A model for estimating the number of glass fragments transferred when breaking a pane: experiments with firearms and hammer

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Numerous publications have shown the importance of transfer in the interpretation of glass evidence. As this phenomenon is also highly variable, it was decided to test the hypothesis that there exists a means to predict the number of fragments recovered at time $t = 0$. Panes of float glass – of different types and thickness – were broken using either a firearm or a hammer. It was decided to choose a firearm as the main breaking device, as it allowed not only to have more reproducible conditions but also to acquire knowledge in a field where little has been published. Despite the inherent variation in the breaking process, the results show that using a statistical model it is possible to predict the number of fragments transferred onto a garment from the number of fragments transferred to the ground. This research also indicates the size and number of particles transferred onto a person, when breaking window panes of different types (float, laminated or toughened) with different breaking procedures.

De nombreuses recherches ont montré l'importance de la connaissance du phénomène de transfert de fragments de verre lors de l'interprétation. Ce phénomène étant hautement variable, nous avons testé l'hypothèse selon laquelle il est possible de prédire le nombre de particules transférées au temps zéro à partir d'éléments présents sur les lieux du délit.

Les vitres (de différents types et épaisseurs) ont été brisées d'une part au moyen d'une arme à feu et d'autre part avec un marteau. Le bris avec l'arme à feu a été choisi comme mode de bris principal, car il est ainsi possible d'avoir des conditions mieux contrôlées; cela a également permis d'acquérir des connaissances dans un domaine où il n'y a eu que très peu de publications.

Malgré la variabilité inhérente du phénomène, les résultats de cette recherche démontrent qu'il est possible de prédire au moyen d'un modèle statistique le nombre de fragments transférés sur un habit à partir du nombre de fragments retrouvés sur le sol. Cette recherche donne également des indications quant au nombre et à la taille des particules projetées sur une personne avec différents modes de bris et l'influence que peut avoir sur ces deux derniers paramètres le type de verre (verre flotté de différentes épaisseurs; verre trempé et feuilleté).

In zahlreichen Veröffentlichungen wurde die Bedeutung der Übertragung von Glasspuren bei der Interpretation der Befunde aufgezeigt. Da dieser Vorgang sehr variabel ist, sollte die Hypothese getestet werden, dass es möglich ist die Zahl der zum Zeitpunkt t = 0 gesicherten Glaspartikel vorauszusagen. Floatglasscheiben verschiedener Art und Dicke wurden mit einer Schusswaffe oder einem Hammer zerbrochen. Eine Schusswaffe wurde gewählt, um dies einerseits unter besser reproduzierbaren Bedingungen durchführen zu können und um andererseits Wissen auf einem Gebiet zu erarbeiten, in dem bislang wenig publiziert wurde. Trotz der inhärenten Streuung beim Bruchvorgang zeigen die Resultate, dass es bei Anwendung eines statistischen Modells möglich ist, auf die Anzahl der auf ein Kleidungsstück übertragenen Glassplitter aus der Zahl auf dem Boden liegenden Splitter zu schließen. Aus dieser Arbeit ergeben sich auch Hinweise auf die Größe und Anzahl der auf eine Person übertragenen Partikel, wenn Scheiben unterschiedlicher Art (Floatglas, beschichtetes oder gehärtetes Glas) in unterschiedlicher Weise zerbrochen werden.

Numerosas publicaciones han demostrado la importancia de la transferencia del vidrio en la interpretación de la evidencia de vidrios. Al tratarse de un fenómeno muy variable se decidió probar la hipótesis de que exista una manera de predecir el número de fragmentos recobrados a un tiempo t=0. Se rompieron con arma de fuego o con martillo varios paneles de vidrio de diferentes tipos y espesores. Se decidió elegir el arma de fuego como el principal agente de rotura no solo por tener mejores condiciones de reproducibilidad sino tambien para adquirir conocimientos en un campo donde se ha publicado muy poco.

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A pesar de la inherente variación del proceso de rotura, los resultados muestran que es posible predecir el número de fragmentos transferidos a una prenda a partir del número de fragmentos transferidos al suelo usando un modelo estadístico.

Esta investigación tambien indica el tamaño y número de partículas transferidas a una persona cuando se rompen paneles de vidrio de difrentes tipos (plano, laminado o endurecido) con distintos procedimientos.

Introduction

The importance of estimating the probability of recovering a given number of fragments [1] cannot be overstated, as it allows one to address activity level propositions such as "The suspect broke the window". These probabilities may be assessed subjectively from experience or semi-objectively with the aid of Bayes Nets or a computer program such as TRANSFER [2]. TRANSFER models the different parameters involved. When assessing the probability of recovering glass fragments, one of the most important factors is the number of fragments transferred just after the breaking. Research [3–6] carried out on this has shown that the number recovered (at time $t = 0$) is highly variable, even when considerable effort is made to standardise experimental conditions, which makes it difficult to predict.

Therefore, we are faced with something of a dilemma: estimation of transfer probabilities is essential in order to interpret glass evidence when addressing propositions at the activity level [7] but these quantities are very difficult to estimate. We decided to undertake research to determine if – as stated by Pounds and Smalldon [8] – there is a clear relationship between the number of fragments transferred onto garments (worn by the breaker and accomplices) and onto the floor. The ultimate aim in such research is to provide a method of predicting the number of fragments transferred from the number of fragments on the floor.

In these experiments, two breaking procedures were chosen: a hammer and a hand gun. The reason for choosing a firearm was twofold. Firstly, it allowed a standardised, but realistic, breaking procedure. Secondly, as there has been no research on how many fragments may actually be transferred onto clothing when a window is broken with a gunshot, it allowed us to gain some insight into the process. In addition to these two reasons, use of a firearm allowed us to test the relationship between energy and number of fragments transferred. Broken glass is not the only physical evidence that remains at a scene after a window is broken with a firearm. Valuable forensic information can be gained from fracture patterns as well as gunshot residue, which is left by the bullet as it passes through the pane. These traces were studied in this set of experiments, but published separately [9].

In this paper we will address the following questions:

1. Do the number and sizes of the fragments transferred to the ground and to clothing depend on how the window was broken?
2. What is the influence (if any) of the glass type on the number and size of fragments of glass transferred?
3. And last but not least: is it possible with the data collected on the crime scene to estimate the number of fragments transferred onto the garment?

To answer these questions some exploratory data analysis and statistical modelling was done. All three questions require an objective method of assessment, and the statistical methods contained herein provide that objectivity.

Method

Materials and experimental set-up

A total of 42 panes of glass were broken for this research. Each pane was a single sheet measuring 0.60 m × 0.60 m. Twenty-two (22) panes were 4 mm float glass. The remaining 20 panes were 8-mm thick but consisted of float glass, toughened glass and laminated glass. To insure consistency, the panes were acquired from the same supplier (Verres industriels SA, Moutier, CH).

Every pane was clamped into a wooden frame with wooden strips. Ten panes were broken with a 460-g hammer (multiple blow breakage), two panes were broken with a sling shot and 30 panes were broken by shooting. In order to test the influence of calibre, two firearms were used in the shooting experiments; a 9 mm Glock pistol was used as the primary breaking weapon and a Llama .22 LR revolver. Francis [10] used similar methodology.

Previous research (see [1]) has shown that the transfer process is highly variable. It is essential therefore to control as much variation as possible. To that end, in each breaking, the breaker attempted to keep the point of impact (see Figure 1) in the middle of each pane. This was approximately 1.40 m high (measured from the ground) and at an angle of 90°.

Figure 1 Approximate point of impact for each breaking experiment.