synthetic fibres used in this study as targets, comparison microscopy is the most discriminating technique and its use as a 'first test' in a scheme of comparison is justified in this instance. However, studies such as those published by *Grieve et al* [26], *Palmer et al* [11], *Buzzini and Massonnet* [10] and *Massonnet et al* [27], demonstrate that this may not be the case for all fibre type colour combinations (especially blue and black) cotton fibres.

These findings are in accordance with the previous target fibre studies listed in *Table 1* and (importantly) support the conclusions of *Wiggins et al* [21] that databases or surveys containing fibre frequency data, which do not take the results of analytical comparison into consideration, should be treated with caution.

It should also be noted that the introduction of UV-visible range diode array detector microspectrophotometers into routine casework around the late 1990's and early 2000, have been shown to offer superior discrimination to previous monochromator based instrumentation, which operated only within the visible range of the electromagnetic spectrum, particularly with regard to coloured cotton fibres [9, 11]. In addition, improvements in computer hardware and software used in MSP control and data acquisition have allowed the application of the first derivative to spectral data, which provided it is used with caution, can assist in discriminating between fibres with very similar, but different dyes [28]. *Grieve and Biermann*, [8] also pointed out that even with improvements in MSP technology, further discrimination between fibres is still possible using thin layer chromatography (TLC).

The improved discrimination of instrumental analysis over the last decade inevitably means that the results of target fibres studies in the 1980's and 1990's may actually be more conservative than they originally appeared and therefore need to be considered in this context.

Conclusion

The results of this study corroborate the findings of previous target fibres studies, that the chances of finding significant numbers of a particular fibre type/ colour combination which has been subjected to appropriate instrumental analysis and comparison, on a random surface are extremely small.

The findings also demonstrate that the comparative strategy currently employed in operational forensic laboratories is fit for purpose.

Importantly, the results also demonstrate that databases and surveys (e.g. fibre population studies) which do not consider the analytical/ comparison processes must not be used in isolation when evaluating evidence at source level as to do so will result in important evidence being woefully understated or wrongly dismissed.

Table 1: List of published target fibre studies

Study	Recipient Items	Sample Size	Target fibres	Number found
Cook and Wilson, (1986)	Garments	335	Blue wool (1)	9
			Blue nylon	0
			Blue acrylic	0
			Red acrylic	2
			Blue wool (2)	1
Jackson and Cook, (1986)	Car seats	108	Red wool	37
			Brown polyester	8
Cook *et al*, (1993)	Garments	56	Blue wool	62
			Pink cotton	4
			Blue cotton	1
			Grey polyester	0
Palmer and Chinherende (1996)	Cinema Seats	67	Red acrylic	14
			Green cotton	3
	Car seats	66	Red acrylic	0
			Green cotton	6
Bruschweiler and Grieve (1997)	Garments	435	Red acrylic	2
Cook *et al*, (1997)	Head hair	100	Blue wool	20
			Green acrylic	2
			Grey acrylic (1)	15
			Grey acrylic (2)	0
Kelly and Griffin, (1998)	Pub seats	80	Blue wool	9
Wiggins *et al*, (2004)	Garments	58	Blue wool	11
			Black polyester	0
			Grey polyester	1
			Blue acrylic	4
Jones and Coyle, (2010)	Garments	100	Black polyester flock	6
			Blue-grey nylon flock	0
			Grey-brown nylon flock	12
			Orange nylon flock	0
			Green nylon flock	0
			Black nylon flock	0
			Grey nylon flock	0
Coyle *et al*, (2013)	Garments	100	Fluorescent Yellow Polyester (52 samples)	0

Table 2: Details of sampled seat sources

Source	Source No.	Seats sampled	Total
Bus	1	10	30
	2	10	
	3	10	
Pubs	1	5	40
	2	5	
	3	6	
	4	7	
	5	5	
	6	6	
	7	6	
	8	5	
	9	5	
Cinemas	2	14	53
	3	39	

Table 3: Number of recovered acrylic fibres not discriminated from the target after each comparison phase

Seats	Number of Tapings	Fibres Recovered	Comparison Microscopy	Vis-MSP
Buses	30	31	0	0
Pubs	40	30	3	0
Cinemas	60	53	1	0
Total	130	114	4	0

Table 4: Number of recovered polyester fibres not discriminated from the target after each comparison phase

Seats	Number of Tapings	Fibres Recovered	Comparison Microscopy	Vis-MSP
Buses	30	13	0	0
Pubs	40	35	2	0
Cinemas	60	20	0	0
Total	130	68	2	0

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