Fire Investigation Origin Determination Survey

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Background

- Lack of a current demographic survey for our profession
  - TWGFEX in 2000
    - 422 participants
- Lack of studies evaluating performance
  - Carman's exercise in 2008
    - 5.7% accurately identified the quadrant of origin

Purpose of this survey

- Gather info on the current demographics and basic thoughts on methodology

- Accuracy of origin determination
  1. Visible observations only
  2. Measurable + visible observations

- Relationship between demographics, methodology, and accuracy
  - Identify systemic errors

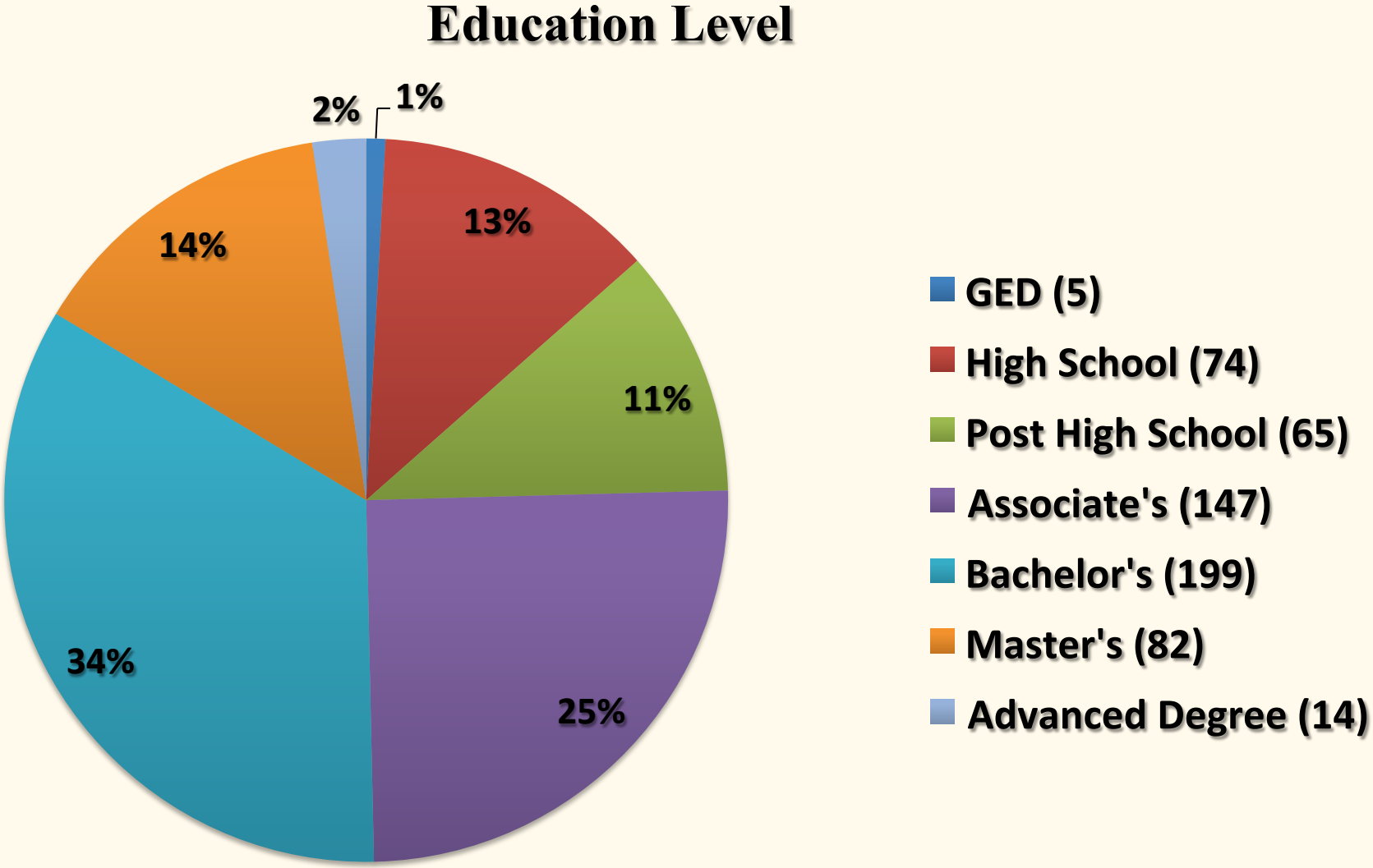
Methodology

- Multi-part survey administered online
  1. Demographics and Methodology
  2. Pattern identification exercise – single photograph
  3. Area of origin determination exercise – photographs only
  4. Area of origin determination exercise – photographs and measurements
- 586 completed responses (~8000 possible)
  - Considered representative due to experiential levels of those that participated

Demographics

- Sex: 96% Male / 4% Female
- Avg. age: 46 years (*SD=10.8*)
- Avg. Experience
  - Full-time Inv.: 10.5 years (*SD=9.4*)
  - Lead Inv.: 50% lead for 100+ fires
- Employment type
  - Private: 35%
  - Public: 65%
    - Employed by FD: (54%)
    - Employed by LE: (14%)

Demographics – Education Level



Demographics–Area of Degree Study

Area of Study	Number	Percentage
Fire Science	210	35.7%
Criminal Justice	82	13.9%
Fire Protection Engineering	47	8.0%
Electrical Engineering	24	4.1%
Mechanical Engineering	19	3.2%
Other Engineering	16	2.7%
Public Administration	23	3.9%
Forensic Science	4	0.7%
Other	161	27.4%

Demographics – Certification Levels

Certifications	Total	Percentage
CFEI	324	55.0%
IAAI-CFI	179	30.4%
PI	98	16.6%
CVFI	93	15.8%
IAAI-FIT	85	14.4%
CFII	64	10.9%
PE	31	5.3%
CFPS	20	3.4%
IAAI-CI	8	1.4%
ATF-CFI	6	1.0%
IAAI-ECT	5	0.8%

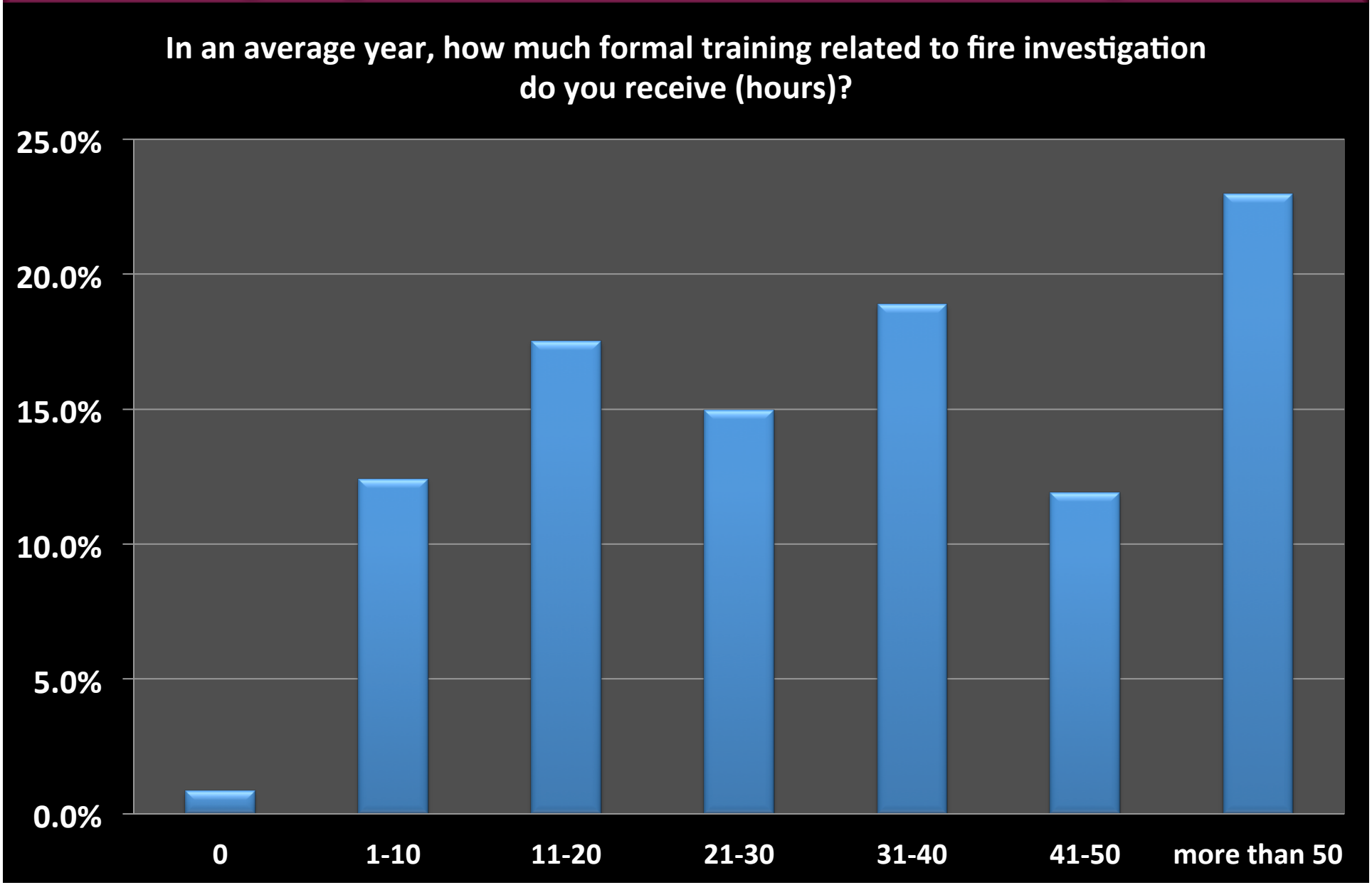
Demographics – Journal Readership

Journal	Total	Percentage
Fire and Arson Investigator	493	83.8%
National Fire Investigator	334	56.7%
Firehouse	277	47.0%
Fire/Rescue	180	30.6%
Fire Technology	177	30.1%
Fire Protection Engineering	112	19.0%
Journal of Fire Protection Engineering	45	7.6%
Fire Safety Journal	32	5.4%
Journal of Forensic Science	24	4.1%
Fire Risk Management	16	2.7%

Demographics – Conference Attendance

Conference	Total	Percentage
IAAI State Chapter Training	335	56.9%
Any National Fire Academy Course	216	36.7%
Public Agency Training Council	207	35.1%
IAAI Annual Training Conference	169	28.7%
NAFI/NFPA National Training Seminar	137	23.3%
Technical Working Group on Fire and Explosions	64	10.9%
NFPA Conference and Expo	54	9.2%
ISFI	52	8.8%
Federal Law Enforcement Training Center	38	6.5%
ICAC Fire and Arson Investigation Seminar	10	1.7%

Demographics – Annual Training Hours



Demographics – Online Training

Training Provider	Total	Percentage
CFI Trainer	500	85.0%
Pennwell Fire Engineering	24	4.1%
UL University	20	3.4%
Fire Protection Engineering	16	2.7%

Demographics – Books Owned

Books	Total	Percentage
NFPA 921	581	98.6%
NFPA 1033	520	88.3%
Kirk's	523	88.8%
Dynamics	287	48.7%
Forensic Fire Scene	239	40.6%
IFSTA	229	38.9%
Ignition Handbook	203	34.5%
Scientific Protocols	137	23.3%
SFPE	89	15.1%

Demographics – Summary

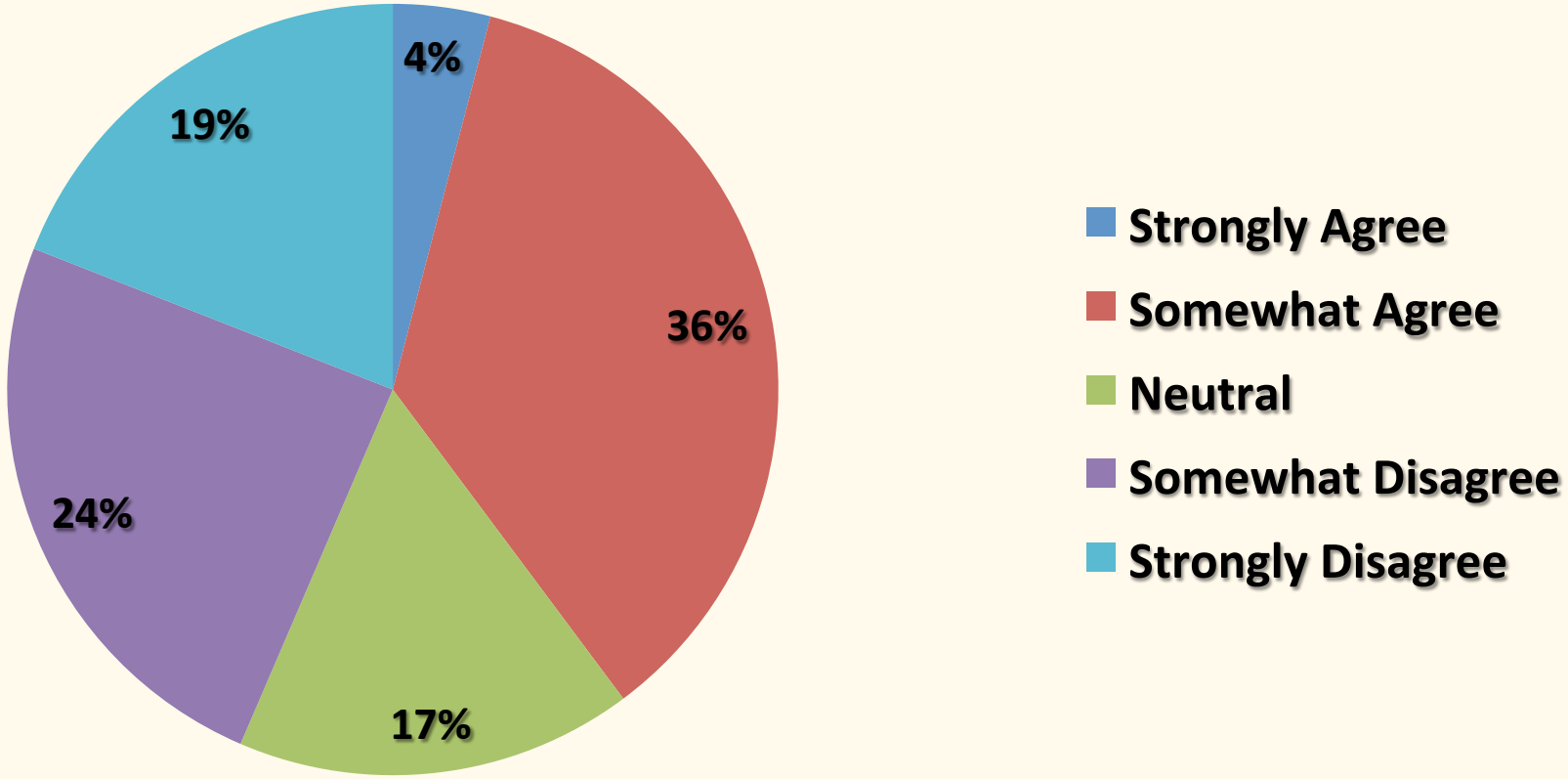
- Over 75% of the respondents holding at least an Associate's degree
- Frequency of certifications: 79% held at least one certification directly related to fire investigations
- Market saturation of the IAAI's CFI Trainer with 85% of the respondents taking classes
- Self-reported formal training hours show an industry that actively educates itself

Initial Opinions

- As part of the demographics portion of the survey, the participant's opinions on a variety of topics related to the fire investigation field were evaluated.

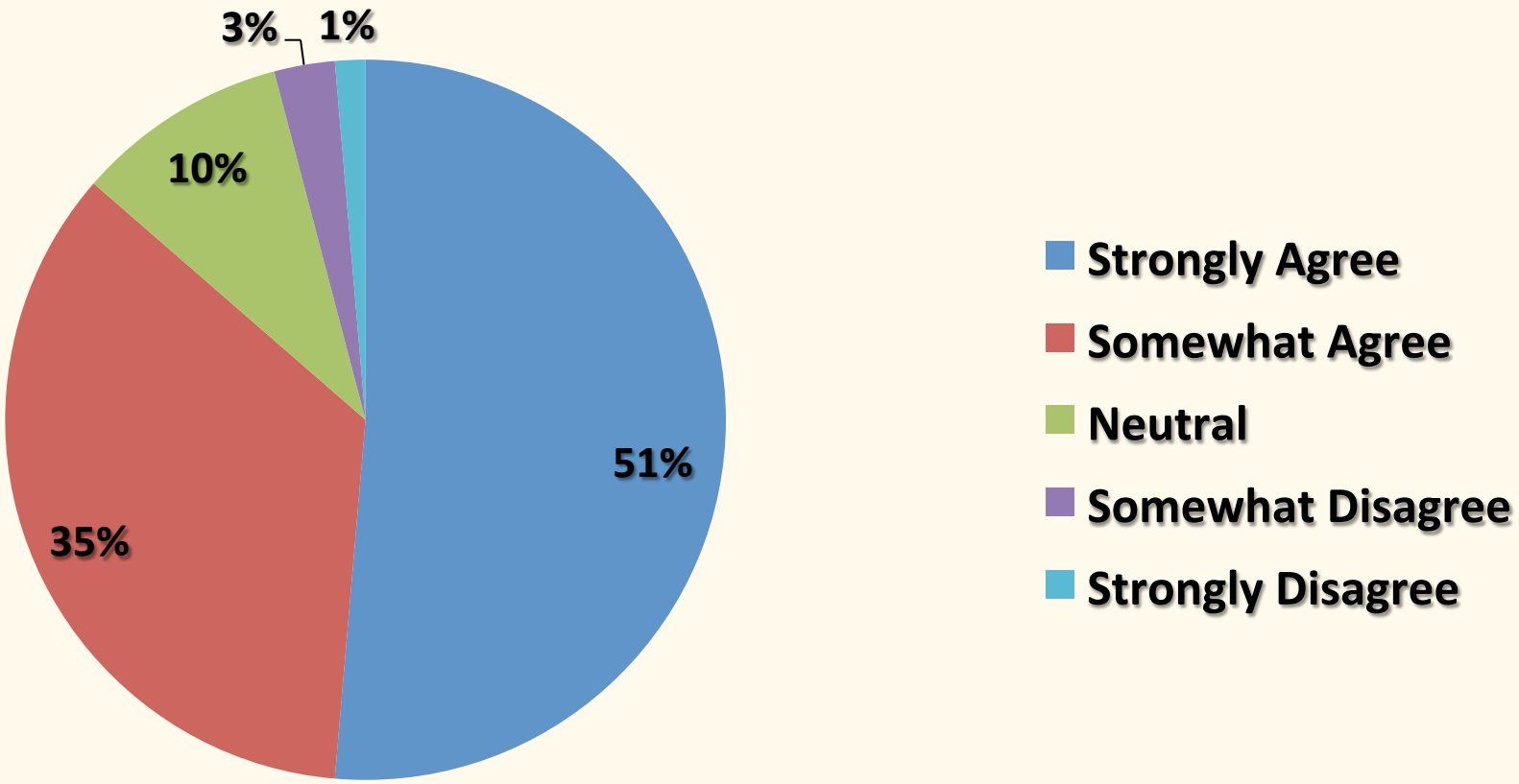
Visible Damage Use

The area of origin determination can be reliably determined through the use of visible damage only.

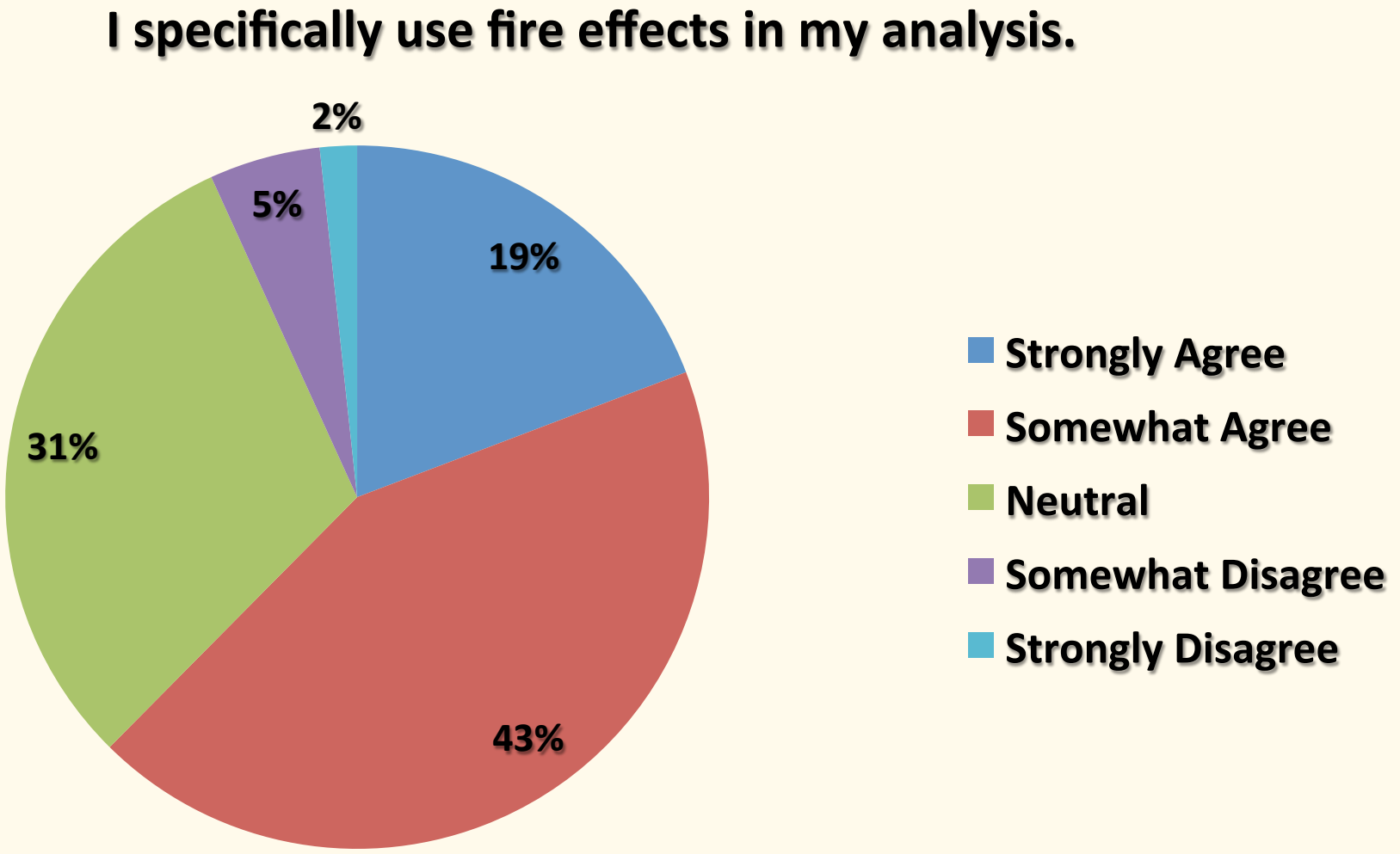


Effects versus Patterns

There is a difference between fire effects and fire patterns.

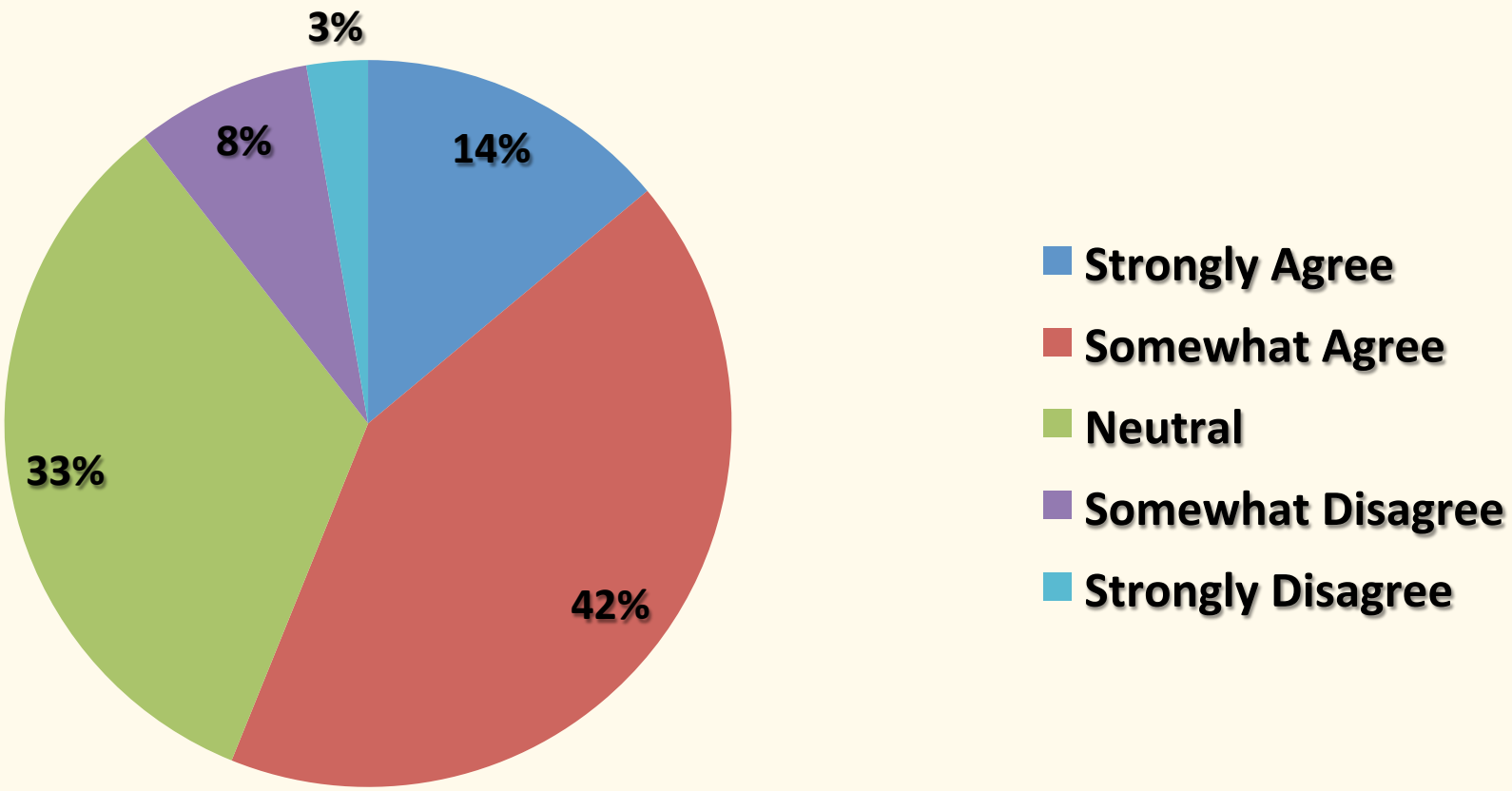


Fire Effects Use



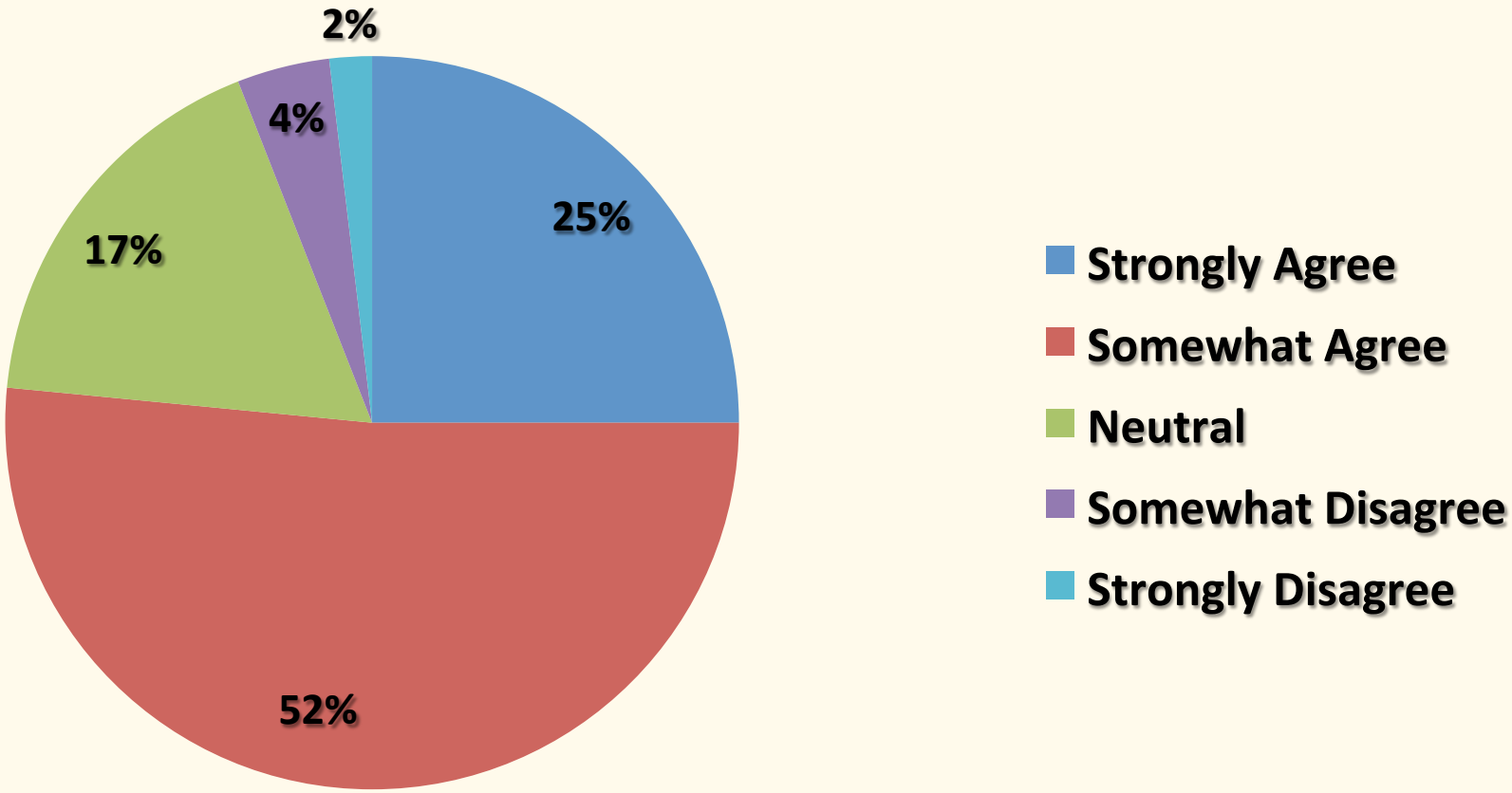
Geometric Shape Use

I use geometric shapes for helping me in my determination of the area of origin.



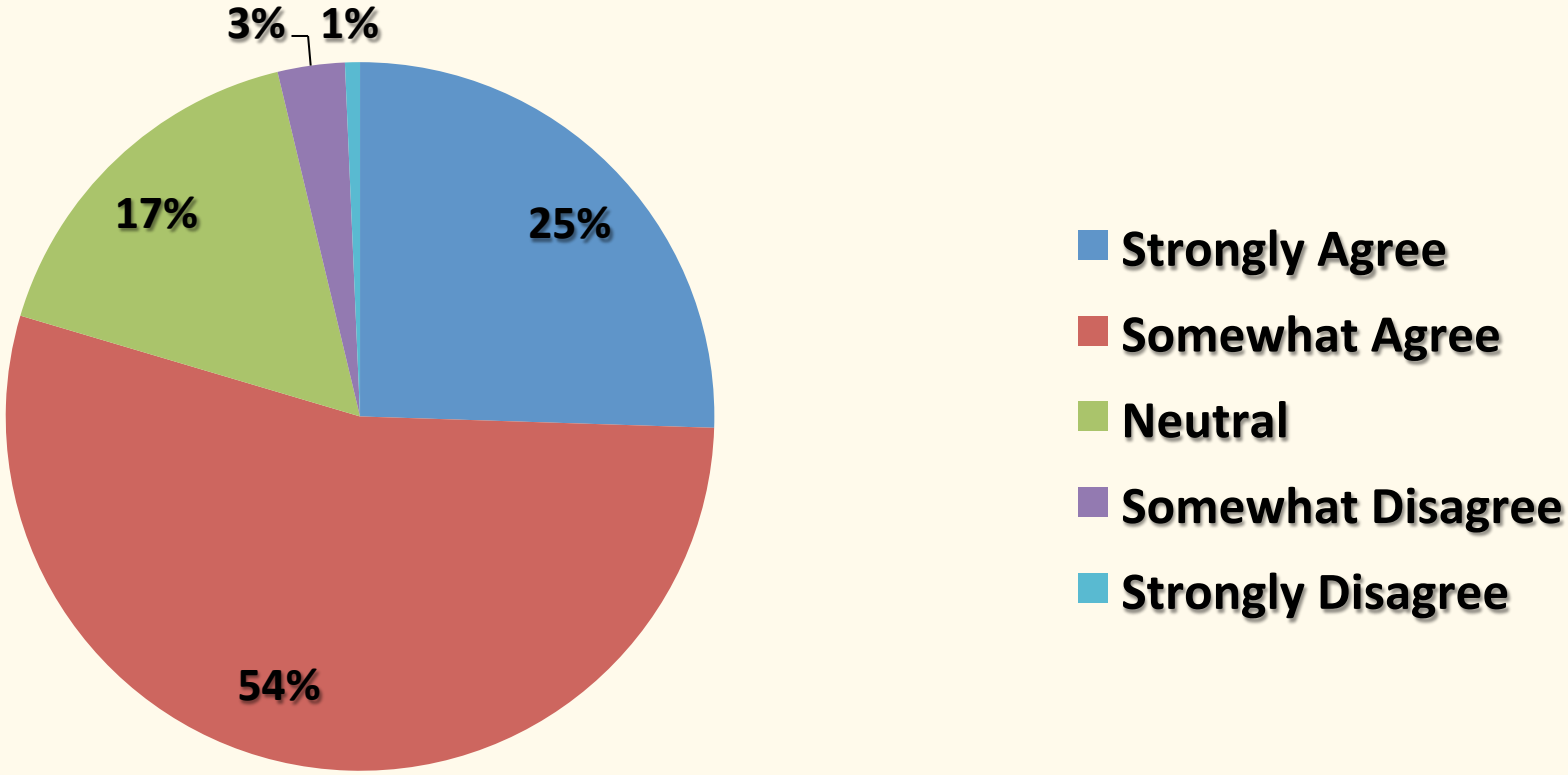
Flame Plume Shape Use

I use flame plume shapes to aid in my origin determination (triangular, columnar, conical).



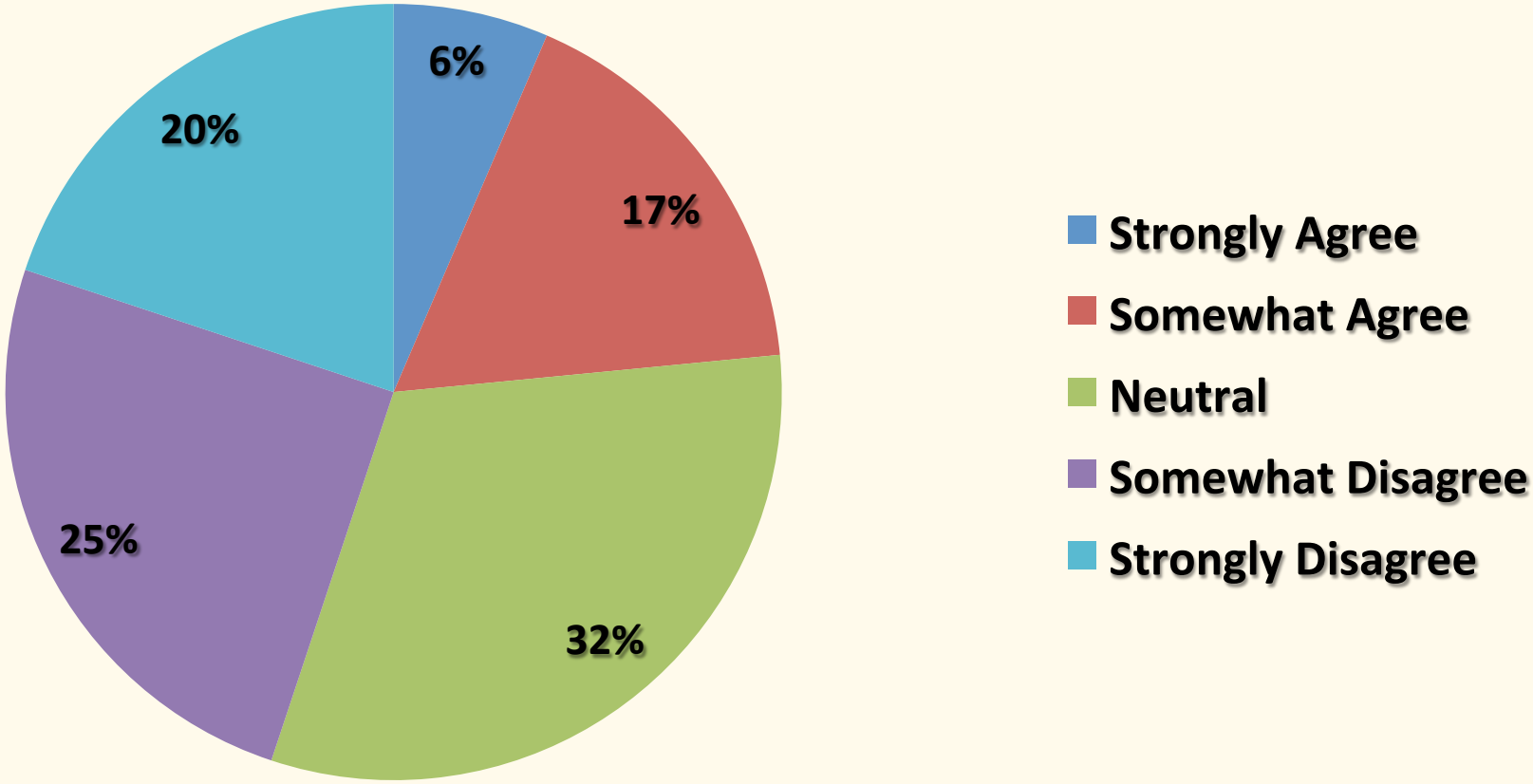
Truncated Cone Pattern Use

I use truncated cone patterns in identifying the are of origin (i.e. V-, U-, Hourglass-shaped patterns).



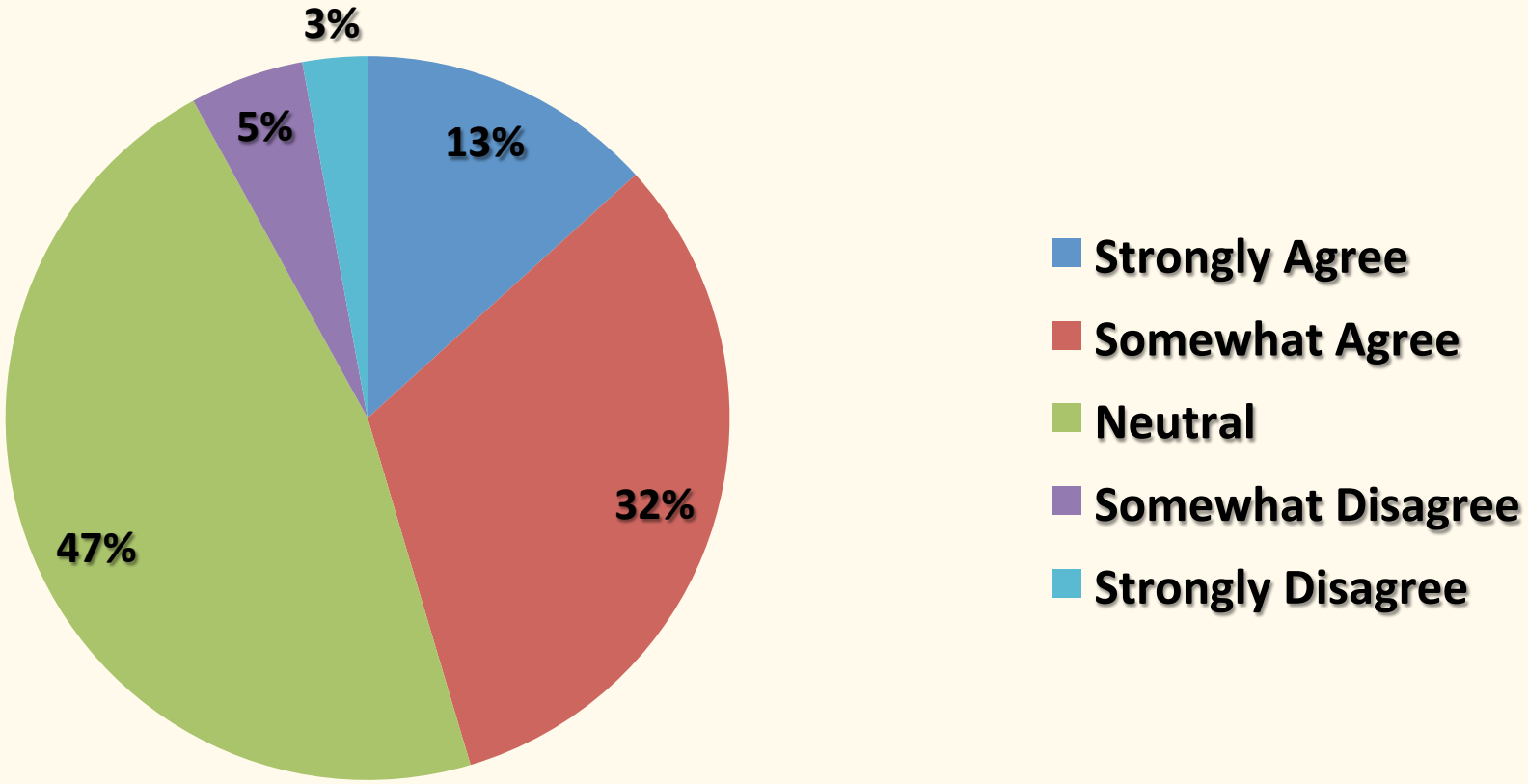
Heat and Flame Vector Use

I typically prepare a heat and flame vector analysis.



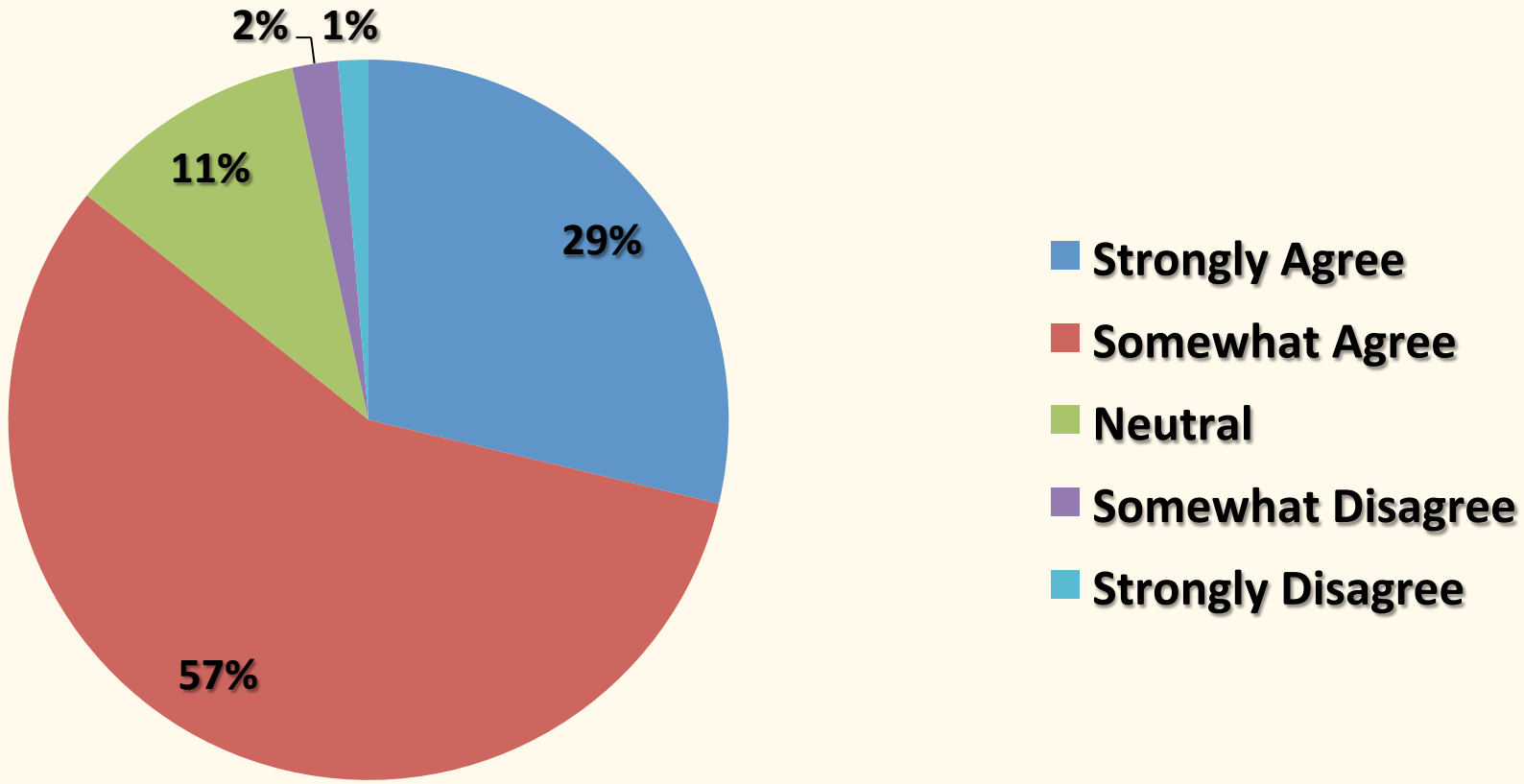
Heat and Flame Vector Opinion

I think performing a heat and flame vector analysis is helpful.



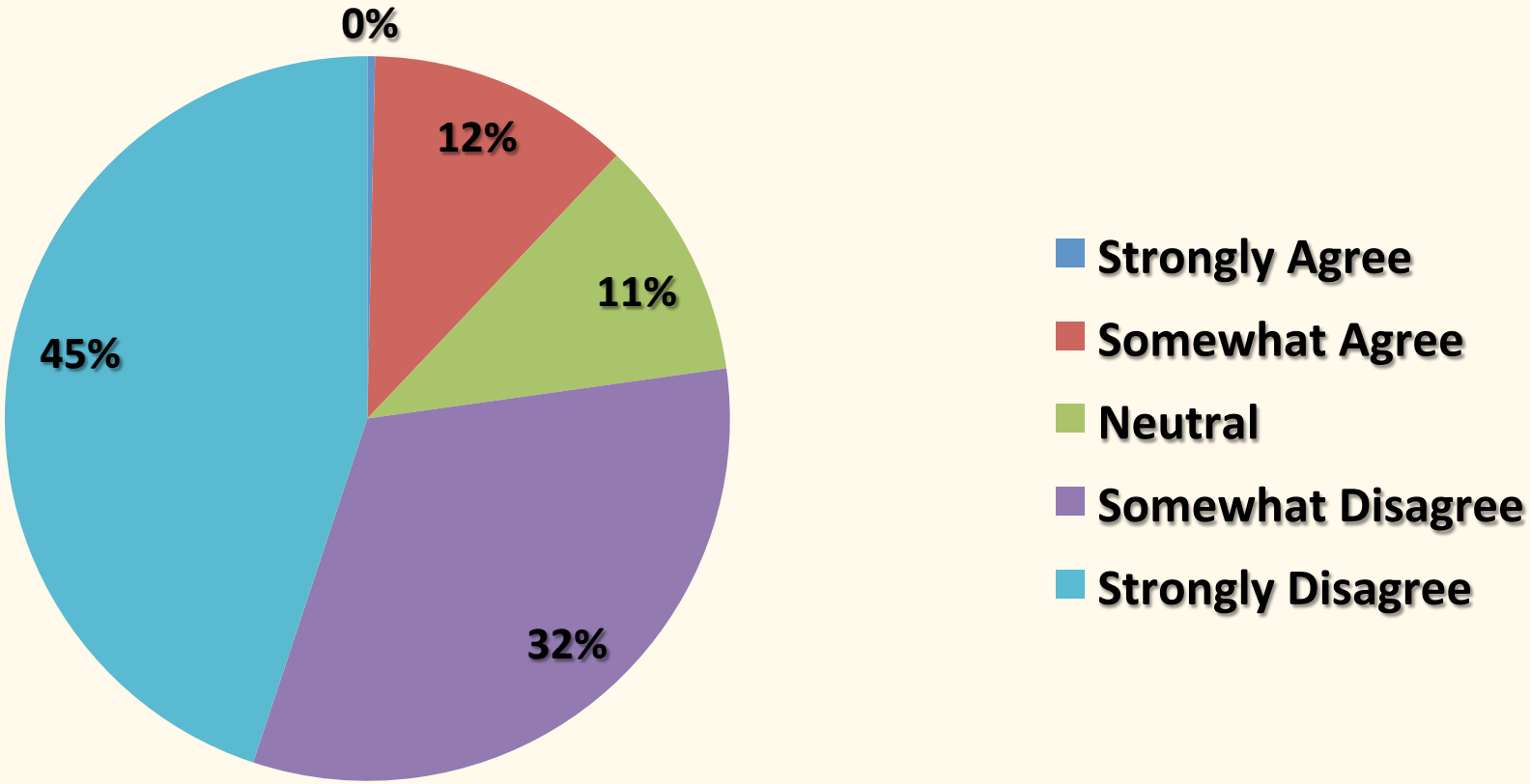
Lines of Demarcation Use

I use comparative lines of demarcation in identifying an area of origin.



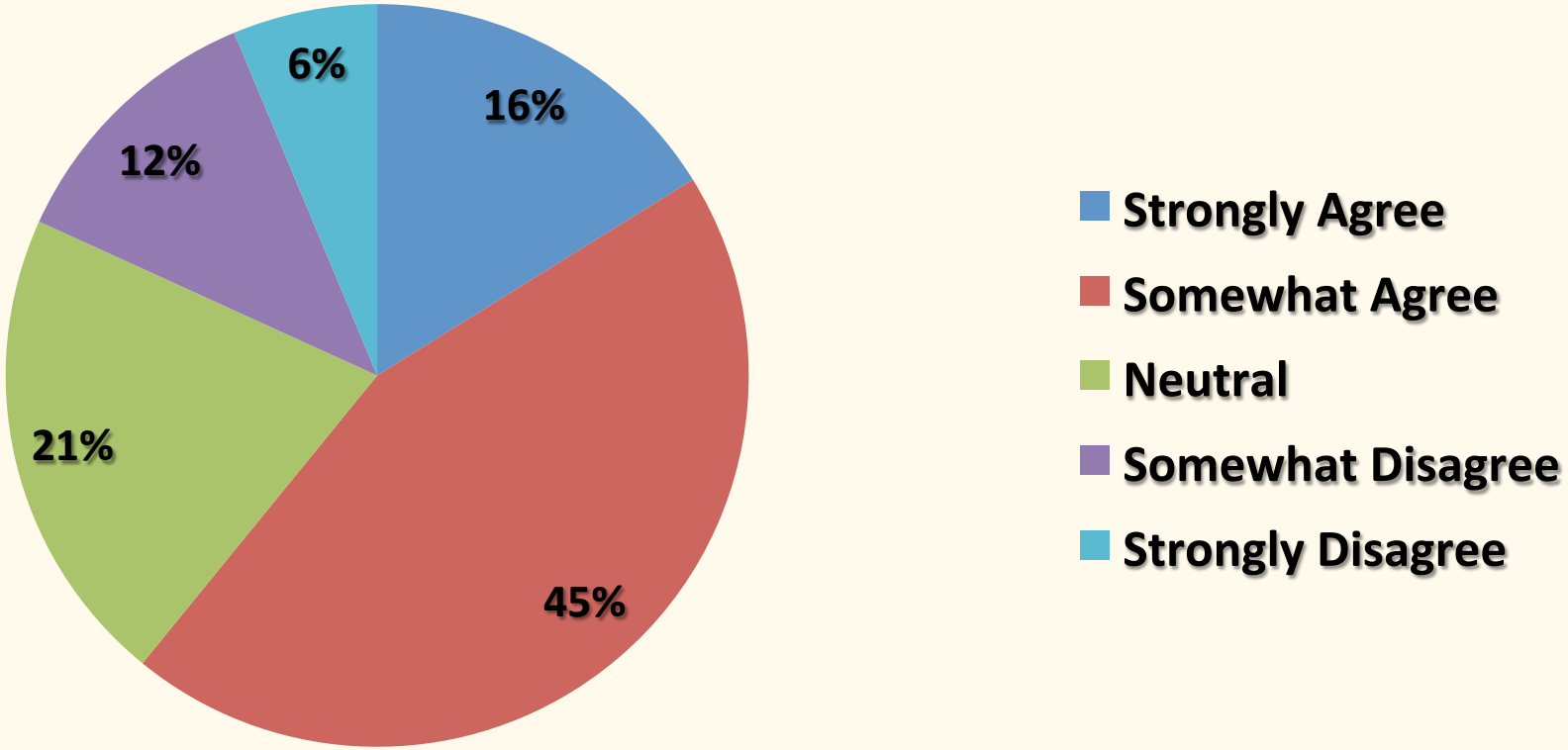
Photographs Only Opinion

I believe the origin of a fire can be accurately determined using photographs alone.



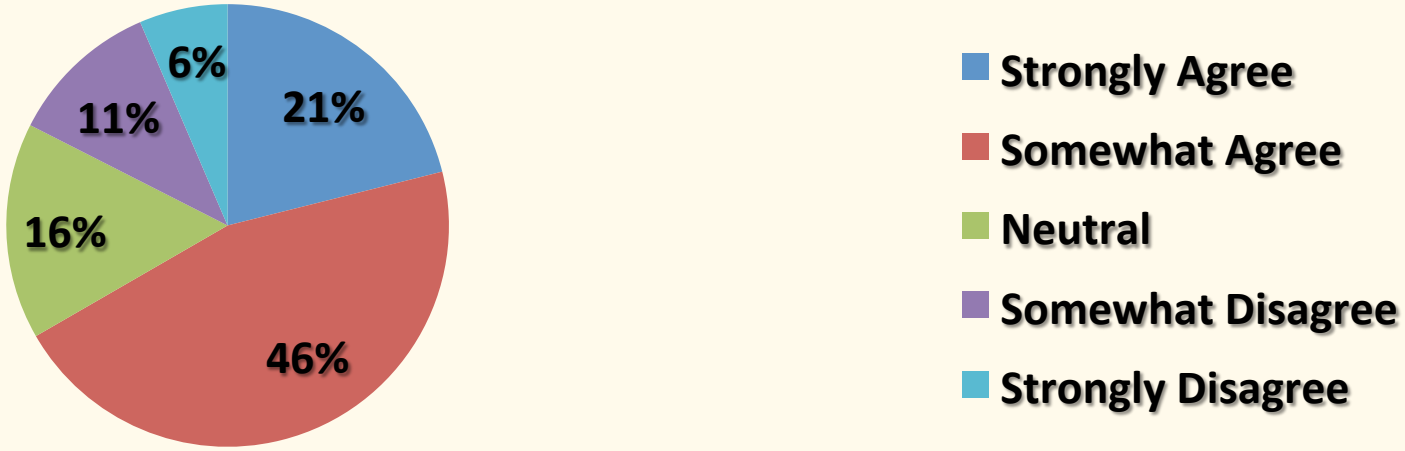
Measurable Data Use

I use measurable data (i.e. depth of calcination, depth of char).



Measurable Data Opinion

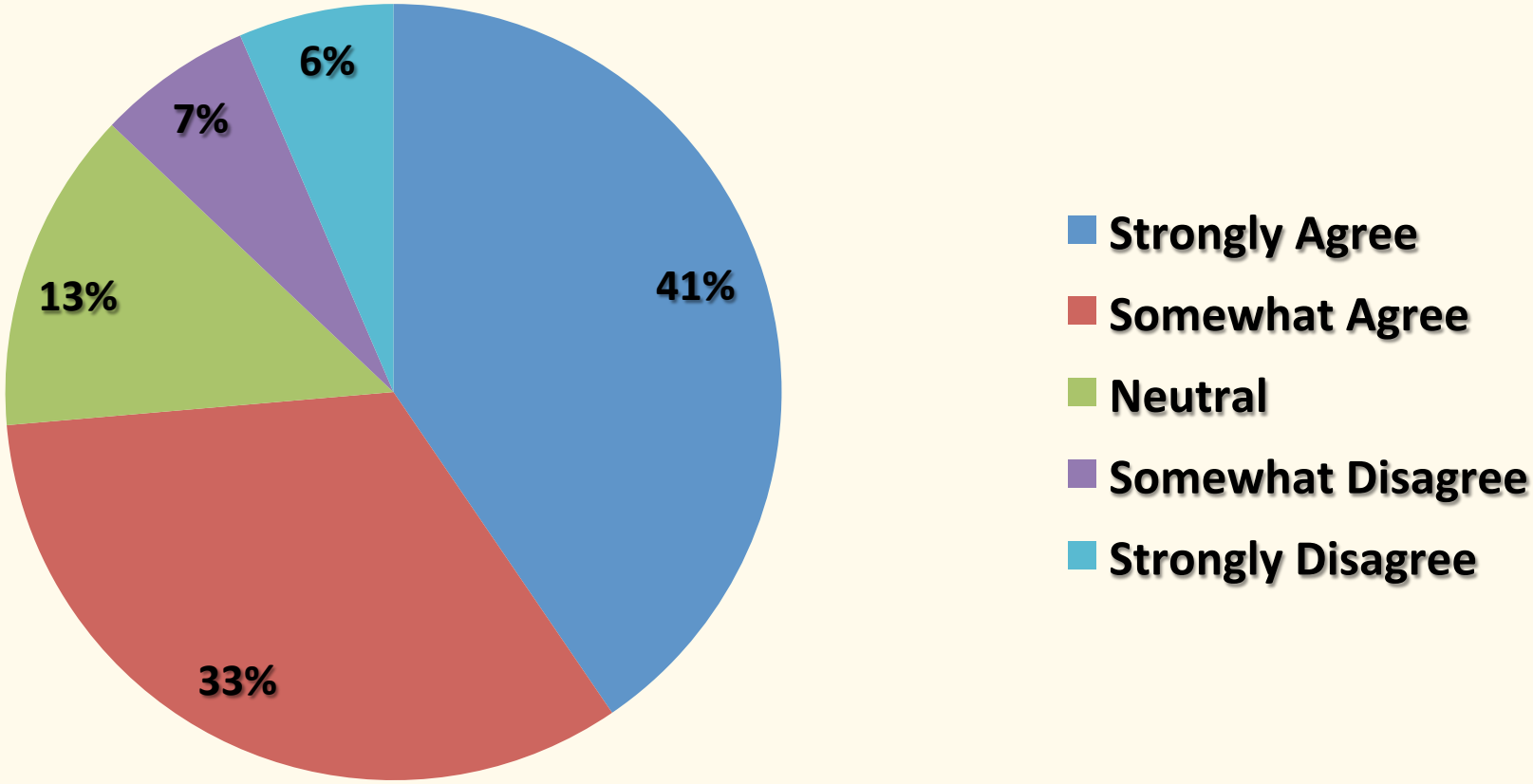
I believe the collection of measurable data is time consuming to collect.



I believe the collection of measurable data yields little relevant data.

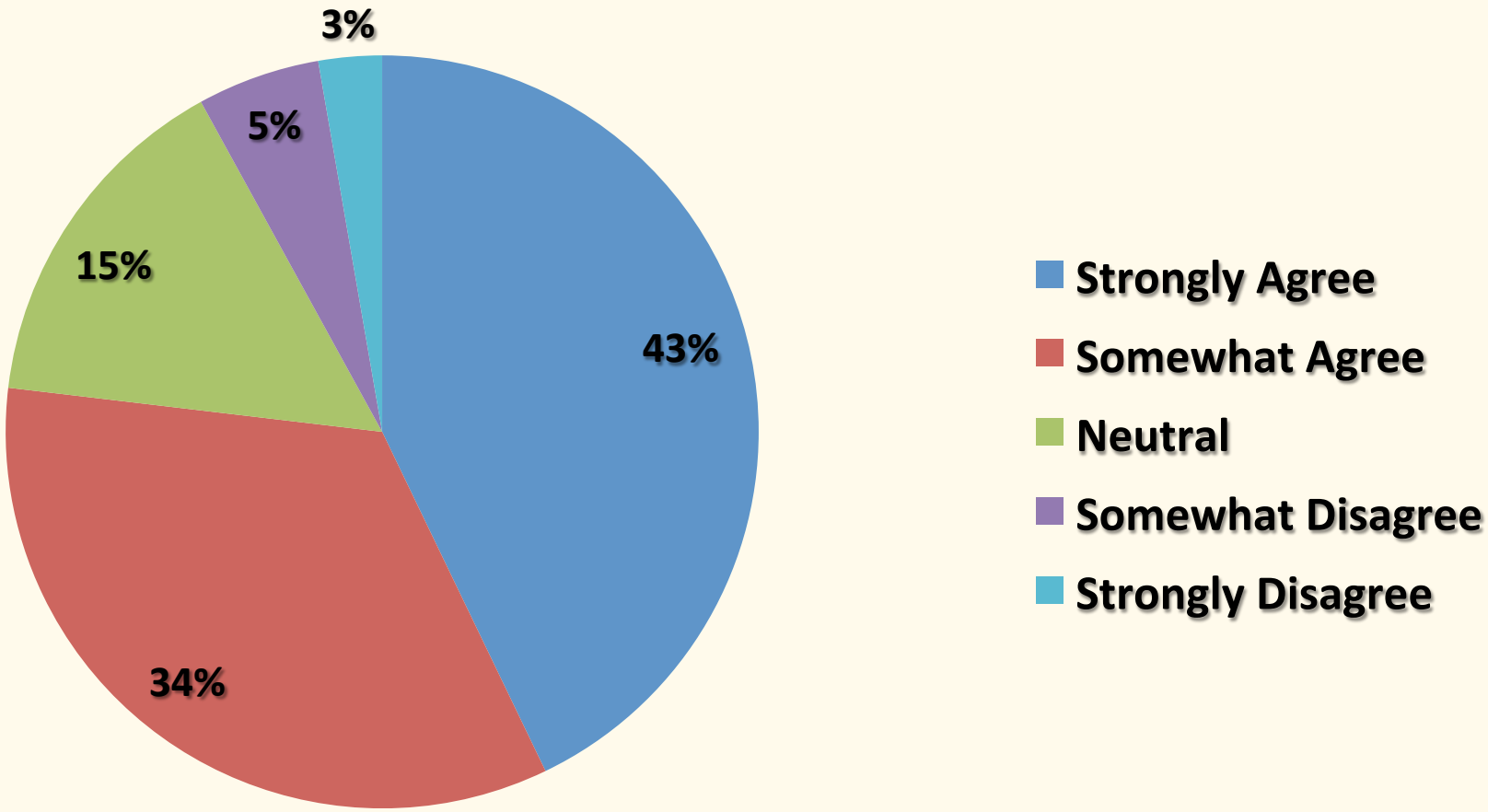
NFPA 921 Opinion

I believe the NFPA 921 is an authoritative document.



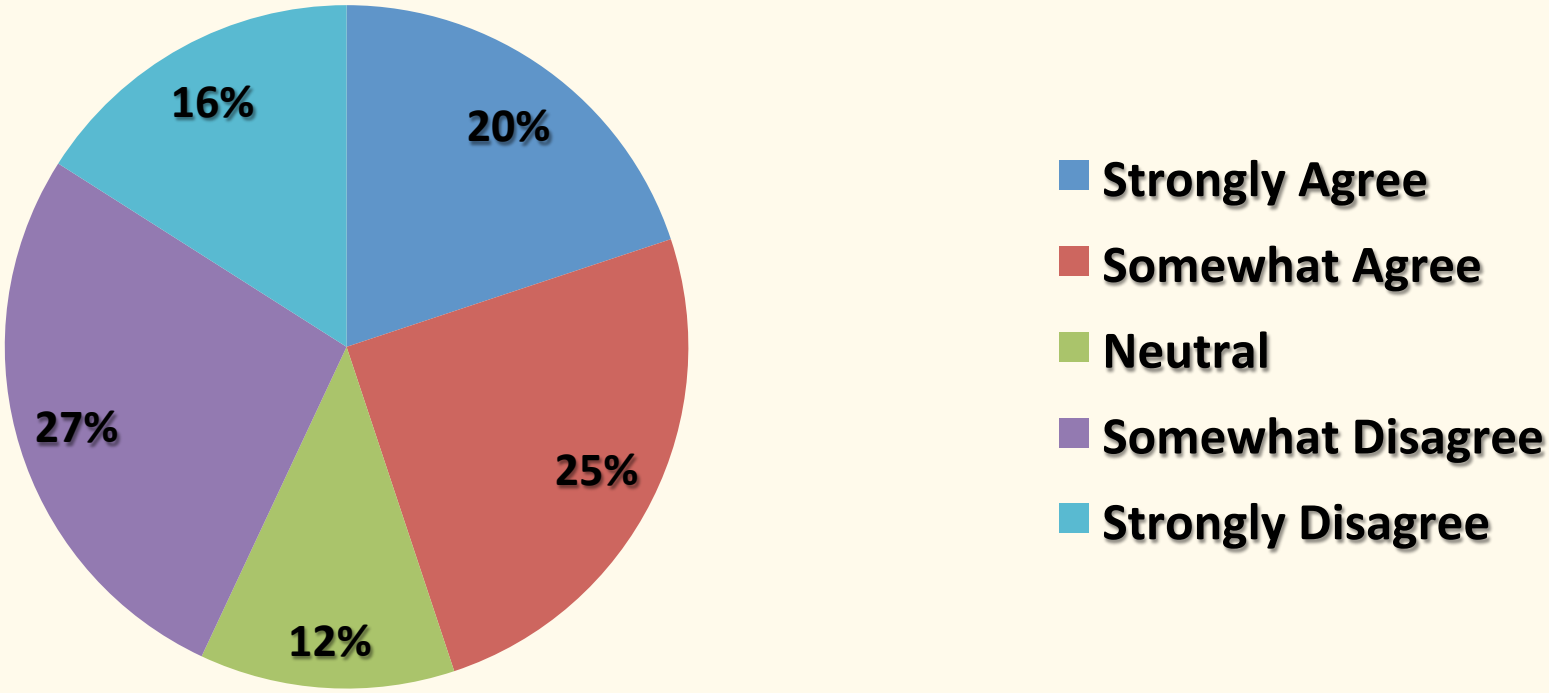
NFPA 1033 Opinion

I believe the NFPA 1033 is an authoritative document.



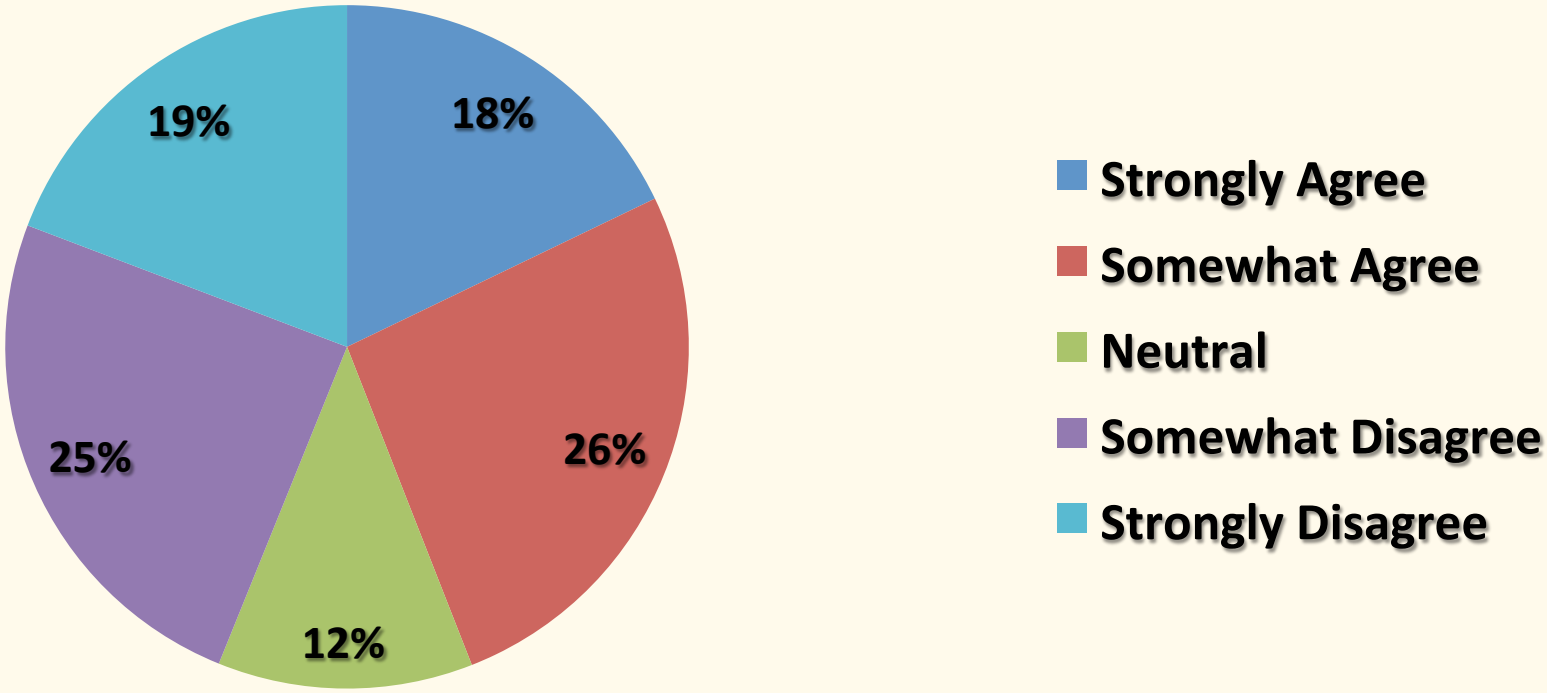
Fuel Item Presence

During your scene examination, a fuel item has to be present at the hypothetical area of origin for the area of origin to be determined.



Ignition Source Presence

During your scene examination, an ignition source has to be present at the hypothetical area of origin for the area of origin to be determined.



Initial Opinions – Summary

- The most interesting results were that only 73.6% and 76.9% of the participants believe NFPA 921 and NFPA 1033 to be authoritative, respectively

Pattern and Effect Recognition

- Single Photograph presented
  - Series of questions posed regarding the investigator's ability to recognize and interpret fire effects and fire patterns

Identified Fire Effects

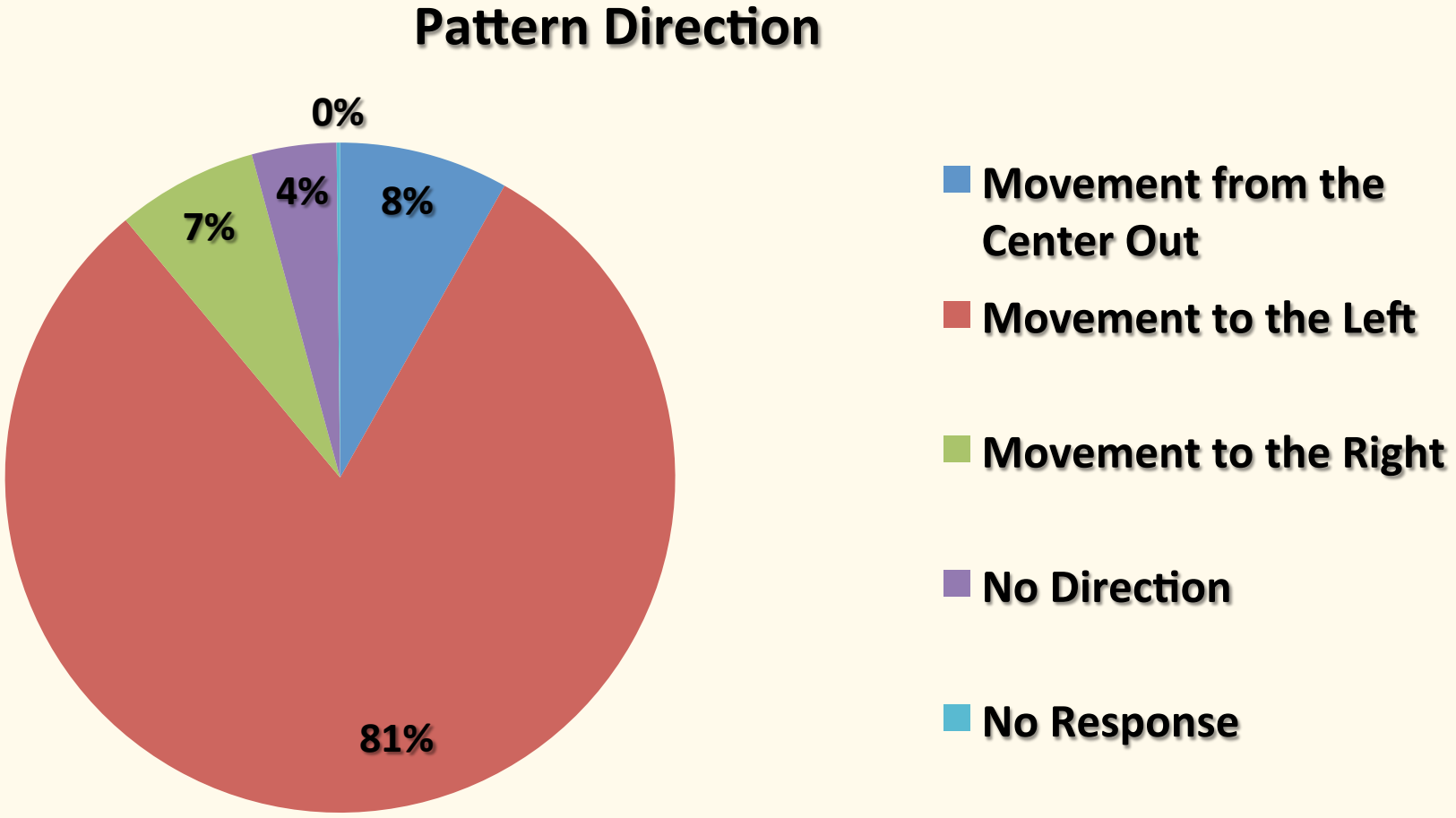
Fire Effect	Number	Percentage	Present?
Smoke Deposition	535	91.0%	Y
Melting	501	85.2%	Y
Char	497	84.5%	Y
Color Changes	444	75.5%	Y
Mass Loss	426	72.4%	Y
Clean Burn	422	71.8%	Y
Thermal Expansion	329	56.0%	N
Oxidation	280	47.6%	N
Shiny Char	152	25.9%	N*
Collapsed Furniture Springs	129	21.9%	N
Spalling	94	16.0%	N
Pour Pattern	74	12.6%	N*
Calcination	73	12.4%	N
Rainbow Effect	31	5.3%	N
Distorted Light bulbs	4	0.7%	N
Victim Injuries	2	0.3%	N
Window Glass	0	0.0%	Y

*Not an accepted fire effect per NFPA 921 and has been associated with myths

Identified Fire Patterns

Fire Pattern	Total	%	Present?	Fire Pattern	Total	%	Present?
Triangular	41	7.0%	N	Circular	48	8.2%	N
Columnar	46	7.8%	N	Radial	51	8.7%	N
Conical	60	10.2%	Y	Irregular	136	23.1%	N
V-pattern	422	71.8%	Y	Donut	7	1.2%	N
Inverted Cone	66	11.2%	N	Linear	28	4.8%	N
Hourglass	17	2.9%	N	Area	87	14.8%	N
U-shape	60	10.2%	N	Saddle Burns	10	1.7%	N
Truncated Cone	50	8.5%	Y	None	30	5.1%	N
Pointer and Arrow	52	8.8%	N				

Pattern Direction



The Correct Answer was 'Movement to the Left'

Pattern & Effect Recognition-Summary

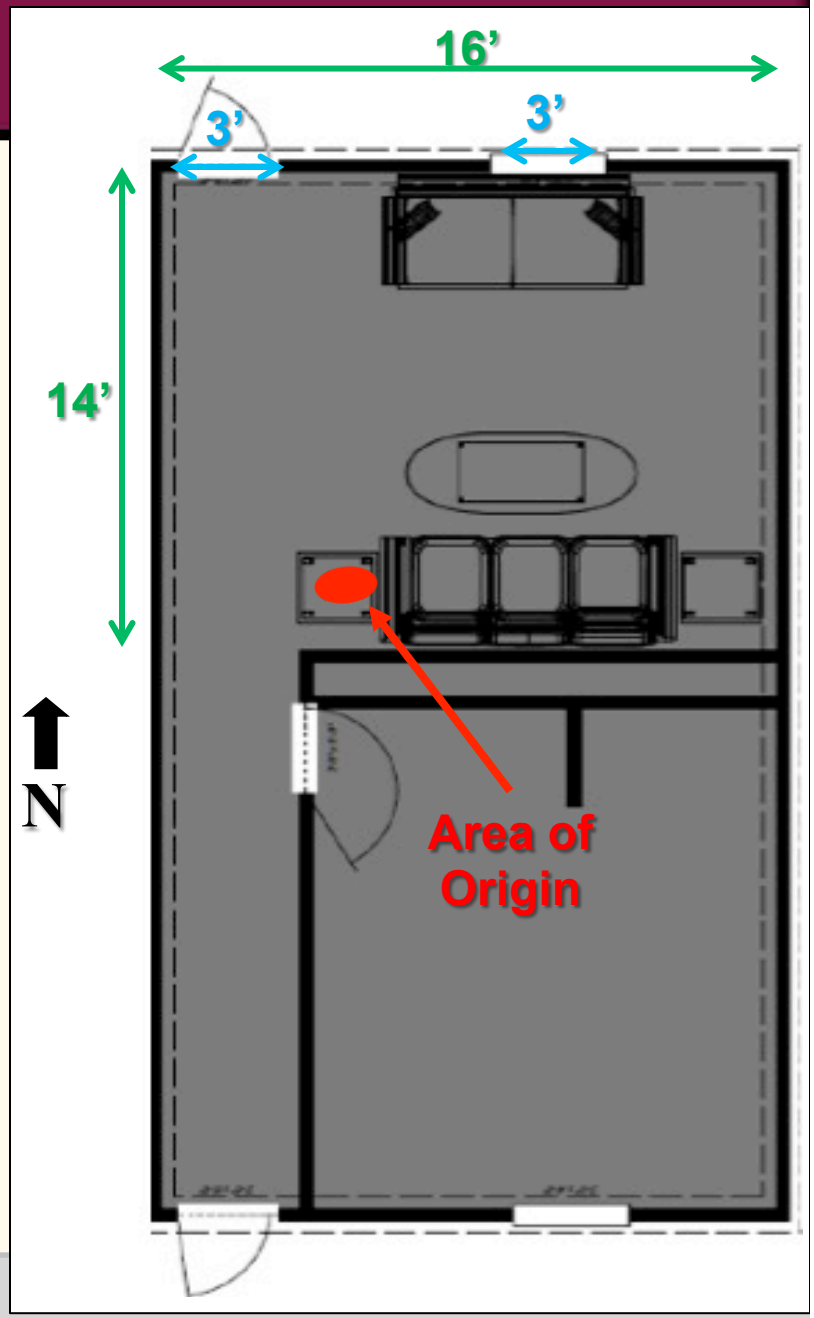
- Glaring Problem Identified
  - Several Effects NOT present were identified as being present
  - Several participants identified effects purposefully included as “myths” and pseudo-science (i.e. shiny char and pour patterns)
- 85% accurately identified movement of damage. 15% misidentified direction

Origin Determination

- Full-scale test fire scene provided
- 3rd Part of the survey – Photographs only
- 4th Part of the survey – Photographs and measurements
  - Depth of calcination measurements provided for all walls
  - Depth of char measurements provided for all furniture items.

EKU Burn Room Layout

- Two Rooms and hallway
  - Wood stud with drywall lining
  - Single pane window
- Living room had the majority of the furnishings

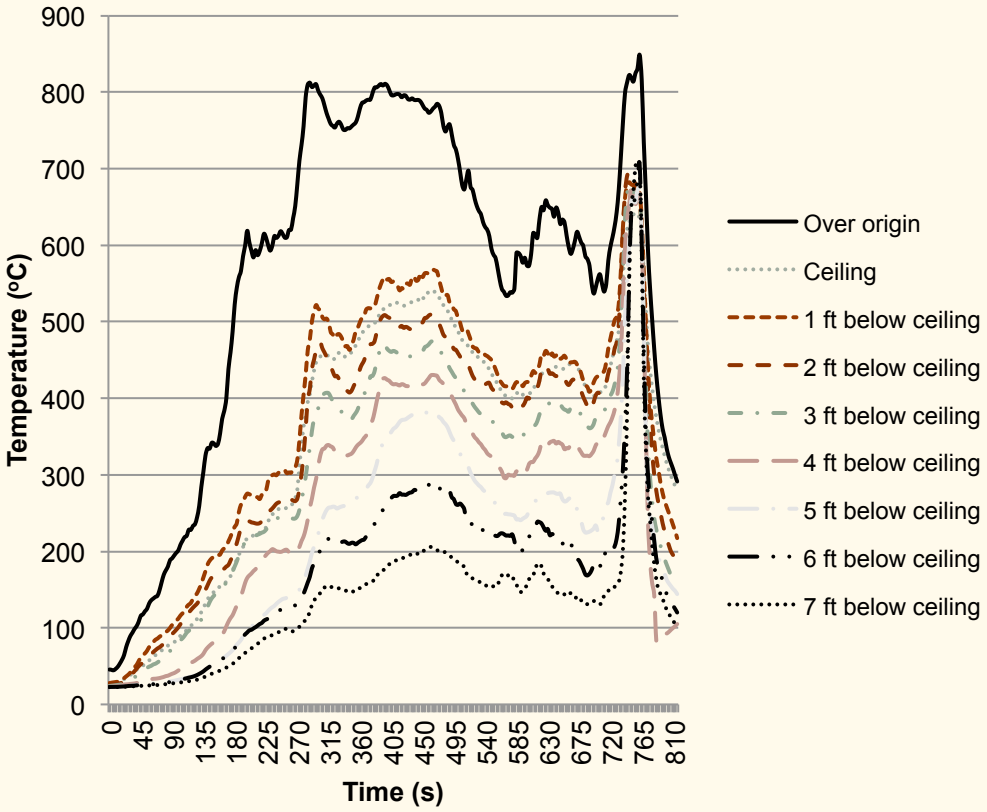


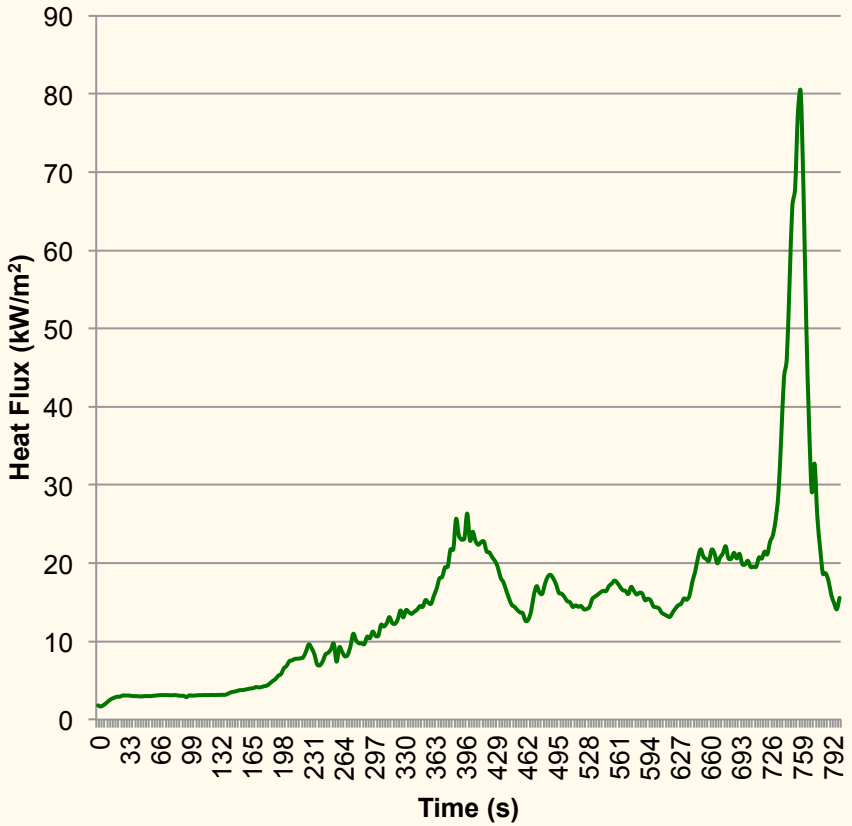
Test Fire

- Underventilated for ~200 seconds
- Window failed
  - Flashover was achieved ~150s later

Test	Temp (°F)/ Humidity	Wind Speed (mph)/Dir	Ignition Location & Method	Ventilation	Window fails (min:sec)	Extinguished (min:sec)
1	66 / 68%	11.5 / SSW	9” heptane pool fire under right end table	Door partially open (11”)	9:30	13:20

Test Fire


900
800
700
600
500
400
300
200
100
0
Temperature (°C)
0
45
90
135
180
225
270
315
360
405
450
495
540
585
630
675
720
765
810
Time (s)
Over origin
Ceiling
1 ft below ceiling
2 ft below ceiling
3 ft below ceiling
4 ft below ceiling
5 ft below ceiling
6 ft below ceiling
7 ft below ceiling

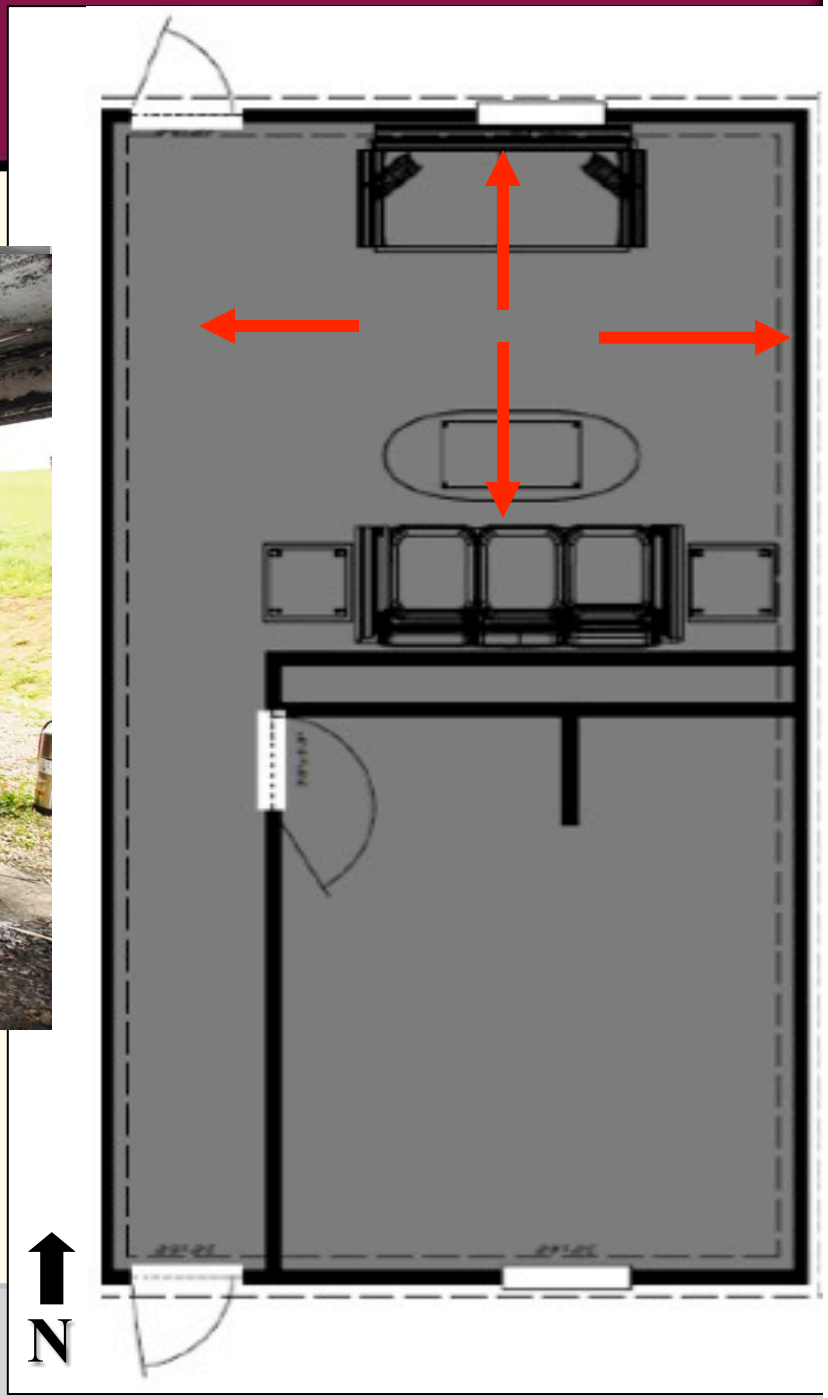

90
80
70
60
50
40
30
20
10
0
Heat Flux (kW/m²)
0
33
66
99
132
165
198
231
264
297
330
363
396
429
462
495
528
561
594
627
660
693
726
759
792
Time (s)

Fire Scene Photographs & Measurements

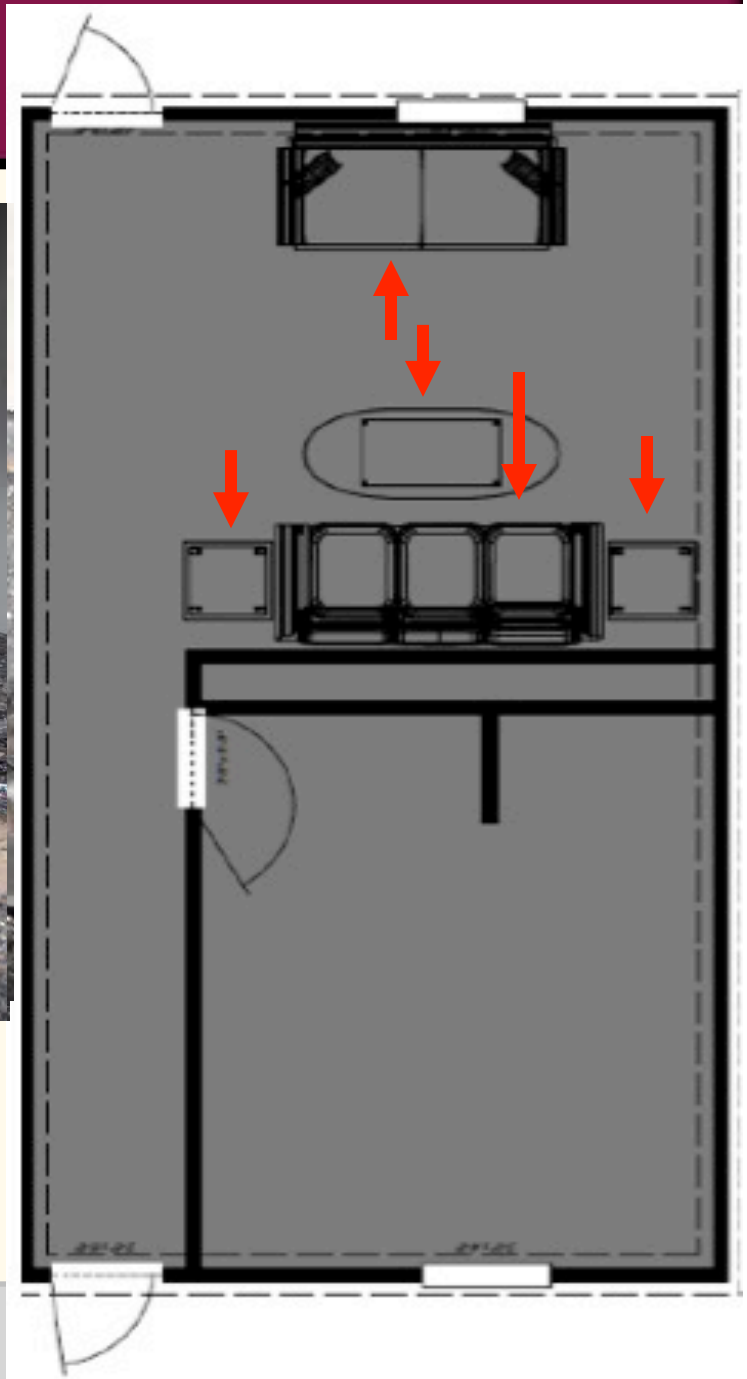
- **Provided photographs of the following**
  1. **Every wall**
  2. **Ceiling Views**
  3. **The front, left-side, and right-side of every content item within the room**

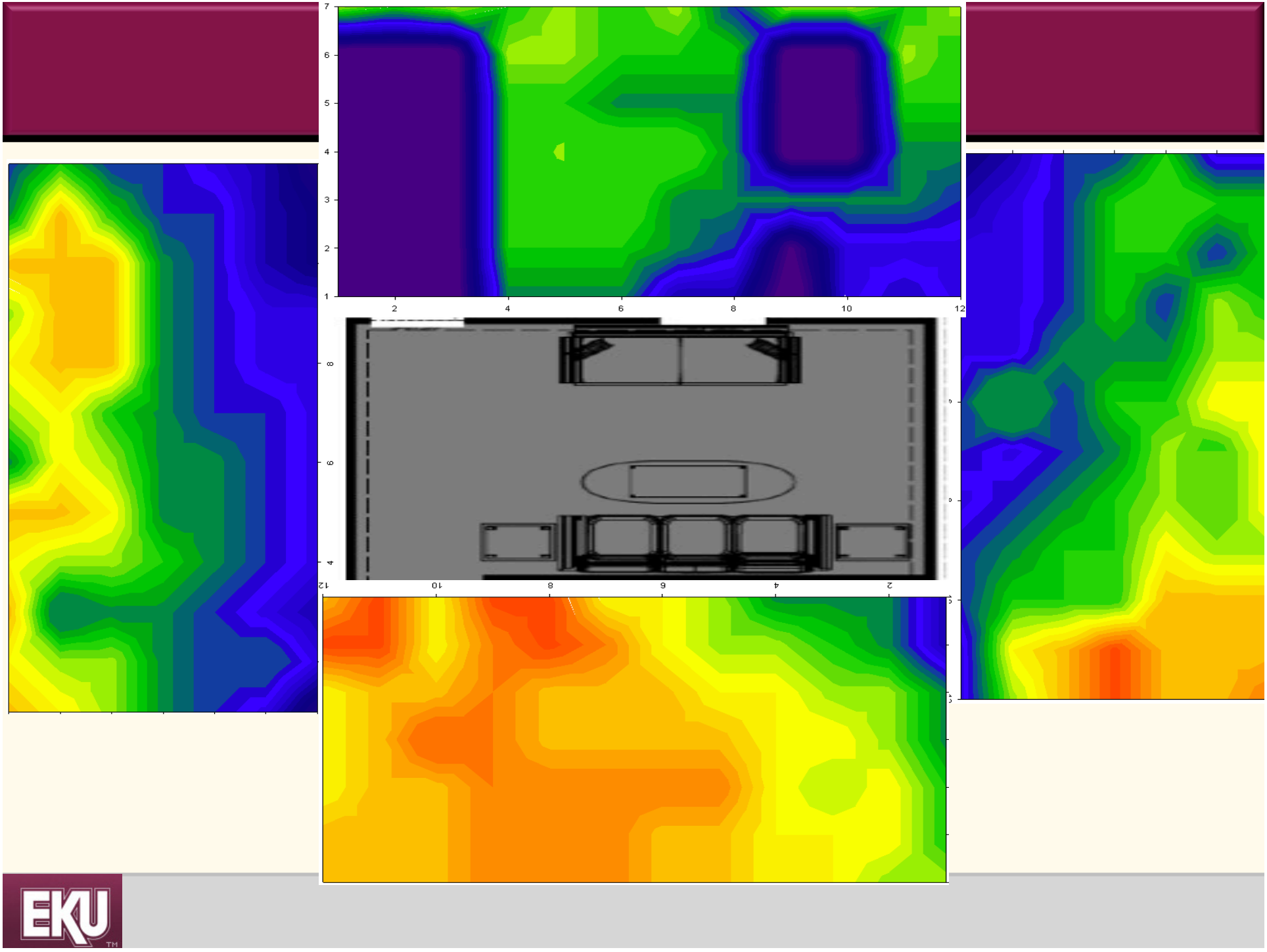
- **Provided Measurements of the following:**
  1. **Contour plots of the depth of calcination measurements for the walls**
  2. **Depth of char measurements provided for all contents**

Walls



Contents




7
6
5
4
3
2
1
2
4
6
8
10
12
8
6
4
12
10
8
6
4
2

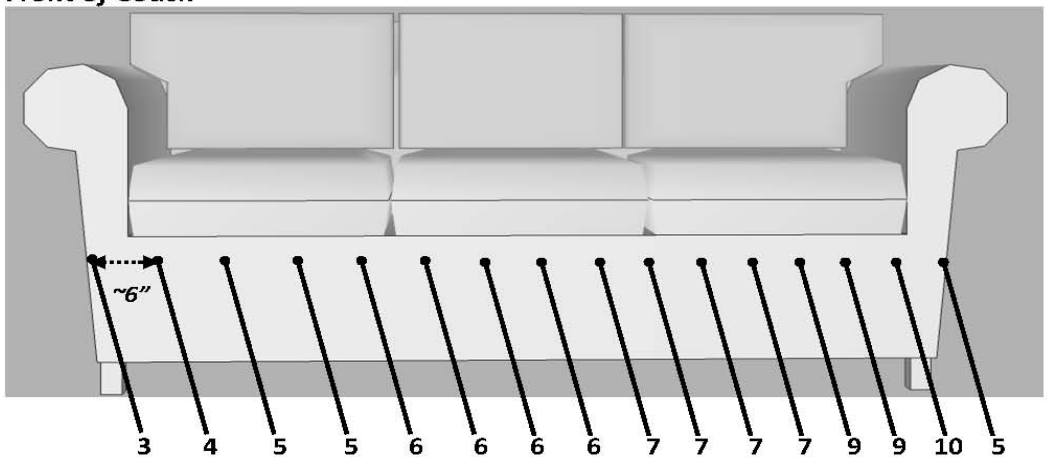
Measurement Example

Couch (South Wall) – Depth of Char Measurements

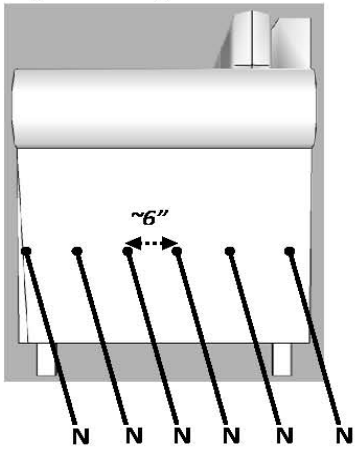
All measurements are recorded in millimeters (N=Nothing remaining to measure)

Note: The principle structural material for the couch is OSB and may not provide accurate depth of char measurements

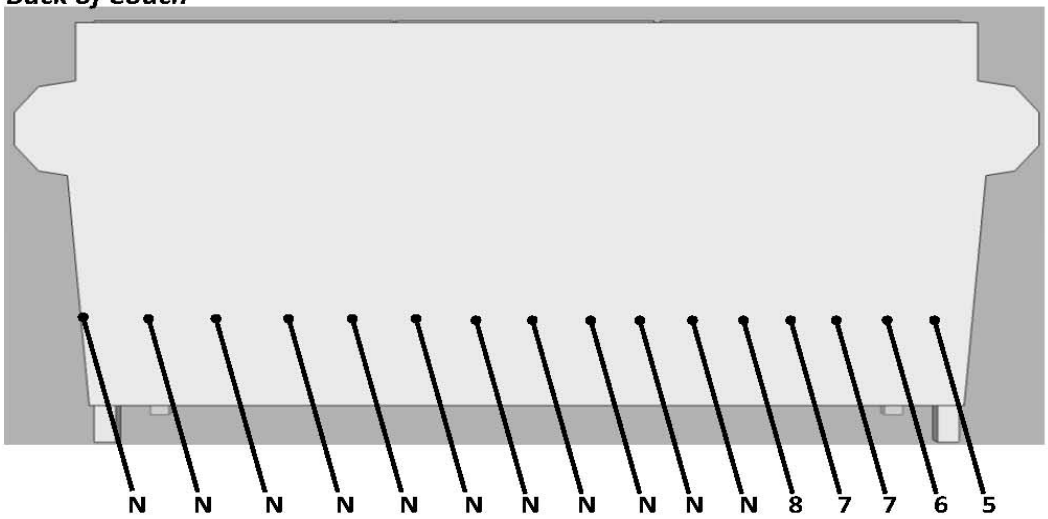
Front of Couch



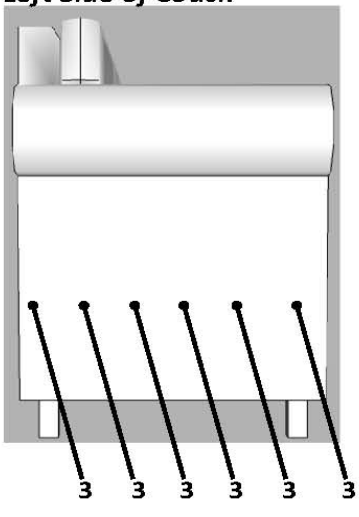
Right Side of Couch



Back of Couch

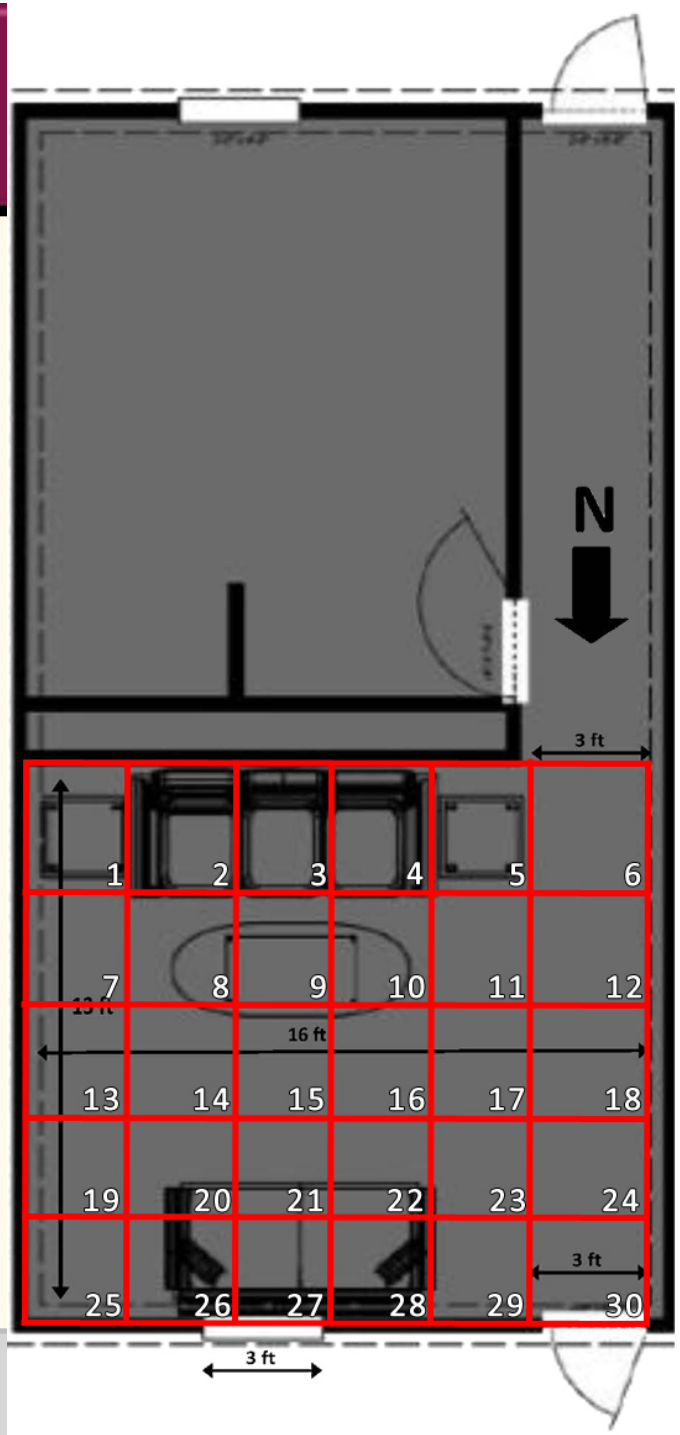


Left Side of Couch



Area of Origin Grid Layout

- The participant was then asked to select the grid which most accurately describes your chosen area of origin
  - Each grid was ~2 ft^2
- Confidence levels and methodology questions were then asked



Origin Grid Results

	Without Measurable		With Measurable	
	Total	Percentage	Total	Percentage
Grid 1	5	0.9%	5	0.9%
Grid 2	7	1.2%	9	1.5%
Grid 3	90	15.3%	72	12.3%
Grid 4	293	49.9%	343	58.4%
Grid 5	140	23.9%	113	19.3%
Grid 18	12	2.0%	8	1.4%
Grid 27	16	2.7%	13	2.2%
Other	24	4.1%	24	4.1%

$\chi^2_{(7,N=587)}=19.81$, $p=.006$

Confidence in Determination

	Without Measurable Data		With Measurable Data	
	Total	Percentage	Total	Percentage
25%	36	6.1%	25	4.3%
50%	105	17.9%	77	13.1%
75%	334	56.8%	315	53.6%
100%	106	18.0%	167	28.4%

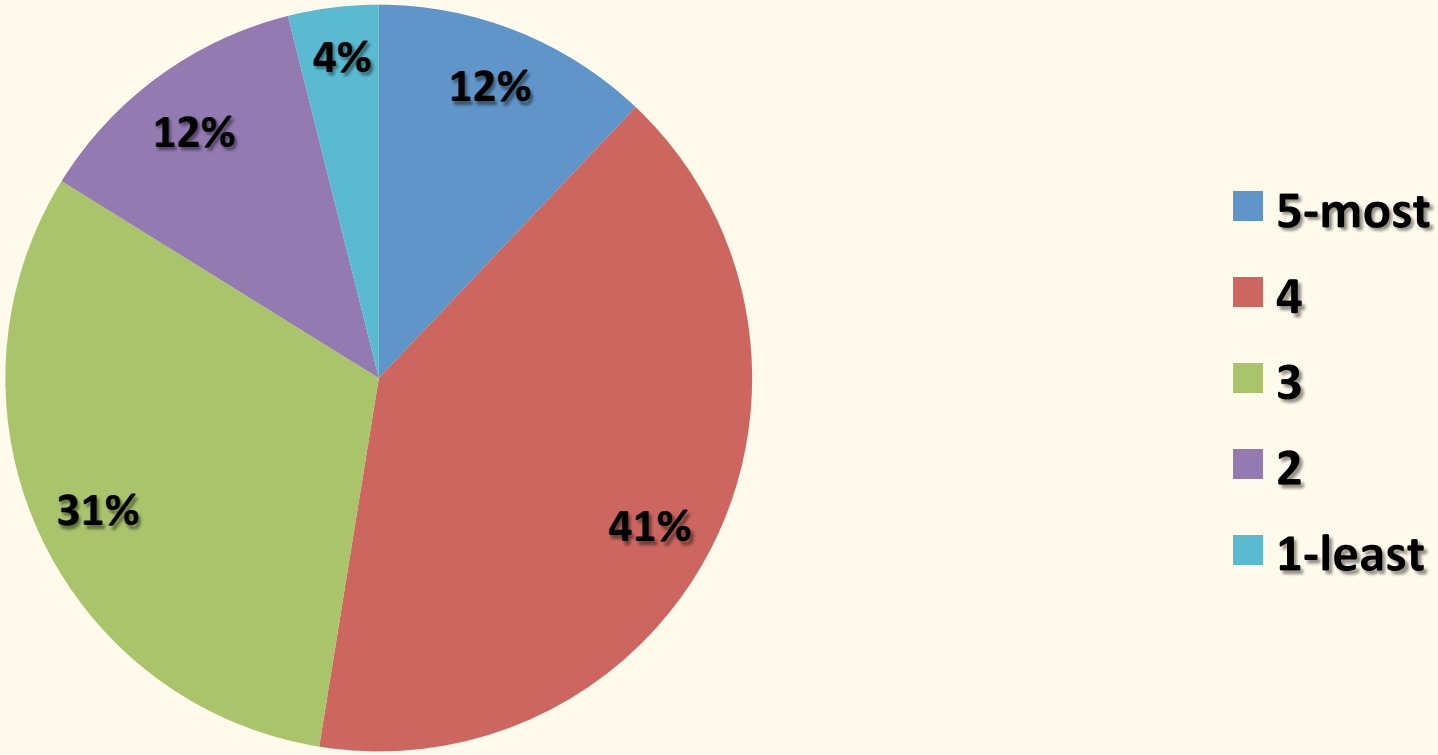
$X^2_{(7,N=587)}=47.01$, $p<.001$

Origin Grid Summary

- **78 (13%) participants changed their area of origin after receiving the measurable data.**
- **89.1% without and 90% with measurable data chose either grid 3, 4, or 5.**
- **Using the assumption that either grids 4 or 5 are within an acceptable boundary for an accurate area of origin, it can be shown that *73.8%* of the participants *without* measurable data and *77.7% with* measurable data accurately determined the area of origin.**

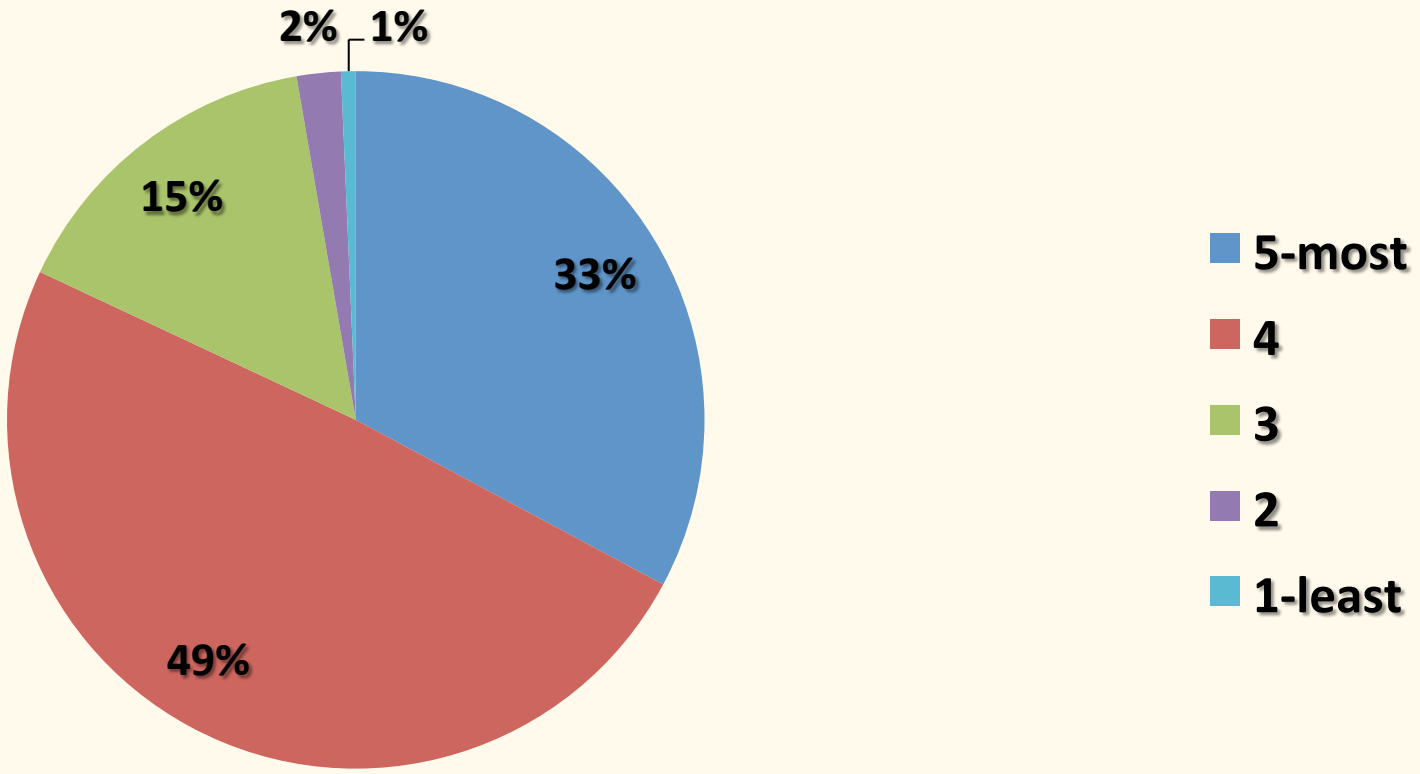
Measurable Damage Value (Walls)

What is the value you placed on Measurable Damage to the Walls in your consideration for the area of origin determination?



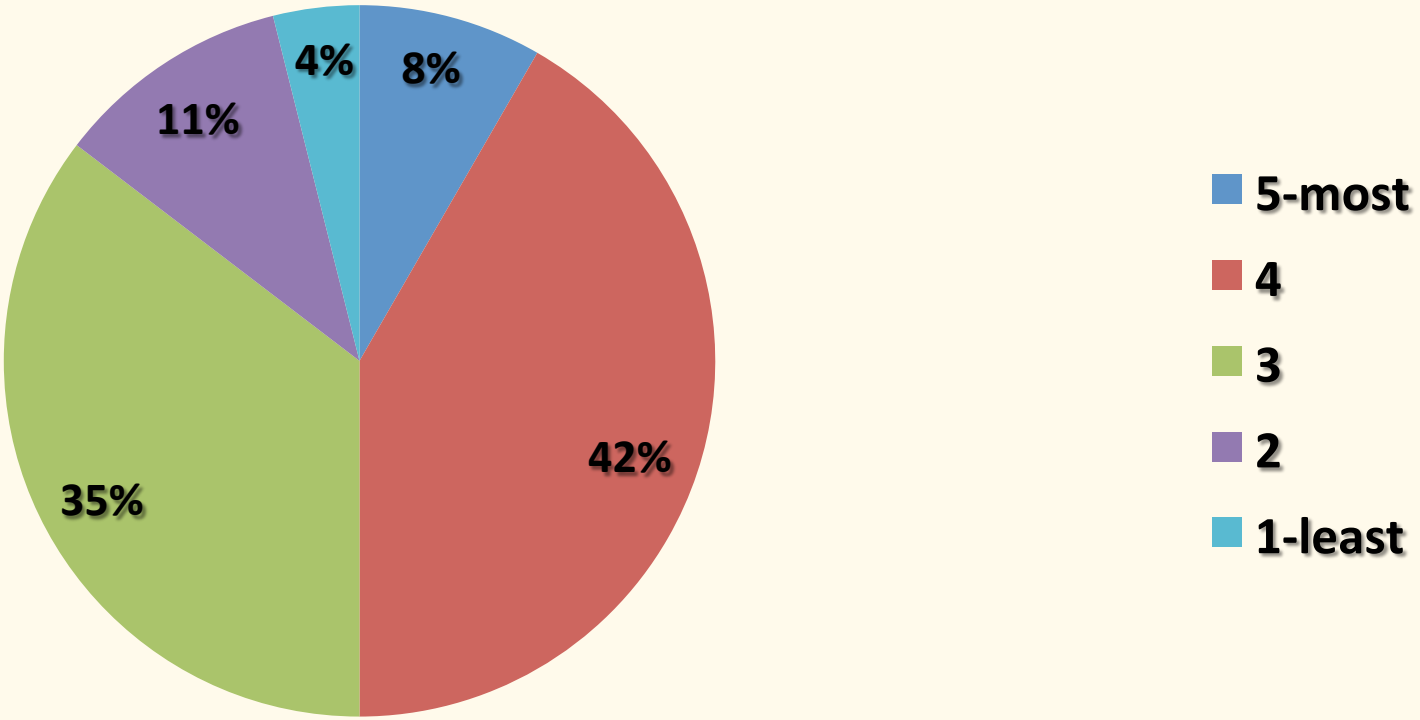
Measurable Damage Value (Contents)

What is the value you placed on Measurable Damage to the Contents in your consideration for the area of origin determination?



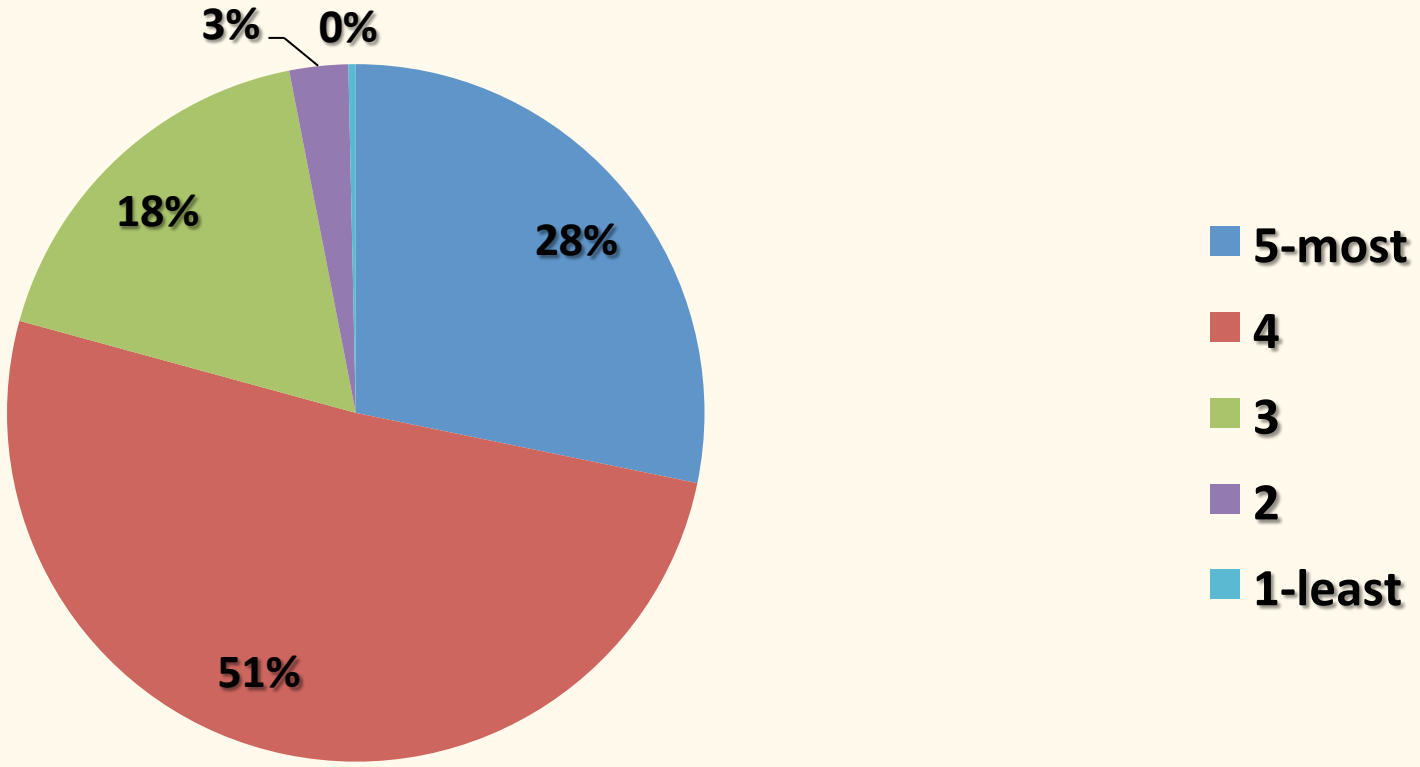
Visible Damage Value (Walls)

What is the value you placed on Visible Damage to the Walls in your consideration for the area of origin determination?



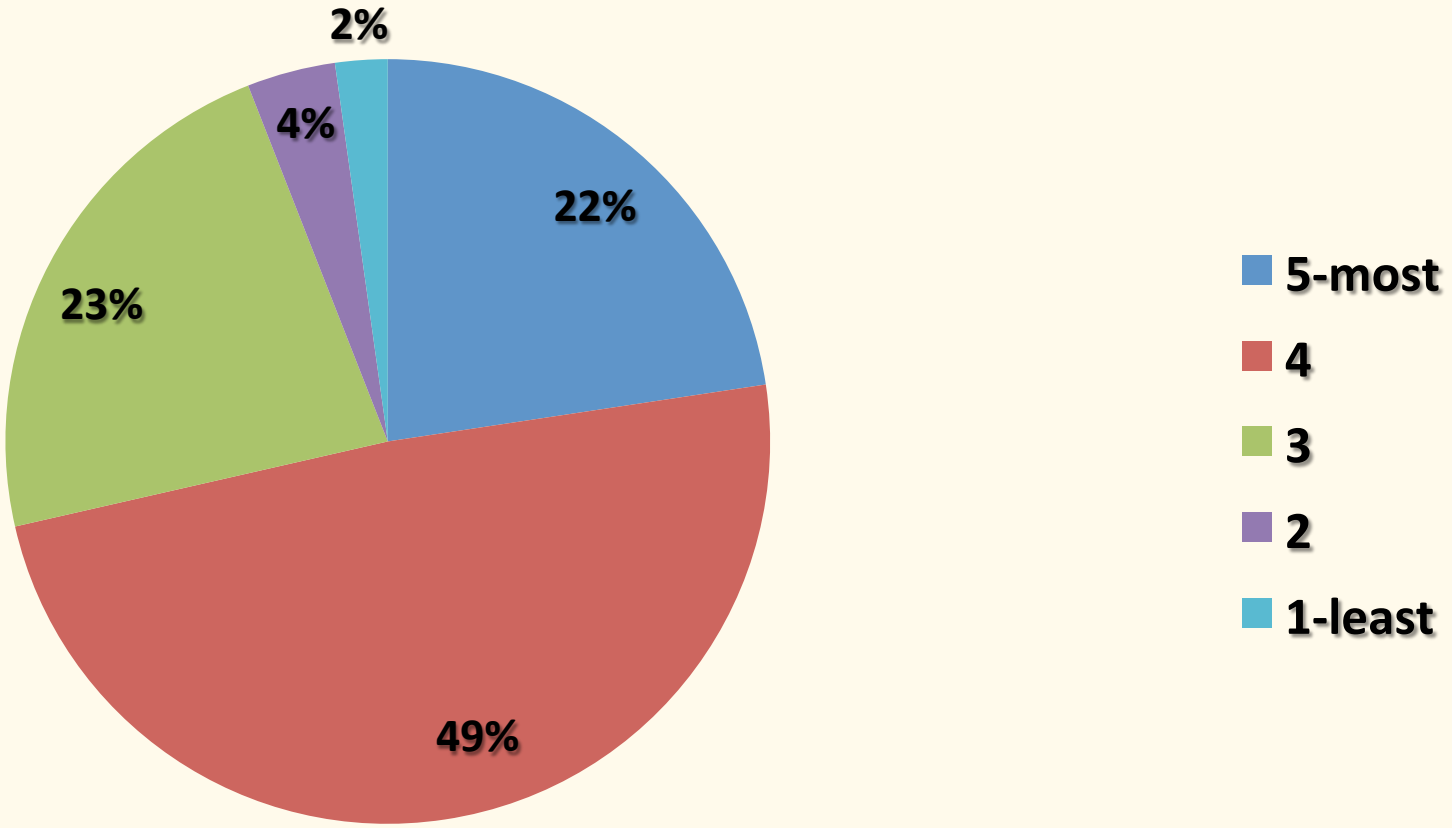
Visible Damage Value (Contents)

What is the value you placed on Visible Damage to the Contents in your consideration for the area of origin determination?



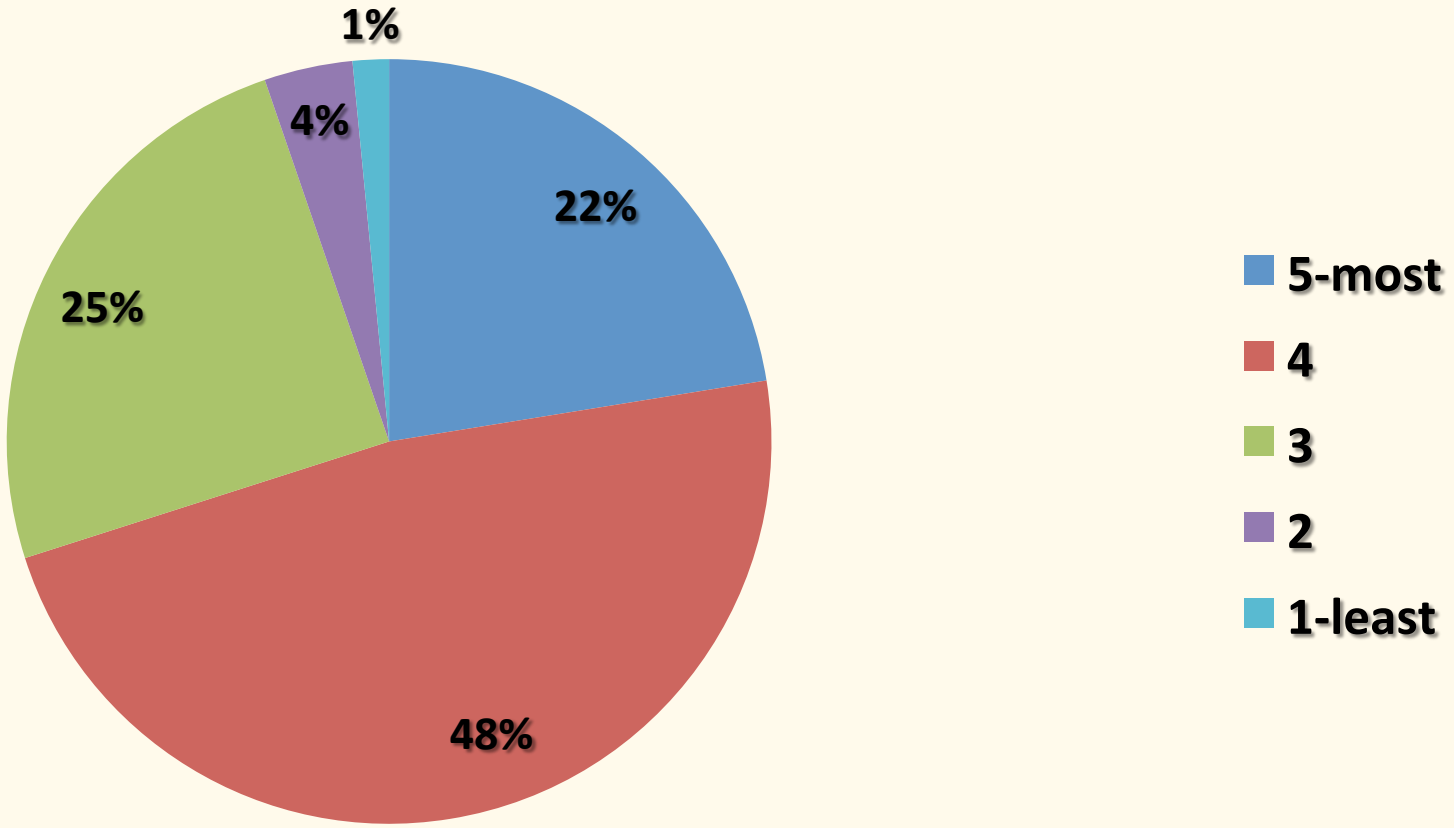
Fire Effects Value

What is the value you placed on Fire Effects in your consideration for the area of origin determination?



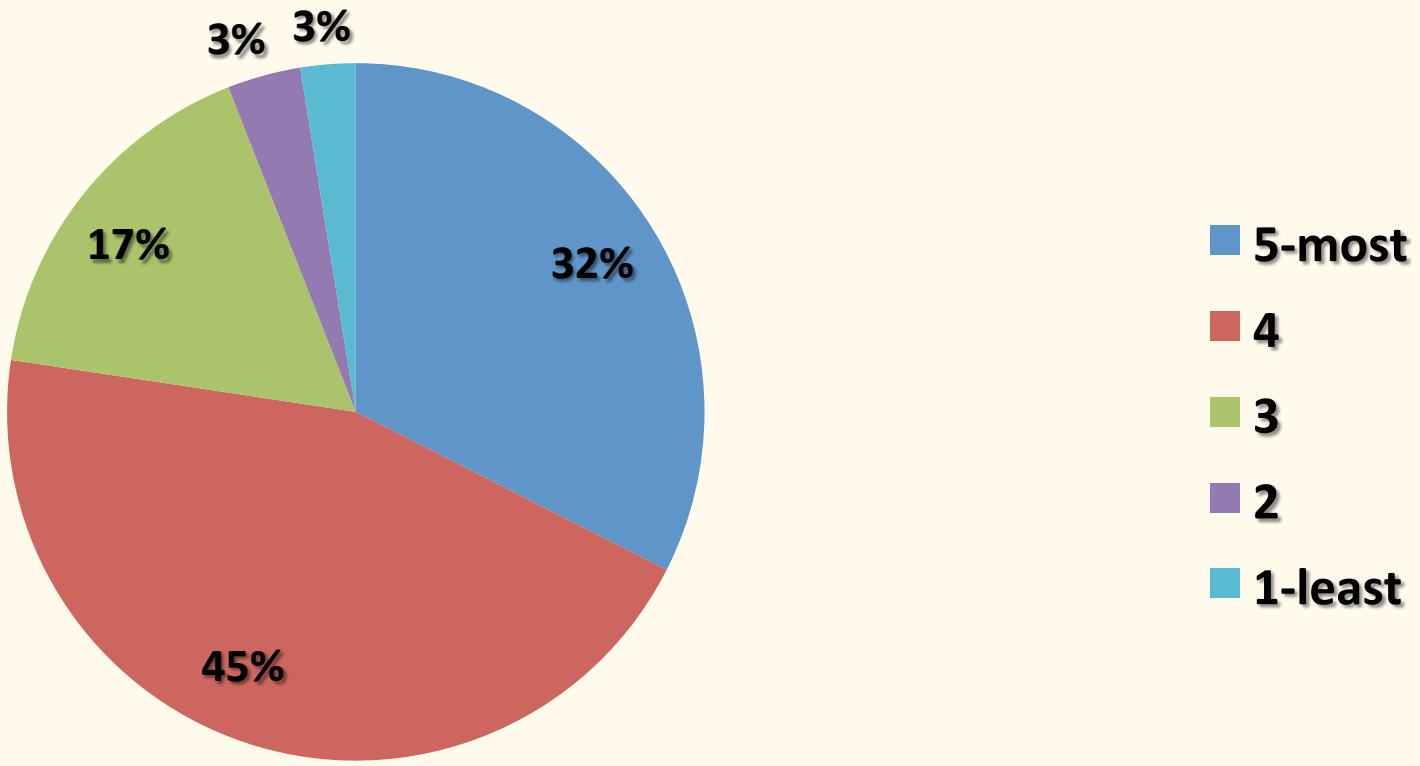
Fire Pattern Value

What is the value you placed on Fire Patterns in your consideration for the area of origin determination?



Degree of Damage Value

What is the value you placed on Greatest Degree of Damage in your consideration for the area of origin determination?



Value Questions – Summary

- Interesting to note here is that measurable damage to contents was provided the highest value in the consideration for the area of origin determination (82.0% of the participants rating 4 or 5), followed by visible damage to contents (79.3%) and greatest degree of damage (77.4%).

- It should be observed that these fire effects are ones that contain the most uncertainty when used in post-fire analysis (Schroeder, 1999)

Relationships

- Comparison of demographic and methodological factors and accuracy

Confidence and Accuracy

	Total Responses	Average Confidence	Accuracy
Strongly Agree	24	74.0%	79.2%
Somewhat Agree	210	73.3%	73.8%
Neutral	98	72.4%	78.6%
Somewhat Disagree	144	69.1%	75.0%
Strongly Disagree	112	68.9%	66.1%

Primary Consideration vs. Accuracy

		Without Measurable		With Measurable	
	Total Responses	#	%	#	%
Fire Effects	314	248	79.0%	258	82.2%
Fire Patterns	224	148	66.1%	159	71.0%
Heat and Flame	48	37	77.1%	38	79.2%
Greatest Degree	0	0	N/A	0	N/A

Without: $\chi^2_{(3,N=586)}=54.31$, $p<.001$ *With:* $\chi^2_{(3,N=586)}=32.08$, $p<.001$

Direction of Movement from Single Photo vs. Origin Determination Accuracy

		Without Measurable		With Measurable	
	Total in Category	#	%	#	%
Movement to Left	475	356	74.9%	376	79.2%
Movement to right	40	24	60.0%	26	65.0%
No Direction	24	17	70.8%	19	79.2%
Movement from Center Out	48	35	72.9%	34	70.8%

Without: $\chi^2_{(3,N=586)}=1.15$, $p=.765$ *With:* $\chi^2_{(3,N=586)}=1.26$, $p=.739$

Relationships – Summary

- Individuals with less confidence in the use of photographs alone tended to have both a lower level of confidence and a lower level of accuracy
- No participants placed the highest weight on the greatest degree of damage (contrary to Carman's exercise)
- Lowest performing were those that weighted fire patterns highest in their consideration. Highest performing were those that weighted fire effects, heat and flame vector analysis as highest.

Relationships (cont.)

- Individuals that correctly identified direction of movement in part 2 tended to be more accurate in the origin determination.
- Those individuals who refused to assign a direction demonstrated similar trends.
- However, those that mis-identified the direction, tended to perform considerably worse on the origin determination part.

Relationships (cont.)

- The more active an individual was in the field tended to favor a higher accuracy rate
  - Modest access to industry texts versus no access to texts
  - Reading one journal as opposed to no journals
  - Attended one conference as opposed to no conferences

Conclusions-Contradictions

- 77.2% agreed that you cannot determine an area of origin, yet when asked to do just this 74.8% provided a confidence level of 75% or greater

- 77% rated greatest degree of damage as a primary consideration when asked the question outside of the scenario, but once within the scenario no participants rated it as their primary consideration.

Conclusions

- It is apparent that the collection and provision of measurable data made a statistically significant difference in both the confidence and accuracy

- Those individuals that read, attend conferences, and keep up with improvements in the industry were shown to be more effective at their job.

Future Research

- On-scene survey
- Relationships investigated further
- Longer Duration Post Flashover Survey

Acknowledgements

- The almost 600 participants of the survey.
  - This work would have been impossible without the sacrifice of your time.

- Funding provided by EKU's Justice & Safety Research POD Committee

- NAFI and IAAI for utilizing their electronic mailing lists as a means of distribution for the survey.

References

- Results of TWGFEX Scene Survey (2000). Retrieved from http://ncfs.ucf.edu/twgfex/docs/Scene_Survey_Results.pdf

- Carman, S. *Improving the Understanding of Post-Flashover Fire Behavior*. 2008 International Symposium on Fire Investigation Science and Technology (2008).

- Schroeder, R. (1999). Post-Fire Analysis of Construction Materials. Doctor of Engineering dissertation, University of California, Berkeley.

- For Complete reference material and survey questionnaire see the following link: http://jsnet.eku.edu/frp

Questions?

"I have no idea what you're talking about, so here's a bunny with a pancake on its head."