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On the Problem of Assessing the Evidential Value of Glass Fragments Embedded in Footwear

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Abstract

The footpaths of metropolitan Auckland, New Zealand were searched for pieces of broken colourless glass, and the probable source of each piece was determined. It was found that the majority of pieces originated from containers. An assessment of the evidential value of glass found in footwear should be made with reference to a survey that reflects the types of broken glass encountered at random. This survey of glass found on footpaths is an attempt at such a realistic assessment.

Key Words: Glass; Refractive Index; Evidential value; Sample survey.

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Introduction

Forensic scientists have an obligation to the court to express an opinion as to the significance of their scientific analyses, for example, by referring to a survey of the known occurrence of a particular value of some variable. One such analysis is the comparison of glass fragments, found on a suspect, with glass broken at the scene of a crime.

Determination of the refractive index provides an accurate and reliable measurement of one of the variables or properties of glass, but the refractive index value is not unique to any one glass. Thus, glass found on a suspect may, by coincidence, have a refractive index that matches the refractive index of glass from the scene of the crime although it originates from a source unrelated to the crime. An assessment of the significance of matching refractive indices is dependent on the frequency of occurrence of the refractive index and is generally expressed as the probability of a coincidental match. This assessment must be made with reference to a relevant survey of glass refractive indices.

The refractive index distributions of the various types of glass (e.g.

container, vehicle, building etc) are known to be different [1]. It has been suggested by Evett and Lambert [2] that if the suspect has recently been exposed to broken glass unrelated to that from the scene of the crime, such as from the smashing of a glass bottle, then the forensic scientist should seek an estimate of a coincidence probability based on a "container glass" survey. If the scientist is aware of no proposed explanation for an alternative origin for the glass from the suspect then it may be decided that the appropriate survey to use is that for "all glass". Since refractive index determinations are time-consuming and a large number is required to compile a survey, refractive index surveys of "all glass" are often compiled from casework glass samples submitted to the forensic laboratory. These samples are typically dominated by building glass and therefore do not necessarily represent glass broken at random in the community. Container glass, for example, rarely occurs as a casework glass sample but might be expected to represent a large percentage of glass broken in the community. Since the refractive index distributions of glass from various categories differ, a survey of "all glass" will reflect the relative proportions of glass types included. Compilation of a survey of "all glass", relevant to assessing the probability of a coincidental match, should not simply reflect the types of glass present in the community, but must represent glass that is broken in the community.

Two situations should be recognised whereby a suspect may gather glass from encounters other than with the glass at the scene of a crime. Firstly, glass fragments recovered from the suspect's clothing and hair probably originated from glass broken in the presence of the suspect. Secondly, glass fragments embedded in the suspect's footwear probably originated from broken glass stood on by the suspect.

A survey of broken colourless glass found on footpaths may reflect the relative proportions of types of colourless glass encountered at random and likely to be found embedded in footwear. An "all glass" refractive index survey, for assessing the evidential value of glass found embedded in footwear, could be compiled by weighting existing surveys of refractive indices of the various categories of glass according to the proportions of these glass categories found in the survey.

Method

The footpaths along the roadsides of metropolitan Auckland, New Zealand were searched for pieces of broken colourless glass. Where footpaths were disrupted by a roadway the interjacent part of the roadway was searched. Footpaths were searched in four different urban environments: the central city area, containing mainly shops and commerical buildings alongside the footpaths; residential areas, containing housing mainly sited away from the footpath and including some suburban shopping areas; light industrial areas,

containing buildings generally near or alongside the footpath; and roadways where buildings were absent.

The first piece of colourless glass encountered that was greater than approximately 3 mm in its smallest dimension, was sampled, ten paces were then taken and the search was resumed. This distance appeared adequate to avoid multiple sampling from a single source. The number of glass pieces at each sampling point was noted.

The source of glass was categorised as container, building window (plain), building window (patterned), vehicle window, vehicle headlamp lens, vehicle headlamp reflector, mirror, or bulb glass. When the source of the glass was obvious at the time of sampling, this source was noted. If the source was not obvious, the following criteria were used as a guide to categorisation. Building and vehicle windows were differentiated from the rest by their flatness. Toughened glass was recognised by its characteristic diced appearance and was assumed to be of vehicular origin, since very little building glass in Auckland is toughened glass. Vehicle headlamp lens glass was recognised by the fluting on the concave surface. Vehicle headlamp reflectors were recognised by the mirrored concave surface. Mirrored glass was obvious. Bulb glass was recognised by its curvature and thinness, and container glass by its curvature, thickness, and any patterning present on the convex surface.

Flat glass was examined for fluorescence at 254 nm, to indicate whether the glass was of float or non-float manufacture.

Results and discussion

The survey comprised 1068 colourless pieces of glass collected from 52 km of urban footpath. The results are presented in Table 1. Intuitively, we would expect that glass broken on or near footpaths was not necessarily broken in the immediate presence of any person. Therefore, fragments of glass from the broken object would not necessarily be deposited on a person's clothing or hair. The number of broken vehicle headlamps would be an obvious anomaly. Hence this survey is only directly relevant to the consideration of glass fragments found in footwear and is not applicable to the assessment of glass fragments found on the clothing or in the hair of a suspect. This problem has been studied by Harrison and others, who have surveyed the refractive indices of glass recovered from clothing of persons suspected of a crime and which was unrelated to the crime reference samples [3]. Their results indicated a predominance of container glass fragments embedded in footwear but suggest that there may be a significant proportion of building glass on clothing, as might be expected with a survey biased towards criminal clothing.

Container glass dominated in all the areas searched, totalling 70% of all

glass collected. Building window glass accounted for approximately 12% of glass collected. As well as approximately 9% of glass being vehicle window glass and approximately 5% being vehicle headlamp glass, the majority of mirror and bulb glass samples probably originated from vehicles. There is no legal requirement for laminated windscreens in New Zealand, so the vehicle window glass results may be different in countries where the usage of laminated windscreens is high.

TABLE 1. Survey of glass samples found on footpaths in different urban areas of Auckland, New Zealand, including the distance surveyed in each area, and the percentage of each type of known glass with respect to area totals

	City (16 km)		*Residential (26 km)*		*Industrial (8.5 km)*		*Roadway (1.5 km)*		*All areas (52 km)*	
Type of glass	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*	*No*	*%*
Known										
Container	264	66.8	357	78.0	90	56.3	12	63.1	723	70.0
Vehicle window	28	7.1	41	9.0	18	11.3	3	15.8	90	8.7
Building window										
Float	5	1.3	1	0.2	2	1.3	0	0	8	0.8
Non-float	52	13.2	23	5.0	17	10.5	0	0	92	8.9
Patterned	18	4.6	5	1.1	4	2.5	0	0	27	2.6
Total	75	19.1	29	6.3	23	14.3	0	0	127	12.3
Headlamp										
Lens	10	2.5	13	2.8	12	7.5	0	0	35	3.4
Reflector	1	0.2	8	1.8	3	1.9	0	0	12	1.2
Mirror	11	2.8	7	1.5	13	8.1	3	15.8	34	3.3
Bulb	6	1.5	2	0.4	1	0.6	1	5.3	10	1.0
Other	0	0	1	0.2	0	0	0	0	1	0.1
Total	395		458		160		19		1032	
Unknown	18		10		8		0		36	

Differences were seen in the proportions of each category in the four areas searched. These differences appeared to reflect the proximity of buildings to the footpath and the probable density of vehicle traffic on the adjacent roads. Container glass was by far the most frequently-encountered type of glass in each area, and was especially so in the residential areas. Many broken milk bottles were noted in this area. Most urban New Zealand households can receive their milk in bottles delivered to their dwellings which are predominantly set back from the footpath. These factors probably account for the increased ratio of container glass to building glass in the residential areas. Nevertheless, in the city, where the most broken building glass might be expected, only 19% of glass encountered was from buildings.

The probability of picking up a piece of glass of a particular type in footwear is not only related to the proportions of the types of glass broken, but also to the

amount of glass broken. This latter factor is difficult to assess. However, an assessment was made of the number of pieces of glass at each sampling point; these results are presented in Table 2. As would be expected, the breakage of vehicle toughened glass results in numerous pieces of glass.

TABLE 2. The number of pieces of glass at each sampling point

Type of glass	*1*	*2 or 3*	*>3*	*Total*
Known				
Container	455	123	145	723
Vehicle	39	9	42	90
Window				
Plain	75	10	15	100
Patterned	19	3	5	27
Headlamp				
Lens	25	3	7	35
Reflector	9	1	2	12
Mirror	13	5	16	34
Bulb	4	2	4	10
Other	1	0	0	1
Unknown	29	6	1	36

This survey showed that container glass is the predominant type of broken glass encountered on Auckland urban footpaths. Therefore the assessment of the probability of a coincidental match of refractive index of glass embedded in footwear with glass from the scene of the crime should be made from consideration of an "all glass" refractive index survey composed mainly of container glass. The effect that the type of glass dominating a survey has on the assessment of the probability of a coincidental match of refractive indices is highlighted when a frequently-occurring refractive index for container glass in the United Kingdom, such as 1.5202 (3.1%), corresponds to an infrequently-occurring refractive index for building glass (0.23%) [1]. A suspect of a crime may have fragments of container glass, of refractive index 1.5202, embedded in his footwear and this refractive index may coincidentally match the refractive index of glass from the scene of the crime. Reference to an "all glass" survey composed predominantly of building glass refractive indices, will result in a low probability of a coincidental match and the suspect may then be unfairly judged culpable. It is important, therefore, that the survey of "all glass" used to assess the significance of glass evidence should realistically reflect the type of broken glass likely to be encountered at random in the community.

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