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The Evidential Value of Automobile Paint. Part II: Frequency of Occurrence of Topcoat Colors

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ABSTRACT: Frequency of occurrence data are valuable to forensic scientists in their quest to properly assess the evidential value of automotive paint exhibits. A survey of automobile topcoat paint colors is presented with a sample size of 43 000 vehicles covering six eastern states in the United States. In addition, the results of a second survey utilizing more discriminating color groups for 2000 vehicles in central Florida is given. Comments on statistical validity and sample size for frequency distribution studies are provided.

KEYWORDS: criminalistics, automobiles, paints, evidential value, topcoat colors, frequency distributions, statistics

In the assessment of the evidential value of automotive paint, frequency of occurrence data are valuable to the forensic scientist. Although attention was called to this problem in 1964 by Kirk and Kingston [*1*], there is currently little of this type of information available in the literature. Collection of this information is quite tedious and time-consuming, and complex, interrelated characteristics lead to a monumental problem in properly collecting and interpreting the raw data. The fruits of the toil will most certainly aid our decisions in giving sound interpretations of qualified opinions in courts of law and, consequently, more simply and accurately describing the probative meaning of the evidence for the jury. The results presented in this study are the beginnings of an attempt to fill this void that exists in the United States.

Several prior studies concerning automobile topcoat color distributions have been published; however, no frequency of occurrence data have been published concerning automobiles in the United States. In 1963, Tippet [*2*] published the results of a survey of the topcoat color distribution for 20 000 cars in England. The survey was intended to discover if the number of particular colors of car models on the road could be predicted by a Poisson distribution. The data dealt with the combined vehicle characteristics of model, make, and topcoat color as well as their variations in frequency depending on the traffic flow rate on the road on which they were counted. Gothard [*3*] examined paint chips from 500 randomly selected automobiles in Australia during 1975. His work investigated the distribution of the samples throughout a complete analytical scheme similar to one that would be used in examining paint chips submitted to the forensic science laboratory as evidence. Manura and

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Saferstein [4] published an evaluation of laser beam emission spectroscopy dealing with the analysis of 112 randomly collected automotive topcoats. Although shedding some light on the distribution of topcoat colors on cars in the United States, their study was not intended to be a frequency of occurrence project, but was instead an evaluation of an instrumental technique. Audette and Percy [5] introduced a series of papers, to be completed in the future, dealing with the frequency of occurrence of automotive finishes in Canada. That work appears to be the first truly comprehensive study of this type.

The authors have previously published the results of a limited survey of 200 randomly sampled automotive paint chips [6], similar to Gothard's study [3]. This introductory work tabulated specimen characteristics throughout a normal forensic science paint analytical scheme (microscopic examination, microchemical tests, organic and inorganic instrumental analysis). This initial part of an ongoing series served to stress the degree of differentiation attainable at various stages throughout an analytical procedure applied to current samples. It was not intended to be a comprehensive frequency of occurrence study, nor an endorsement of any specific instrumental method. By documenting the degree of discrimination possible at various stages throughout the analysis, it provided a barometer to assess the evidential importance of paint comparisons where limited sample or lack of instrumentation prevents a comprehensive examination. In addition, the study demonstrated the capability of differentiating paint chips having similar general topcoat colors and provided a general "feel" for the specificity of various characteristics in the microscopic and microchemical examinations. More importantly, justifications for these interpretations were documented. The authors used this work as a preliminary study to assess the methods to be used for the valid collection of data in future studies.

The present paper presents the results of a comprehensive frequency of occurrence study concerning automobile topcoat color distributions for vehicles in the eastern United States. In evaluating these distributions, we obtain a better assessment of the statistical probability for the occurrence of an alternate source of paint having a topcoat color generally similar to the questioned paint in the case being examined. Subsequent studies will deal with the evaluation of frequency of occurrence data for other important forensic science characteristics, such as number of layers, base primer colors, and undercoat layer structure.

Examination Procedure

This study of automobile topcoat distributions was conducted in two phases: first, general color groups and second, more specific color groups.

During the first phase, data were collected from June to August of 1979. Automobile topcoat colors of vehicles on the road were recorded both from stationary observation points and from a moving vehicle. Random sampling was undertaken on rural and city roads as well as on interstate highways. The authors interchanged observer/recorder duties frequently to insure unbiased interpretation of the color definitions set forth prior to the beginning of the data collection. Half of the vehicles were counted within the state of Florida (21 444), and an additional 21 563 vehicles were counted in several eastern states (Georgia, South Carolina, Pennsylvania, and New York) in order to detect any variation in topcoat color frequency attributable to geographic location in the eastern United States.

Fourteen general color groups were chosen: black, blue, brown, gold/bronze, gray, green, orange, purple, red, maroon, pink, off-white/beige, white, and yellow. An attempt was made to create as many categories as possible, keeping in mind the practical constraints of rapid discrimination and recording of colors on moving automobiles observed at a distance. This type of observation prevented the differentiation of metallic and nonmetallic finishes. When two-toned cars were encountered, the lower color was recorded because this area would be the most likely to be involved in an accidental paint transfer typically encountered in case samples.

The counts were recorded on a data board constructed to facilitate rapid data collection. The count sheets had a vertical column for each of the color groups with representative color chips at the top of each column. To ensure the recording of each vehicle passing the observation point, the observer called out the color and the recorder placed an entry in the appropriate column. At the end of each observation period, the entries were totaled and recorded on a master chart.

The color group classifications covered a wide range of chroma and value. Examples of the ranges are illustrated in Table 1 with the codes of National Bureau of Standards (NBS) color chips from the Automotive Paint Collection [7] and the codes of color chips in the Munsell Color Book [8]. It is stressed that these references are presented only to give the reader a reference point for correlating color groups used in this study with his, and not as a precise definition of the range of the group. Accurate description of automotive paint colors is extremely difficult. For example, in this study the tan/beige group is defined as a color

TABLE 1—*Color definition examples.*

Second Survey	NBS Codes [7]	Munsell Codes [8]	First Survey
Black	74C0034, 77C0307	N/0, N/0.5	black
Light blue	74L0098, 74L0021, 77L0309	7.5B(8/4)(9/2)(7/6), 10B(7/6)	blue
Medium blue	74L0131, 74L0099, 74L0045, 74L135	7.5B(6/8)(5/10)(4/8), 10B(6/8)	blue
Dark blue	74L0081, 74L0101, 77L0350	7.5B(2/6)(2/4), 10B(2/4)(2/6)	blue
Green-blue	74L0063, 77K0340, 77L0321	7.5BG, 10BG, 10G(6/10)(5/10)	blue
...	74A0121, 78C0514	2.5Y(9/2), 10YR(9/1)	tan/beige
Light brown	74H0029, 74H0065, 77F303, 77F351	5YR(6/4), 7.5YR(8/4)(7/4)	brown
Medium brown	74F0112, 74F109, 74F126, 77F305	5YR(3/2)(3/4)(4/4), 7.5YR(6/4)	brown
Dark brown	74F0032, 74F0111, 77F339, 77F283	5YR(2/4)(2/2), 7.5YR(2/4)	brown
Red-brown	74F0116, 74F0110, 77F302, 77F379	2.5YR(4/10)(3/8)	brown
Red	74E0094, 77E342, 76E222	7.5R(3/12)(4/16), 5R(4/14)(3/10)	red
Red-orange	76G0263, 75E0236	7.5R(5/14)	red
Gold/bronze	74F133, 74F0012, 74F139, 77F324	...	gold/bronze
Light gray	74B0129, 77B355, 77L349	N/8.5, N/7.5	gray/silver
Medium gray	74B0020, 77B308	N/6.0, N/4.0	gray/silver
Dark gray	74C0080, 78B389	N/3, N/2	gray/silver
Light green	74K0014, 77K322, 77368	7.5GY(9/2)(8/4), 2.5G(9/2)(8/4)	green
Medium green	74K0015, 74K0064, 77K323, 77K290	7.5GY(4/6), 10Y(5/8), 2.5G(7/10)	green
Dark green	74K0016, 74K0136, 77K0311	2.5G(3/10)(3/6), 5G(2/6)	green
Yellow-green	74K0058, 77K343, 76H0253	10Y(8.5/12), 2.5GY(8/10)	green
Light yellow	74K0104, 76H0241	5Y(9/6)(9/4), 7.5Y(9/6)(8.5/12)	yellow
Medium yellow	74H0043, 74H0035, 74H0008, 76H241	10YR(8/16)(8/12), 5Y(8.5/14)	yellow
Dark yellow	74H0006, 78H0500	10RY(7/12), 7.5YR(7/16)(6/12)	yellow
Maroon	74E0068, 74F0071, 78F421, 77F353	2.5R(2/6)(2/4)(3/10), 10RP(2/8)	maroon
Orange	74G0070, 74G0115, 77G312, 77G352	10R(5/18)(6/14), 2.5YR(6/16)	orange
Purple	74E0017, 74E0085, 77E319	7.5PP (all above chroma 2)	purple
Pink	...	2.5RP(8/6), 7.5RP(6/12)(7/8)	pink
White	74A0042, 78A0466	N/10, N/9.5	white
Off-white	74L0097, 77A0364	N/9.0	white

falling between white and light brown. On moving cars, the transition between a light brown and a tan/beige is quite difficult to discern. Blue-greens were placed into the blue group and yellow-greens (lime) were placed into the green group. By alternating observer/recorder duties and by employing wide color group ranges, little effect in the frequency of occurrence statistics resulting from slight variations in color perception was realized.

Observation periods ranged from 0.5 to 1.5 h, during which the number of vehicles recorded ranged from 400 to 4300. By repetitive counting in smaller groups, an attempt was made to ascertain empirically the number of vehicles necessary for a representative sample of cars on the road. If the percentage of occurrence of a particular color (based on the total number of vehicles counted in that observation period) is consistent from one period to another, the sample size can be justified as an experimentally representative one.

The second part of the project was undertaken with more discriminating color groups and a total sample of four times the previously determined minimum representative sample size. Topcoat colors were recorded on 2018 randomly sampled automobiles in public parking lots in central Florida during the period of August to November 1979. By observing stationary vehicles at close quarters, more time was available for careful discrimination and recording of topcoat color than in the first phase. This portion of the investigation also permitted the differentiation of metallic and nonmetallic finishes. The color groups chosen are listed in Table 1 along with the corresponding codes for representative NBS automotive color chips and Munsell color chips. Because of the increase in observation efficiency, additional color groups were added to the initial list: green-blue, red-brown, yellow-green, red-orange, and off-white. The off-white/beige group used in the first study was divided into the new off-white and light brown categories. In addition, light/medium/dark differentiation was recorded on all major color groups, while only metallic/nonmetallic differentiation was tabulated on the minor color groups.

A second survey chart having data blocks for each of the new color groups as well as a metallic and nonmetallic block for each group was constructed. Representative color chips were attached to the board to provide a convenient reference to color "definitions" while the observations were made. The light, medium, or dark discrimination was the most difficult. If there was any doubt as to the proper classification owing to an intermediate color value, the sample was recorded in the medium group.

The final data were accumulated by adding the results of several observation periods over the three-month period. The automobiles were observed by walking up and down successive rows of cars in the public parking lots of various shopping centers, discount department stores, and food stores in both rural and urban areas during various times of the day. To ensure randomness in the survey, the order of progression was maintained at all times, with all cars being recorded as they were passed.

Results and Discussion

First Survey

Although a higher discrimination in color groups was desired, the 14 classifications were picked based on the practicalities of observing and recording moving traffic. A trial run was performed before the data collection was begun to ensure efficient data collection and agreement in color definitions by different observers.

The distribution of the topcoat colors of 21 444 randomly sampled automobiles in Florida is recorded in Table 2. These values are the totals accumulated during 19 observation periods over a three-month span. The distributions, in percent, from one observation period to another were found to be surprisingly similar as depicted by the mean and standard deviation values. This suggests that if there were statistically significant differences, the differences would indeed be very small for our practical purpose of estimating the general frequency of

TABLE 2—*First survey—Florida data.*

Color Group	n	% of Total	Mean % of 19 Observations	Standard Deviation of % Among 19 Observations
Black	567	2.7	2.6	0.7
Blue	4 482	20.9	20.6	1.4
Brown	3 412	15.9	15.7	1.6
Gold/bronze	583	2.7	2.9	0.8
Gray/silver	1 744	8.1	7.9	1.3
Green	2 800	13.1	12.5	1.7
Orange	313	1.5	1.5	0.5
Purple	28	0.1	0.2	0.1
Red	1 452	6.8	7.0	1.0
Maroon	820	3.8	3.9	0.8
Pink	7	0.03	0.01	0.03
Tan/beige	802	3.8	3.8	1.5
White	3 096	14.4	14.7	1.5
Yellow	1 338	6.2	6.7	1.4
Totals	21 444	100.0	100.0	...

occurrence for the various color groups. Reproducible distributions were observed with a sample as small as 500 vehicles, indicating future update surveys could use this relatively small representative sample size. It should be noted, however, that a statistical price in confidence level and confidence interval must be paid if this small sample size is used. With each color group treated as a binomial distribution, a sample of 500 will yield a confidence interval of ±3.6% for the blue color group with a 95% confidence level, whereas a sample of 21 444 yields a confidence interval of ±0.8% for the same color group with a 99% confidence level. While samples of 500 to 1000 may be satisfactory for data updates and checks, they obviously do not hold the statistical validity of the 21 444 sample size.

A comment on the sample size required for examiners who wish to accumulate and verify data in their own area is in order. If a specified color has a true probability of occurrence p, then an approximate 95% confidence interval estimate for p is given by

$$p = \hat{p} \pm 2[p(1 - p)/\mathrm{n}]^{1/2}$$

where $\hat{p}$ is the sample estimate of p and n is the sample size. From this, it is easy to deduce that if one wishes to estimate p to within an amount $\pm D$ with approximately 95% confidence, the required sample size is

$$n = 4\hat{p}(1 - \hat{p})/D^2$$

(If an approximate confidence of 99% is desired, the numbers 2 and 4 in the above formulas should be replaced with 3 and 9, respectively.) Thus, if a color occurs 5% of the time, then a sample of 475 is required if one wishes to be within ±2% of the true value with 95% confidence.

Table 3 gives the accuracy ($\pm D$) of estimation (95% confidence) using sample sizes of 500 and 1000 for various hypothetical values of p, the true proportion. It may be inferred that, especially for small values of p, a sample size of 500 would usually be statistically adequate.

As stated previously, the observer/recorder duties were changed frequently from one observation period to another. As suggested, this had little effect on the reproducibility of the color distributions. This corroborates the results of the initial trial observation period, indicating effective color group definitions and no real change in distribution values resulting from slight variations in color perception by different observers.

In an effort to evaluate the effect of geographical location and climatic variation on the distributions, data were recorded in five other states on the eastern coast of the United States, ranging from subtropical to northern temperate climatic zones. In discussing the concept of topcoat colors on vehicles with colleagues before this study, it was commonly believed that one would expect to find a greater frequency of light colors, especially white, in the subtropical climates because of their ability to reflect the suns rays and keep a car "cooler" in the hot summer sun. Conversely, one might suspect darker colors to be more popular in the northern temperate climates, where sun is not so much a problem as the visibility of one's car in the snow. The results are recorded in Table 4. It is easily confirmed that there are differences in color distribution from state to state (based on the data in the survey) by using a contingency table analysis and χ^2 test of significance. However, once again, it is more important that the differences are small for our practical purposes. This can be seen in the values reported for the standard deviation from the mean for the various color groups in Table 4. These results do reduce the problem in accumulating frequency of occurrence data, since there is apparently little variation in the topcoat color distribution between the six states sampled in the eastern United States. Thus, the values reported in Table 4 can act as a preliminary data base for the reader in his area. It should be noted that it is obviously advisable to follow up these data with a verification of color frequency distribution in the area where it is to be applied.

Because of the similarity in color distributions between the five states, their data were added together. This sum was added onto the Florida statistics (again because of the reproducibility of color distributions) and yielded a total sample count of 43 007. This distribution is also reported in Table 4. Statistical evaluation of the data, with each color group treated as a binomial distribution, revealed a maximum confidence interval (for the blue color group) of $\pm 0.6\%$ with a 99% confidence level. Therefore, we can expect these values to be quite reliable as a prediction of the frequency of occurrence of automobile topcoat colors on the road when the color groups are used as defined.

Second Survey

As noted previously, the second part of this project was designed to provide data that would offer more discrimination of topcoat colors. Since practicality demands a reasonable number of color groups, the distribution values will still not truly reflect the high power of discrimination offered by a careful microscopic comparison of two similar automotive paints. However, compared to the first survey, a more effective assessment of the probative value of a particular color group is realized with an increase in the number of color groups to include metallic/nonmetallic as well as light/medium/dark classifications in the major color groups.

The result of the examination of 2018 randomly sampled automobiles is given in Table 5. This sample size is four times the representative sample size empirically ascertained in the first survey. A statistical evaluation of the data treating each group as a binomial distribu-

TABLE 3—*Accuracy* ($\pm$D) *of estimation (95% confidence).*

	True Proportion p						
Sample Size	0.01	0.05	0.10	0.20	0.50	0.80	0.90
$n = 500$	0.009	0.019	0.027	0.036	0.045	0.036	0.027
$n = 1000$	0.006	0.014	0.019	0.025	0.032	0.025	0.019

TABLE 4—*First survey—combined states data.*

	Black	Blue	Brown	Gold/ Bronze	Gray/ Silver	Green	Orange	Purple	Red	Maroon	Pink	Tan/ Beige	White	Yellow	Totals
Florida															
n	567	4482	3412	583	1744	2800	313	28	1452	820	7	802	3096	1338	21 444
%	2.7	20.9	15.9	2.7	8.1	13.1	1.5	0.1	6.8	3.8	0.03	3.8	14.4	6.2	100
Georgia															
n	124	820	766	52	399	575	48	7	234	56	1	67	540	189	3 878
%	3.2	21.2	19.8	1.3	10.3	14.8	1.2	0.2	6.0	1.5	0.02	1.7	13.9	4.9	100
South Carolina															
n	105	658	560	67	347	427	47	6	220	95	0	58	407	168	3 165
%	3.3	20.8	17.7	2.1	11.0	13.5	1.5	0.2	7.0	3.0	0	1.8	12.9	5.3	100
North Carolina															
n	107	892	684	90	387	510	48	7	306	103	2	59	537	138	3 870
%	2.8	23.0	17.7	2.3	10.0	13.2	1.3	0.2	7.9	2.7	0.05	1.5	13.9	3.6	100
Pennsylvania															
n	147	797	539	53	327	524	64	12	309	118	2	34	396	219	3 541
%	4.2	22.5	15.2	1.5	9.2	14.8	1.8	0.3	8.7	3.3	0.05	1.0	11.2	6.2	100
New York															
n	256	1575	1228	128	381	1097	137	5	694	258	2	85	879	384	7 109
%	3.6	22.2	17.3	1.8	5.4	15.4	1.9	0.07	9.8	3.6	0.03	1.2	12.4	5.4	100
Totals															
n	1306	9224	7189	973	3585	5933	657	65	3215	1450	14	1105	5855	2437	43 007
%	3.0	21.4	16.7	2.3	8.3	13.8	1.5	0.2	7.5	3.4	0.03	2.6	13.6	5.7	100
$\bar{\%}$	3.3	21.8	17.3	2.0	9.0	14.1	1.5	0.2	7.7	3.0	0.03	1.8	13.1	5.3	...
σ, %	0.5	0.8	1.5	0.5	1.8	0.9	0.2	0.08	1.3	0.8	0.02	0.9	1.1	0.9	...

tion revealed a maximum confidence interval of ±1.4% with a 95% confidence level for the 11.0% white nonmetallic color group to a ±0.2% confidence interval for the groups with 0.2% frequency levels. Although the accuracy of the very low percentage values is questionable (as evidenced by a confidence interval almost equalling the value itself), it must be kept in mind that the values reported are approximate frequencies. Therefore, it does not really matter whether a frequency of occurrence is 0.1% or 0.4%. The important point is that more than 99.6% of the automobiles on the road do not fall within this color group (stated with a 95% confidence level).

As noted in Table 5, 52% of the vehicles had a metallic finish and 48% a nonmetallic finish. The blues, browns, and whites are the most frequently encountered colors.

A comparison of the distribution values in this survey with those in the first survey is presented in Table 6. In order to make this comparison, the blues and green-blues in the second survey must be grouped together just as must the browns and red-browns, the greens and yellow-greens, the reds and red-oranges, and the whites and off-whites. The tan/beige group must be added to the browns in the first study, since it was defined such that a tan/beige in the first study would appear as a very light brown in the second survey. As mentioned earlier, this was a result of the increased discrimination capability in the method of observation in the second project.

A contingency table analysis of the distribution of colors for the first and second surveys showed a difference between the two. However, as can be seen from Table 6, the differences are small, with the largest observed difference being for yellow (5.7% for the first survey and

TABLE 5—*Second survey—parking lot data.*

	Metallic		Nonmetallic		Totals		
	n	%	*n*	%	*n*	%	Group Totals, %
Black	1	0.05	44	2.2	45	2.25	2.25
Light blue	14	0.7	84	4.2	98	4.9	
Medium blue	196	9.7	39	1.9	235	11.6	18.2
Dark blue	21	1.0	14	0.7	35	1.7	
Green-blue	30	1.5	8	0.4	38	1.9	1.9
Light brown	5	0.3	124	6.1	129	6.4	
Medium brown	98	4.9	24	1.2	122	6.1	16.8
Dark brown	83	4.1	3	0.2	86	4.3	
Red-brown	60	3.0	3	0.2	63	3.2	3.2
Gold/bronze	70	3.5	0	0	70	3.5	3.5
Light gray	128	6.3	10	0.5	138	6.8	
Medium gray	23	1.1	3	0.2	26	1.3	8.4
Dark gray	6	0.3	0	0	6	0.3	
Light green	39	1.9	23	1.2	62	3.1	
Medium green	104	5.2	9	0.5	113	5.7	10.8
Dark green	37	1.8	5	0.2	42	2.0	
Yellow-green	15	0.7	10	0.5	25	1.2	1.2
Maroon	67	3.3	17	0.8	84	4.1	4.1
Orange	1	0.05	19	0.9	20	0.95	0.95
Red-orange	2	0.1	11	0.5	13	0.6	0.6
Purple	4	0.2	3	0.2	7	0.4	0.4
Pink	0	0	0	0	0	0	0
Red	38	1.9	92	4.6	130	6.5	6.5
White	0	0	223	11.0	223	11.0	11.0
Off-white	0	0	43	2.1	43	2.1	2.1
Light yellow	0	0	65	3.2	65	3.2	
Medium yellow	0	0	87	4.3	87	4.3	8.1
Dark yellow	0	0	13	0.6	13	0.6	
Totals	1042	51.6	976	48.4	2018	100	100

TABLE 6—*Comparison of the first and second surveys.*

	Black	Blue	Brown	Gold/ Bronze	Gray/ Silver	Green	Orange	Purple	Red	Maroon	Pink	White	Yellow	Totals
First survey														
n	1306	9224	8292	973	3485	5933	657	65	3215	1450	14	5855	2436	43 005
%	3.0	21.4	19.3	2.3	8.3	13.8	1.5	0.2	7.5	3.4	0.03	13.6	5.7	100
Second survey														
n	45	406	400	70	170	242	20	7	143	84	0	266	165	2 018
%	2.2	20.1	19.8	3.5	8.4	12.0	1.0	0.4	7.1	4.1	0	13.2	8.2	100
Combined survey														
n	1351	9630	8692	1043	3755	6175	677	72	3358	1534	14	6121	2601	45 023
%	3.0	21.4	19.3	2.3	8.3	13.8	1.5	0.2	7.5	3.4	0.03	13.6	5.7	100

8.2% for the second). This implies that the two sampling methods, as used in the study, are equally accurate for obtaining the color sampling distributions. It also confirms that the parked car population, as might be expected, is apparently similar to the "on the road" automobile population.

Conclusion

In a recent review of the forensic sciences, Saferstein [9] states that the 1970s saw a development of technical tools with which to conduct our work, "but as yet we have failed to define in statistical terms the meaning and significance of the data they generate." For forensic science paint evidence evaluation, the problem is more serious than that. As Kirk [1] noted in 1964, "At this state of development of the forensic sciences there are few areas indeed in which there is any collection of reference data suitable for statistical or any other mathematical analysis." He goes on to discuss the concept of statistical data, arguing that it is not a goal in itself, but rather a basis for the making of decisions.

Qualified forensic paint examiners seldom have difficulty in relating their results to a court of law. They are constantly sharpening their skills at presenting technical information in a clear and concise manner. However, because of the class evidence nature of most paint evidence, the expert witness must be careful in a statement of interpretations drawn from the analytical results. The difficult responsibility of properly interpreting the meaning of these conclusions should not be avoided, for it is the expert's true reason for being there.

Conclusions such as "could have originated from" and "originated from this source or another source having all of the same characteristics" are frequently given to the court at face value, with no attempt to further educate them as to the limited probability of the "did not originate from" or "the *other* source" possibilities. Although the former statements of these interpretations are technically correct, they tend to underplay the significance of the evidence. Trace evidence analysts have often been forced into omitting evaluations of these types of statements as a result of the lack of personal experience or published frequency of occurrence data to substantiate their interpretations.

It is to provide such data that this survey was done. Although in testifying we are required to acknowledge the possibility that automobiles other than the one in question may have an indistinguishable topcoat paint on their surfaces, we can also relate the approximate frequency of occurrence of this particular color and that further discrimination by detailed microscopic and instrumental examinations significantly reduces this value. Thus, for example, a statement such as, "At least 97% of the vehicles on the road can be eliminated as possible sources of the questioned paint on the basis of general topcoat color alone," can give the court a better scale for evaluating the "could have" conclusion.

It should be remembered that the actual examination of paint fragments would of course involve a comparison not only of topcoat colors but also of chemical constituents and other layers and thus the statistical data based on topcoat color alone will substantially overestimate the number of vehicles to be considered as possible sources. Although this study is only the beginning of the quest to gather data to corroborate our opinions based on experience, the authors hope it will be an aid to forensic paint examiners until more data can be made available in subsequent surveys. It is again recommended that the data should be accumulated and verified by examiners in their own areas with a sample size of their choosing, keeping in mind the constraints of a statistically valid study as reflected in confidence intervals and confidence levels.

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