Paper 136-31

Graphical Analysis of Clandestine Methamphetamine Laboratories Utilizing PROC GMAP: A Visual Inventory of Activity Across the United States

Wendy B. Dickinson, University of South Florida, Tampa, FL
Anthony J. Onwuegbuzie, University of South Florida, Tampa, FL
Constance V. Hines, University of South Florida, Tampa, FL

ABSTRACT

Nationally, a proliferation of clandestine methamphetamine laboratories (meth labs) has resulted from the growing popularity of the drug (Santos et al., 2005). The nature of this illicit process poses inherent dangers for the "cook", the first responders, bystanders including children, and the environment (Caldicott et al., 2005).

By combining data from two sources, the National Clandestine Laboratory Database and the Drug Enforcement Agency (DEA) website, a visual inventory representing both frequency and location of illicit lab activity across the United States was developed.

Within PROC GMAP, statement options of rotation, light source coordinates, plane assignments (x, y, and z), midpoint, and angle of tilt were written to produce effective visual displays of the United States with both surface map and prism map presentations. Secondly, algorithmic components of color, pattern, and scaling were modified to maximize information display. Lastly, for comparison of observed variables, composite graphical images were produced utilizing PROC GREPLAY.

CONTEXT

TRENDS IN METHAMPHETAMINE USE

Due to the growing popularity of methamphetamine there has been a proliferation of clandestine methamphetamine laboratories (meth labs) in the USA for manufacture of the drug (Santos, Wilson, Hornung, Polk, Rodriquez, & Franklin, 2005). The drug not only poses serious short-term and long-term effects to users, but in addition, the nature of the illicit manufacturing process poses inherent dangers for the "cook", the first responders, bystanders including children, and the environment (Caldicott, Pigou, Beattie, & Edwards, 2005).

Methamphetamine, which is also known as "meth," "crystal," "crank," "chalk," "ice," "glass," "uppers," "speed," or "poor man's cocaine," is a central nervous system stimulant that can be injected, smoked, snorted, chewed, or ingested orally **(**Fleming, 2005). This Schedule II controlled substance can be legally and legitimately prescribed to treat illnesses such as narcolepsy; however, it is a lethal drug with unpredictably dangerous effects when abused (Hargreaves, 2000). Methamphetamine may appear as an odorless, bitter-tasting crystalline powder that easily dissolves in liquid (e.g., water, alcohol). This drug may appear in many colors including white or brown, and it may appear in various yellow shades, depending on the ingredients used to make it

(Minnesota Department of Health, 2006). Methamphetamine, a derivative of amphetamine, was routinely prescribed in the 1950s and 1960s as a medication for obesity and depression, with a peak of 31 million prescriptions issued in the United States in 1967 (Anglin, Burke, Perrochet, Stamper, & Dawud-Noursi, 2000). However, since this period, methamphetamine has been used illegally.

According to responses to the 2004 National Survey on Drug Use and Health conducted by the Department of Health and Human Services, nearly 12 million people in the United States have used methamphetamine at least once in their lives (“Meth Cases,” 2006), with approximately 1.5 million persons being regular users (Jefferson, 2005). In previous decades, methamphetamine was viewed as a “poor man’s cocaine” that was abused predominantly by White individuals with low socioeconomic status who lived in rural areas. However, today, the landscape has changed substantially, with methamphetamine abusers representing all ethnicities, levels of socioeconomic status, and regions of the country.

EFFECTS OF METHAMPHETAMINE

Short-Term Effects

Once consumed, methamphetamine acts directly on the brain by forcing the release of high levels of the neurotransmitter dopamine (Wells, 2006). Dopamine, which is essential for the normal functioning of the central nervous system, stimulates the brain cells that make a methamphetamine user feel a “rush” or "high" (i.e., under the influence). The increased level of dopamine intensifies the individual’s feelings of happiness and satisfaction. Most users “binge and crash." An individual “binges” on methamphetamine by taking it every 2 or 3 hours during a daylong consumption. These binges might occur continuously (i.e., “tweaking”) for three to five days (Hargreaves, 2000). During this period, users do not perceive a need to sleep or eat and feel they have sufficient energy to enhance physical activity. Users feel that they have unlimited energy, which may last from 6 to 14 hours (Hargreaves, 2000). In fact, it is not unusual for an abuser to stay awake for more than one week. If an extreme amount of methamphetamine is consumed, the user’s body temperature may rise to dangerous levels, and convulsions may ensue.

As the potency of the methamphetamine wears off (i.e., user comes down from the high), the person may experience the effects of sleep deprivation, which include nervousness, anxiety, paranoia, and/or insomnia. Violence and erratic behavior may ensue at this stage. Some users have hallucinations, such as believing they have been abducted by aliens. Other unusual behaviors might include obsessive and relentless cleaning and grooming or disassembling mechanical devices (Hargreaves, 2000; Wells, 2006).

Once the effects of the methamphetamine subside, the person “crashes,” leading to paranoia, depression, and aggression. The only way an individual can purge these feelings is to consume more methamphetamine, commencing the binge-and-crash cycle all over again. This makes methamphetamine an extremely addictive drug. Thus, few people use methamphetamine one time only (Hargreaves, 2000).

Long-Term Effects

Long-term health effects of methamphetamine use include cardiac arrhythmia, stroke, stomach cramps, shaking, anxiety, paranoia, insomnia, hallucinations, severe weight loss, tremor, mood disturbances (e.g., homicidal or suicidal thinking), amphetamine psychosis, and structural changes to the brain (Anglin et al., 2000; Minnesota Department of Health, 2006). Most disturbingly, long-term methamphetamine abuse may cause permanent brain damage. Indeed, abuse of this drug can culminate in complications involving almost every major organ system. By releasing high levels of dopamine, methamphetamine deprives the brain cells of dopamine, which, in turn, can make a person demonstrate symptoms of schizophrenia and Parkinson's disease (Minnesota Department of Health, 2006). Long-term methamphetamine users can exhibit memory loss, similar to Alzheimer's disease. Further, increased blood pressure, rapid heartbeat, and damage to blood vessels in the brain all represent life-threatening manifestations of long-term abuse. Long-term abuse also results in addiction, a condition that makes it nearly impossible for a user to relinquish without medical treatment. The use of methamphetamine by pregnant women can cause premature birth, growth retardation, and developmental disorders in neonates, as well as long-term cognitive deficits in children (Anglin et al., 2000). In addition, children of methamphetamine abusers are at greater risk of neglect and abuse (Anglin et al., 2000).

According to the National Association of Counties, for 47% of the 200 hospitals funded or run by counties in 39 states and Washington, D. C. that were surveyed, methamphetamine abuse accounts for more visits to the emergency room than does any other drug ("Meth Cases," 2006). Unfortunately, there are no medications to treat methamphetamine addiction. At the same time, withdrawal can cause anxiety, depression, paranoia, fatigue, aggression, and intense drug craving (Minnesota Department of Health, 2006). Currently, cognitive-behavioral interventions coupled with support groups represent the most effective treatments, wherein addicts are helped to find new and non life-threatening ways to attain contentment in their lives. Antidepressant medicines also can be effective. As noted by Anglin et al. (2000), although severe cases of long-term methamphetamine dependence may necessitate inpatient hospitalization, optimal treatment for methamphetamine abusers relies on an intensive outpatient treatment with three to five visits per week of comprehensive counseling for at least the first three months. Disturbingly, even users who have refrained from consuming methamphetamine for a number of years still exhibit psychotic behaviors.

In addition to effects on a person's health, the rampant abuse of methamphetamine has had societal costs. In particular, methamphetamine abuse has been associated with increased crime (e.g., property crime, interpersonal violence, child abuse and neglect); increased demand for social services (e.g., foster care) and public health services; increased demand on prison, prison resources, and law enforcement and fire department agencies; and increased burden on educators, parents, and communities (Minnesota Department of Health, 2006).

Methamphetamine Laboratories
Until the late 1980s, the illegal manufacture of methamphetamine in the United States was, for the most part, limited to California. However, since 1995, the scope of illegal use and manufacture has broadened substantially (Hargreaves, 2000). Presently, clandestine laboratories in California continue to produce more methamphetamine than does any other region of the United States; however, thousands of independent traffickers operate in the Midwest, with increasing numbers being identified in the southeast. These traffickers tend to be involved in smaller scale operations that are commonly referred to as “mom and pop” or clandestine laboratories (Hargreaves, 2000). These laboratories also are called “clan labs” or “meth labs.” In fact, apart from marijuana, methamphetamine is the most commonly abused illegal drug that a person can manufacture alone. Indeed, chemists represent less than 10% of the manufacturers of methamphetamine who are arrested. For approximately $100 worth of agents purchased in a hardware or grocery store, a “cook” can manufacture $1,000 worth of methamphetamine (Daley & Onwuegbuzie, 2001; Fleming, 2005). Thus, the trafficking of methamphetamine can be a lucrative business.

Clandestine methamphetamine laboratories appear in a variety of locations, such as apartments, houses, motels, hotels, campers, trailers, vehicles, public storage facilities, wooded areas, or other buildings. Once manufactured, traffickers then distribute the methamphetamine. Trafficking often is undertaken by youth (Daley & Onwuegbuzie, 2001).

Methamphetamine is manufactured (or “cooked´) from common, easily available materials by using one of numerous basic chemical processes. These methamphetamine "recipes" are easy to obtain from the Internet or from other “cooks.” There are hundreds of chemical products and substances that can be used interchangeably to produce methamphetamine. However, substituting one chemical for another in methamphetamine recipes may cause the cooking process to be more hazardous—culminating in chemical fire or explosion, or in a finished product with undesirable or dangerous effects. For example, certain brands of drain cleaner contain a high concentration of sulfuric acid that, when mixed with table salt, produce hydrogen chloride gas, which is toxic for both the methamphetamine manufacturers and others living in close proximity to the laboratory. In fact, each pound of methamphetamine can yield up to 5 or more pounds of toxic waste (Hargreaves, 2000). The cooking process causes chemicals and methamphetamine to be deposited on surfaces and household belongings. Methamphetamine cooking also produces solid and liquid wastes that can contaminate a building and its contents, or the groundwater or soil where they are dumped. Thus, when a methamphetamine laboratory is seized, the seizure typically involves fire department and environmental personnel to clean up the toxic waste at the site, in addition to members of other county agencies such as local law enforcement, the courts, child protective services, and local health care providers (Fleming, 2005). Cleaning up these sites necessitates very specialized training and costs an average of $3,000-$8,000 per site (Fleming, 2005). Large production laboratories can result in clean-up costs of $100,000 or more (Hargreaves, 2000).

In 1995, 327 methamphetamine laboratories were seized by drug enforcement agencies across the United States. By 2004, this number had increased substantially to approximately 18,000 (Fleming, 2005).

PURPOSE

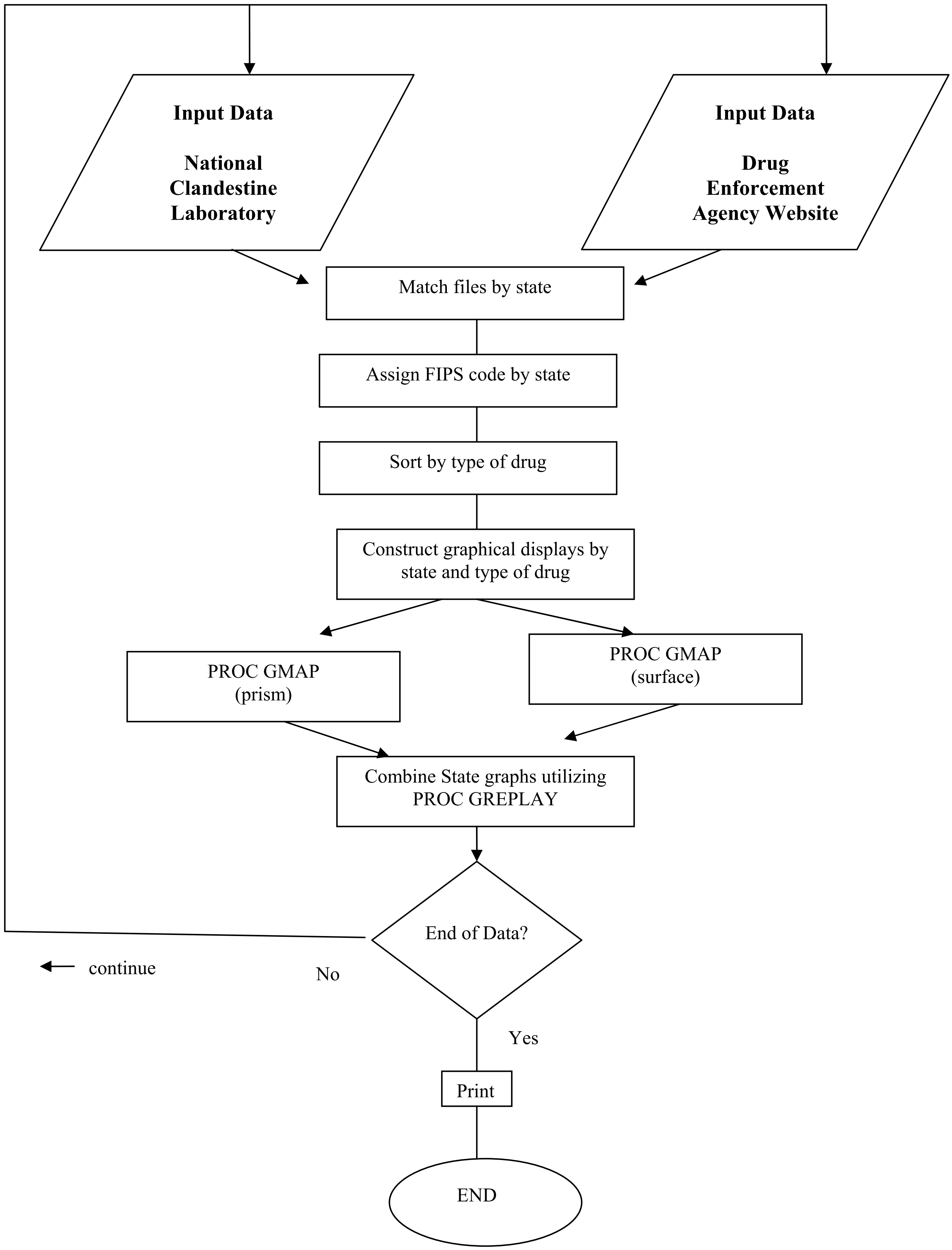
With the growing popularity of methamphetamine and the ease with which the drug can be manufactured, there has been a proliferation of clandestine methamphetamine laboratories (meth labs) across the United States. Due to this rapid increase in the illicit manufacture and subsequent distribution of methamphetamine, drug enforcement and social service agencies are struggling to keep pace. By combining data from two sources, the National Clandestine Laboratory Database and the Drug Enforcement Agency (DEA) website, a visual inventory representing both frequency and location of illicit lab activity across the United States was developed. SAS 9.1 was utilized to combine quantitative information with geographical referents to create this visual mapping of illicit drug activity to aid in public awareness of the scope and intensity of methamphetamine abuse.

METHOD

This study began by examining two multivariate, large-scale databases: the National Clandestine Laboratory Database and the Drug Enforcement Agency website. Each database was scrutinized to determine the variables best suited for inclusion. An algorithm was generated to input data from the databases, assign FIPS codes by state, sort by selected variables of interest, and construct graphical displays by state and type of drug. As noted by Wainer, (2005), “An efficacious way to add context to statistical facts is by embedding them in a graphic” (p. 86). Within the SAS program, context was added by utilizing the United States maps, ‘SAS-maps-library,’ as a presentation matrix for the statistical summary of illicit laboratories.

A summary of the algorithm is shown in Figure 1, Algorithmic Flowchart. Within PROC GMAP, statement options of rotation, light source coordinates, coordinate plane assignments (x, y, and z), midpoint, and angle of tilt were written to produce effective visual displays of the United States with both surface map and prism map presentations. Secondly, algorithmic components of color, pattern, and scaling were modified to maximize information display. Lastly, for comparison of observed variables, composite graphical images (“small multiples”, Tufte,1990) were produced utilizing PROC GREPLAY.

FIGURE 1. **Algorithmic Flowchart**



RESULTS AND DISCUSSION

PROC GMAP – Surface Maps

PROC GMAP was utilized to combine a surface map of the United States with the corresponding frequencies of clandestine methamphetamine laboratories by state. The frequency of the labs-by-state is displayed by the height of each graphical element (spike). There is one spike per state, as state is the unit of analysis. Significantly, each spike base is a polygon. By referencing the distance decay function, we can specify the base width of the spikes that are drawn to display data values; thus modifying the size and summative shape of each spike. These algorithmic procedures are summarized in Table 1, Surface Map: Changes and Enhancements.

Table I. Surface Map: Changes and Enhancements

Aesthetic/Operational Basis for Change	Algorithmic Modification	Resultant Display
Spike Size	(Default code) CONSTANT = 10	Base size of spike is determined using default constant value.
• Spike base is a polygon • Utilizing distance decay function, $D^k = (x – x^k)^2 + (y – y^k)^k$		
	(Modified code samples)	
	CONSTANT=5 With constant < default value, spike base value is decreased (spikes emerge from a smaller base).	Base size of spike is modified via decreased constant value.
	CONSTANT=20 With constant > default value, spike base value is increased (spikes emerge from a wider base).	Base size of spike is modified via increased constant value.

PROC GMAP – Surface Maps

Using the TILT option allows the specification of angle measure (in degrees) for the graphical visual presentation. The value of angle measures specified by the TILT option can range from zero to ninety degrees. This range of value allows for movement analogous to picking up a piece of paper from a flat surface, and then slowly tilting the page towards you. Therefore, no tilt (TILT=0) would result in a horizontal view of the page. Increasing the TILT = value allows the viewer to increase the visual differentiation between the spikes emerging from the map surface.

Table 2. Surface Map: Angle Measures of Tilt

Aesthetic/Operational Basis for Change	Code Components	Resultant Display
Provide a basis for page movement towards viewer	$0 \leq$ TILT ≤ 90	Allows the view of map surface to vary from horizontal to lateral orientations

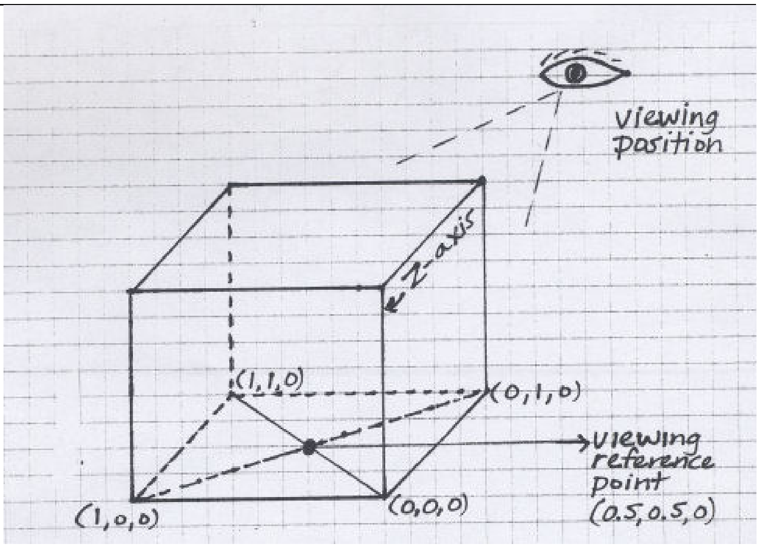
PROC GMAP – Prism Maps

By using a three-dimensional coordinate system, we 'can label any point in space' (Downing, 1995, p. 36). Within SAS/GRAPH software, in three dimensions, 'the X axis represents width, the Y-axis represents depth, and the Z-axis represents height' (SAS Institute, 2004, p. 1549). At the center of the base grid (corners labeled with coordinate values) is the viewing reference point. This viewing reference point is at the intersection of the diagonals; with the coordinate location of (0.5, 0.5, 0).

Therefore, by specifying values for XVIEW, YVIEW, and ZVIEW, we can change the viewing position of the coordinate plane from which the prisms emerge. With default XVIEW value = 0.5, an increase in value will push the viewing point along the horizontal (X) axis, to the right. With the default value of ZVIEW = 3, an increase in ZVIEW value will raise the viewing point even higher (as the Z-axis represents height).

The value for ZVIEW cannot be less than zero, because this would place the imaginary viewing position underneath the graphical display. To reiterate, if we think of a setting sun, once it reaches the horizon line, the image of the sun disappears. This is analogous to the value of ZVIEW: once it reaches zero (the 'horizon line'), it cannot become any smaller (negative number) because the graph image will disappear from view. An approximate illustration is contained below in Table 3, Prism Map: Coordinate Plane Viewing Position.

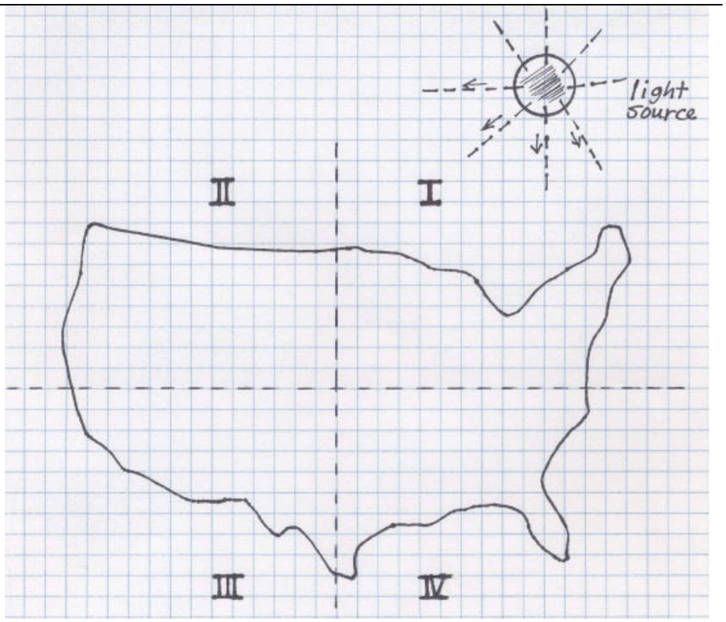
Table 3. Prism Map: Coordinate Plane Viewing Position

Aesthetic/Operational Basis for Change	
Code Components	(Default code) XVIEW = 0.5 YVIEW = -2 ZVIEW = 3 (Modified code sample) XVIEW = 0 YVIEW = 1 ZVIEW = 1
Resultant Display	The default code locates the viewing position to the right and above the viewing reference point. Modified code values relocate and lower the viewing position.

PROC GMAP – Prism Maps

If the light source options are not invoked, 'the light source location is the same as the viewing position' (SAS Institute, Inc., 2004, p. 1064). Within the prism mapping algorithm, we can move the light source location horizontally by changing the value assigned to XLIGHT. As the assigned value of XLIGHT increases, the light source location shifts to the right. This subsequently causes the right side of the prisms to be in the 'light', and the left side of the prisms to be in the 'shade'. Therefore, we can alter shadow depth, and how much shadow is present (distribution), by modifying the SAS code. PROC GMAP has options of XLIGHT and YLIGHT to specify the location coordinates of the imaginary light source within the three-dimensional coordinate graphing system. This system is shown in Table 4, Prism Maps: Light Source Coordinates.

Table 4. Prism Maps: Light Source Coordinates

Aesthetic/Operational Basis for Change	
Code Components	(Default code) [[XLIGHT=] [YLIGHT=] not invoked (Modified Code Sample) XLIGHT = 10
Resultant Display	(Default) Light source = viewing position shadows not generated on side view (polygons) (Modified Code) Light source moves Horizontally > Deep shadows generated on prism sides

As noted by Tukey (1989), by far the greatest strength of visual display lies in the vibrancy and accessibility of the intended message. The overwhelming premise of visual imagery is that of communication (Dickinson, 2001); thus the PROC GMAP statement option modifications were incorporated into the graphing algorithm to enhance visual display of the national illicit laboratory datasets. For the viewer, this unspoken message can be more potent than spoken or written communication. The visual inventory of illicit activity developed using SAS 9.1 provides an effective vehicle of context and content for the composite observations of drug manufacture and drug activity across the United States.

REFERENCES

Anglin, M. D., Burke, C., Perrochet, B., Stamper, E., & Dawud-Noursi, S. (2000). History of the methamphetamine problem. *Journal of Psychoactive Drugs, 32*, 137-141.

Caldicott, D. G., Pigou, P. E., Beattie, R., & Edwards J. W. (2005). Clandestine drug laboratories in Australia and the potential for harm. *Australian and New Zealand Journal of Public Health*, 29, 155-162.

Daley, C. E., & Onwuegbuzie, A. J. (2001). Educational, familial, social, and criminal profiles of male juvenile offenders. *Educational Research Quarterly, 25(*1), 12-26.

Dickinson, W. B. (2001). Escaping flatland: Chernoff's faces revisited. *Proceedings of the SAS Users Group International Conference*. Cary, NC: SAS Institute, Inc.

Downing, D. (1995). *Dictionary of mathematics terms*. Hauppage, NY: Barron's Educational Series.

Fleming, S. (2005). The meth effects. *American City & County, 120*(1), 42-45.

Hargreaves, G. (2000). Clandestine drug labs: Chemical time bombs. *FBI Law Enforcement Bulletin, 69*(4), 1-6.

Jefferson, D. J. (2005, August 8). America's most wanted drug. *Newsweek, 146*(6), 40-48.

Meth cases put strain on ERs. (2006, January 18). *USA Today*, p. 01a.

Minnesota Department of Health. (2006). *Methamphetamine and meth labs*. Retrieved January 24, 2006, from http://www.health.state.mn.us/divs/eh/meth.

Santos, A. P., Wilson, A.K., Hornung, C.A., Polk, H. C., Rodriguez, J. L., & Franklin, G.A. (2005). Methamphetamine laboratory explosions: A new and emerging burn injury. *Journal of Burn Care and Rehabilitation* 26, 228-232.

SAS Institute, Inc. (2004). *SAS/GRAPH 9.1 Reference, Volumes 1, 2 and 3.* Cary, NC:

SAS Institute, Inc.

Tufte, E. (1990). *Envisioning information.* Cheshire, CT: Graphics Press.

Tukey, J. W. (1989) Data-based graphics: Visual display in the years to come. *Proceedings of the American Statistical Association*, 84, 366-381.

Wainer, H. (2005). *Graphic discovery: A trout in the milk and other visual adventures.* Princeton, NJ: Princeton University Press.

Wells, K. (2006). *Medical aspects of methamphetamine abuse*. Retrieved January 24, 2006, from http://www.nmtf.us/methamphetamine/methamphetamine.htm

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CONTACT INFORMATION

Your comments and questions are valued and encouraged.
Contact the authors at:

Dr. Wendy Dickinson
University of South Florida
4202 E. Fowler Ave. EDU162
Tampa, FL 33620
Fax: 941-953-5071
E-mail: statgirl@aol.com