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Investigation of secondary DNA transfer of skin cells under controlled test conditions

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ABSTRACT

There is a paucity of data on the relative transfer rates of deposited biological substances which could assist evaluation of the probability of given crime scene scenarios, especially for those relating to objects originally touched by hand. This investigation examines factors that may influence the secondary transfer of DNA from this source, including the freshness of the deposit, the nature of the primary and secondary substrate and the manner of contact between the surfaces.

The transfer rates showed that both the primary and secondary type of substrate and the manner of contact are important factors influencing transfer of skin cells, but, unlike other biological fluids, such as blood and saliva, the freshness of the deposit in most instances is not. Skin cells deposited on a non-porous primary substrate transferred more readily to subsequent substrates than those deposited on a porous substrate. Porous secondary substrates, however, facilitated transfer more readily than non-porous secondary substrates, from both porous and non-porous surfaces. Friction as the manner of contact significantly increased the rate of transfer.

The findings of this study improve our general understanding of the transfer of DNA material contained in fingerprints that is left on a surface, and assist in the evaluation of the probability of secondary and further DNA transfer under specific conditions.

1. Introduction

Goray et al. [1] found that transfer of biological fluids such as blood and saliva is significantly affected by the type of substrate on which it is deposited, the type of substrate it subsequently comes into contact with, the moisture of the sample and the manner of the contact. These data on the percentage of transfer under particular combinations of the variables investigated will assist in developing general assumptions when estimating probabilities of DNA transfer events under specific scenarios.

Scenarios in which aspects of transfer are relevant often include crime scene items that have been touched by skin, mainly by handling of an item by a hand. As the composition of deposits onto handled objects is different from body fluids, such as blood and saliva, and may affect transfer differently, it is important to investigate transfer of biological material left by touching an item with a hand. DNA containing biological material is easily transferred to touched objects [2–13] and has been targeted in many criminal investigations for DNA profiling of suspected offenders.

Only a few studies however have contemplated the possibility of the further transfer of deposited biological material left after touching an object [2–8,14,15]. Whilst some studies report being able to detect secondarily transferred DNA [8] others questioned its relevance in case work [2].

Scenarios involving multiple transfer events are increasingly being proposed by lawyers as an explanation for the presence of a particular person's genetic material at a crime scene. Without data on the approximate transfer rates under a set of particular variables it is very difficult to estimate the probability of an outcome in a given scenario of transfer events. Here we investigate some key variables affecting transfer of DNA containing material initially deposited by touch (contact with hand) using the experimental design of Goray et al. [1]. The variables include; freshness of deposit, nature of primary and secondary substrate materials and the manner of contact between the substrates. The findings should further assist in providing guidelines for the interpretation of DNA evidence when multiple transfer events are proposed as the mechanism to explain the presence of a DNA profile at a crime scene.

2. Materials and methods

2.1. Biological sample

A primary deposit of touch (skin) DNA was established by rubbing one hand over the designated area for approximately 10–15 s.

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The palm, the fingers and the side of the hand were used in a rubbing motion on to each deposit area. In a single session three such consecutive deposits were performed using the left hand and three using the right hand of a single depositor. Each series of six deposits was assessed for a separate configuration of variables. A single individual, identified as a good shedder (data not shown), performed all deposits. An interval of at least 24 h was allowed between the preparations of each series of deposits.

2.2. Variables tested, experimental design, sample processing and data analyses

The variables tested were as in Goray et al. [1]; moisture (fresh, dry), primary and secondary substrates (soft porous cotton, hard non-porous plastic), manner of contact (passive, pressure, friction).The experimental design was also as described in Goray et al. [1], with the exception of the template being divided into three squares instead of four (one template for each hand). The squares onto which the skin cells were deposited were larger in size (6.5 × 4.5 cm) to ensure a reasonable amount of deposited cells. The processing of the samples (extraction, quantitation and profiling) was as described in Goray et al. [1] except that all samples were concentrated with Amicon Ultra® (Millipore) as per manufacturer's instructions prior to quantitation.

2.3. Controls

Control swabs of the plastic and cotton substrates, the transparency and the weight were taken at random throughout the length of the experiment prior to sample deposit. No DNA was found on any of these swabs.

DNA profiling of the sample with the largest amount of DNA within each set of six replicates from each combination of variables tested showed that all the generated profiles were those of the depositor.

3. Results

3.1. Deposit amounts

The amounts of retrievable DNA deposited on cotton (average of 11.68 ng and 6.12 ng for fresh and dried deposits, respectively) are markedly greater than for plastic (0.396 ng and 0.482 ng for fresh and dried deposits, respectively), irrespective of manner of contact.

A comparison of the percentage transferred of the largest and the smallest deposit within each set of six repeats, for each set of variables, showed no significant differences ($p = 0.261$, data not shown).

3.2. Transfer of freshly deposited skin cells

The mean percentage transfer (and SD) of DNA from freshly deposited skin cells for each combination of primary and secondary substrate, and manner of contact, is presented in Table 1. When the deposit is fresh the type of both primary and secondary substrate is important. Non-porous primary substrates generate increased, but not significantly so, transfer rates (average of 17.93%; max. of 76.8%) compared to porous substrates (average of 7.32%; max of 73.7%) ($p = 0.159$). In contrast, porous secondary substrates facilitate significantly greater transfer (average of 15.44%; max. of 76.8%) compared to non-porous ones (average of 9.81%; max of 76.2%) ($p = 0.013$). Thus, the combination of a non-absorbent primary and absorbent secondary substrate gives the highest transfer (average 19.05%).

Table 1
Mean% transfer (standard deviation) of primary and secondary substrate combinations under passive, pressure and friction contact with freshly deposited touch (skin) cells.

Primary substrate	Secondary substrate					
	Plastic			Cotton		
	Passive	Pressure	Friction	Passive	Pressure	Friction
Plastic	2.7 (6.6)	18.38 (27.2)	29.34 (30.7)	18.46 (19.19)	24.7 (26.1)	14 (18.59)
Cotton	0.28 (0.5)	0.26 (0.43)	7.9 (3.9)	2.07 (2.32)	0.84 (0.72)	32.55 (20.7)

Transfer rates approximately double from passive contact (average of 5.88%) to pressure (average of 11.05%) and increase further with friction (average of 20.95%), but this order is not observed in all instances (Table 1). K-W one-way analysis of variance of all substrate combinations showed that the manner of contact had a significant impact on the percentage of DNA transferred, except for plastic/cotton ($p < 0.05$, data not shown). The Mann–Whitney post hoc test demonstrates that friction is responsible for much of this impact (Table 2) (only K-W significant combinations are tabulated).

3.3. Transfer of dried deposits of skin cells

The mean percentage transfer (and SD) of DNA from dried skin cells for each combination of primary and secondary substrate, and manner of contact are presented in Table 3. Transfer rates depend on the substrate combination and manner of contact. As found with freshly deposited samples, plastic as the primary substrate facilitated greater transfer of skin cells (average of 17.49%) compared to cotton (average of 9.03%) but this difference is insignificant ($p = 0.407$) and influenced by the type of secondary substrate. Cotton as a secondary substrate produced significantly greater transfer (average of 20.77% and 8.19% for plastic and cotton primary substrates respectively) than plastic (average of 14.21% and 9.87% respectively) ($p = 0.033$).

Table 4 shows that, as with freshly deposited skin cells, passive and pressure contact in most instances produced similar transfer rates, whereas friction increased the rates significantly.

Table 2
Mann–Whitney post hoc comparison of differences between contact types for freshly deposited touch (skin) cells.

Manner of contact	Cotton/cotton	Cotton/plastic	Plastic/plastic
Passive vs. Pressured	n/s	n/s	n/s
Passive vs. Friction	**	**	*
Pressured vs. Friction	**	**	n/s

n/s denotes insignificant.
* Denotes significant relationship at $p < 0.05$.
** Denotes significant relationship at $p \leqslant 0.01$.

Table 3
Mean% transfer (standard deviation) of primary and secondary substrate combinations under passive, pressured and friction contact with dried touch (skin) cells.

Primarysubstrate	Secondary substrate					
	Plastic			Cotton		
	Passive	Pressure	Friction	Passive	Pressure	Friction
Plastic	2.09 (5.12)	0.65 (1.3)	39.9 (8.5)	3.63 (3.69)	9.66 (8.62)	49.02 (30.9)
Cotton	0.37 (0.35)	0.33 (0.45)	28.9 (26.8)	1.86 (3.67)	9.75 (4.64)	12.97 (5.7)