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SHORT COMMUNICATION

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Evaluating forensic DNA mixtures with contributors of different structured ethnic origins: a computer software

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Abstract The effect of a structured population on the likelihood ratio of a DNA mixture has been studied by the current authors and others. In practice, contributors of a DNA mixture may belong to different ethnic/racial origins, a situation especially common in multi-racial countries such as the USA and Singapore. We have developed a computer software which is available on the web for evaluating DNA mixtures in multi-structured populations. The software can deal with various DNA mixture problems that cannot be handled by the methods given in a recent article of Fung and Hu.

Keywords DNA mixtures · Ethnic origins · Likelihood ratio · Population structure · Computer software

Introduction

It is not uncommon to find DNA samples containing materials from more than one person and the interpretation of mixed stains has been studied under the Hardy-Weinberg (H-W) law [1, 2, 3]. Curran et al. [4] and Fung and Hu [5] investigated the mixed stain problem in a structured population. These reports on mixtures mainly studied the situation that contributors to the mixed stain came from the same ethnic group. In practice, we may have contributors coming from different ethnic groups, especially in countries with multiple races such as the USA or Singapore. The ignorance of the information about the different ethnic origins of contributors may give misleading results in assessing the weight of evidence of the mixed stains. One famous example of this sort is the OJ Simpson case in which the defendant was an African-American, the two victims were Caucasians and the perpetrator(s) could be African-American(s), Caucasian(s), or of any other race. Formulae for handling such problems have been suggested [4, 6, 7]. Recently, Fung and Hu [8] reported expressions of likelihood ratios for six common cases in which the contributors to a DNA mixture belonged to different ethnic groups.

In the next section, we illustrate with an example the importance of taking into account the ethnicity of contributors of mixed stains. The example is so complex that it cannot be handled by the methods given in [8]. In this respect, we have developed a general computer software for dealing with various DNA mixture problems of this sort. The software is based on ideas of [4] and [5] for multiple structured ethnic groups. The aim of this paper is to demonstrate and provide the software that can handle the complex DNA mixtures. This software largely extends the applicability of the methods given in [4, 5, 8] and can be obtained from http:/www.hku.hk/statistics/staff/wingfung/dnamixm.exe.

Case example

The example is the well-known OJ Simpson case in which a three-banded profile $A_1A_2A_3$ at an RFLP locus D2S44 was obtained for DNA recovered from the center console of an automobile owned by the defendant. The profiles of the defendant, Mr. Simpson, and a victim, Mr. Goldman, were found to be A_1A_2 and A_1A_3 respectively. In this case, the court ordered that the number of contributors (n) to the DNA mixed stains be set to two, three or four. The following propositions are considered:

H_p: The contributors were the victim, suspect and m unknowns
H_d: The contributors were n unknowns.

Regarding the single-banded alleles as true homozygotes, the effects of different ethnic groups and coancestry coefficients θ are investigated. The defendant and the victim were an African-American and a Caucasian, respectively. The unknown persons could be from various ethnic groups and they are taken to be African-Americans (AA), Caucasians (CA) and/or Chinese (CH). The following allele frequencies are used for the three alleles A_1, A_2 and A_3, respectively, AA: 0.0316, 0.0842, 0.0926, CA: 0.0859, 0.0827, 0.1073, and CH: 0.0169, 0.0749, 0.1522 [9, 10, 11].

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Table 1 Likelihood ratios for the OJ Simpson case example

n	Under H_d, the number of unknowns belong to group			Scenario					
	AA	CA	CH	1		2		3	
				θ=0	0.03	0	0.03	0	0.03
2	2	0	0	1623	518	70	36	124	56
	0	2	0	396	218	17	15	30	23
	0	0	2	1773	1536	77	108	135	165
	1	1	0	727	329	32	23	55	35
	1	0	1	1519	739	66	52	116	79
	0	1	1	599	420	26	29	46	45
3	3	0	0	21606	2561	938	180	1645	275
	0	3	0	3112	799	135	56	237	86
	0	0	3	16007	7432	695	521	1218	798

Scenarios 1, 2, 3 correspond to hypothesis Hp: the contributors were the victim, the suspect and *m* unknowns.
Scenario 1, *m*=0.
Scenario 2, *m*=1 unknown of African-American.
Scenario 3, *m*=1 unknown of Caucasian.
AA African-American.
CA Caucasian.
CH Chinese.

The problem is investigated using the developed computer program. For brevity, only some of the results for n=2 and 3, and m=0 and 1 are listed in Table 1. A few points are noticed. Firstly, the likelihood ratio (LR) is highly affected by the different sets of propositions (hypotheses or explanations), and this is not unusual. Secondly, ethnicities of the contributors can have a large effect on the size of the *LR*. For example, in scenario 1 with m=0 and θ=0.03, the *LR* when the two unknowns in H_d are Chinese is about 7 times of that when they are Caucasians. A similar phenomenon is also found for the other two scenarios with m=1. Thirdly, the effect of population structure on the size of the *LR* can be substantial. In some cases, taking θ=0.03 can reduce the size of the *LR* by several factors. However in three cases, the *LR* increases with θ, indicating that taking $\theta \neq 0$ is not always more conservative than the H-W rule.

This example demonstrates the importance of taking ethnicities of contributors into account, and the flexibility of the developed program in dealing with various situations. Forensic scientists can choose one or some of the LRs in Table 1 that they find appropriate, or choose to average out different possibilities to obtain an overall *LR*.

Conclusion

In this paper, we use a developed computer program to analyse a case example of DNA in mixed stains. The example clearly demonstrates the importance of taking into account the ethnicities of contributors in the interpretation of mixed stains. The software can be downloaded from the second author's home page.

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