The Security Printing Practices of Banknotes

A Senior Project

presented to

the Faculty of the Graphic Communication

California Polytechnic State University, San Luis Obispo

In Partial Fulfillment

of the Requirements for the Degree

Graphic Communication; e.g. Bachelor of Science

by

Corbin Nakamura

March, 2010

Table of Contents

Abstract

Counterfeit goods continue to undermine the value of genuine artifacts. This also applies to counterfeit banknotes, a significant counterfeit problem in today's rapidly growing world of technology. The following research explores anti-counterfeit printing methods for banknotes from various countries and evaluates which are the most effective for eliminating counterfeit.

The research methods used in this study consists primarily of elite and specialized interviewing accompanied with content analysis. Three professionals currently involved in the security-printing industry were interviewed and provided the most current information about banknote security printing.

Conclusions were reached that the most effective security printing methods for banknotes rest upon the use of layering features, specifically both overt and covert features. This also includes the use of a watermark, optical variable inks, and the intaglio printing process. It was also found that despite the plethora of anti-counterfeit methods, the reality is that counterfeit will never be eliminated.

Unfortunately, counterfeit banknotes will remain apart of our world. The battle against counterfeit banknotes will have to incorporate new tactics, such as improving public education, creating effective law enforcement, and relieving extreme poverty so that counterfeit does not have to take place.

I - Introduction and Purpose of Study

Authenticity is a virtue in society because it requires honesty, integrity and moral fiber. It is disturbing to know that an overwhelming percentage of goods are counterfeit and that counterfeiters are not diminishing. Fortunately, there are industries that focus on reducing counterfeit goods. A significant segment of the graphic communication industry includes the practice of security printing. Security printing is the area of the graphic communication industry that focuses on maintaining secure printed media by using "limited-access materials and supplies along with unique or specialized technologies and a multiplicity of printing processes to produce security end products under secure operating procedures and manufacturing/distribution protocols" (Warner 1). Security printing is a broad term that includes many secure printing businesses, processes, international relations, and ethical issues.

There are many types of security printing processes available today. With the proper technology, security printers can produce secure documents with a low level of concern for counterfeit. However, when the technology that security printers use begins to become easily attainable, the secure documents are open to unlawful reproduction. The main considerations that fuel counterfeit practices are the relatively low cost of technology, including digital computers, color copy machines, and image scanners. Thus, it is extremely vital for security printers to be ahead of counterfeiters by using the latest security printing technology.

Security printing processes can start with simple techniques such as printing on special paper or including watermarks. The key is controlling the security of the substrate and not the content printed on it. In addition to securing the substrate, specialty print-related techniques such as intaglio printing, lithography, letterpress, micro-printing, security inks, security threads, serial numbers, anti-coping marks, registration features, and design effects. Unique documents such as banknotes require multiple security printing techniques to ensure their security and effectiveness in society. Ultimately, this study asks the question: What are the most effective security printing techniques for banknotes?

Perhaps the best answer to this question is that the most effective security printing requires a combination of processes. For instance, a document could include a watermark as well as security threads. It is logical to deduce that the more features that are used on a banknote increases the security of the document, thus making it harder to successfully counterfeit. However, a deeper look into the counterfeit problem will illustrate that the difference between a successful counterfeiter and an unsuccessful counterfeiter is perception. If a counterfeiter can produce a document that is perceived to be real by the recipient, the counterfeiter has succeeded. The problem is that no matter how stringent or effective a security printing technique is, it will unfortunately be only one strategy to combat counterfeiters. The remaining strategies are increasing the accessibility of screening devices, which verify the legitimacy of the banknote, and narrowing the perception of what is considered authentic. Nonetheless, making improvements in security printing is a crucial element in the battle against counterfeiters.

The purpose of this study is to evaluate different methods of security printing in developed countries and to determine what methods are the most effective in eliminating counterfeit production. The most effective security printing technique is the one that is the hardest to counterfeit while simultaneously acting as an effective means of graphic communication through banknotes. There will be an emphasis on the printing of banknotes, domestic and foreign. Due to its extreme versatility and value, banknotes require complex security printing practices. Thus, there is a great amount that can be evaluated by understanding the security printing practices of producing banknotes.

II - Literature Review

The history of civilizations conducting transactions has been documented since 3000 B.C. During this time, the Sumerians began to use metal coins instead of barley for making their transactions ("Paper Currency"). Eventually, metal coins would evolve into paper notes, of which China was the first to use during the seventh century. For centuries to follow, printed banknote currency would undertake myriad changes, with most of these changes focusing on deterring counterfeiters and ultimately maintaining the integrity of the banknote.

In 1690, the first paper money in the United States was issued by the Massachusetts Bay colony and was valued in British Pounds ("Paper Currency"). When the American Revolution occurred among the colonies, the first paper money printed in the United States lost its value due to extreme counterfeiting by the British and uncertainty as to the outcome of the war. Thus, it was not until the mid 1800s when paper notes would be printed again in the United States. During these years, as many as 1600 different kinds of paper money were in circulation in the United States and as much as a third of it was counterfeit ("Paper Currency"). To rectify this problem, the United States Congress authorized the issue of a stable and universal paper currency in 1863 (Warner 4). In the next two years, this universal paper currency would be subject to many counterfeiters. As a result, President, Abraham Lincoln established the Secret Service in 1865, whose primary goal was to eliminate counterfeiters. Stopping counterfeiters is a worthwhile action, however, the ultimate goal is try to prevent unauthorized duplication in the first place. In the book, *Introduction to Security Printing*, authors, Richard Warner and Richard Adams define the goal of security printing by stating, " The goal for today's security printer is to produce documents, labels, packages and cards with multiple layers of new counterfeit deterrents while

maintaining the aesthetics and functionality of the printed product" (Warner 4). To help make this goal attainable for banknotes, several security-printing techniques are used in the process of banknote printing. Warner distinguishes banknotes as a high-tech security end product (SEP) and acknowledges that the more security devices that are employed in creating a high-tech secure document, the more difficult it is to counterfeit. Today there are over forty techniques used to produce high-tech security end products. However, the most commonly used techniques in the production of banknote printing involve security paper, security ink, lithography, intaglio, letterpress, optical variable devices, machine reading, durability, forgery protection, micro-printing and design effects.

SECURITY PAPER

Banknotes, like most secure documents, depend on the substrate as the foundation for security. A watermark is a component of security paper that acts as a highly effective security device. Put simply, a watermark is an image that is embedded into the substrate during the paper making process by, "varying the fiber thickness and thus the paper translucency" (Warner 38). The watermark is one technique that is created in the paper production process that has, "become synonymous with security because of its long and reliable use" (Renesse). The watermark is the primary and most secure feature because the public easily recognizes it. For example, consider the $100 banknote of the United States, which contains a watermark in the form of Benjamin Franklin's portrait adjacent to the portrait of him in the center of the note. Watermarks are more effective when, "they can be easily viewed and recognized by examination, and it is recommended that the watermark is clear of any printing" (Renesse). This type of watermark

provides a “high level of security, and is recommended by Interpol for banknotes” (Renesse 97). Furthermore, multi-tone watermarks can be more complex as they can vary in tone, with some areas of the watermark darker or lighter than others. The multi-tone watermark provides protection against scanners, copiers, chemical, mechanical, and reproduction attempts (Warner 42). Thus, banknotes will continue the use a multi-tone watermark to fight against counterfeiters.

Another security feature that involves the substrate is the absence of brighteners in the paper making process. Security paper must be ultraviolet-dull (UV-dull), in which that paper is free from optical brightening agents (Warner 38). This UV-dull paper improves security for two reasons. One, “It allows for the use of fluorescent inks as a security feature, and two, by not fluorescing under UV light as would counterfeits produced on ordinary, brightened colored paper” (Warner 38). As such, nearly all of security printed documents use uncoated substrates with no brighteners.

Security threads and fibers are another component of security that involves the substrate. Similar to a watermark, security threads and fibers are incorporated into security paper during manufacture (Warner 41). Security fibers offer visibly different color fibers to the documents that act as an overt security feature. An overt security feature is one that is easily detectable by the naked eye. Also, security fibers can be almost invisible colors that fluoresce when illuminated with UV light, making authentication easy (Warner 41). Security fibers are often used in addition to a watermark and also provide protection against color photo-copying (Warner 41). An example of security threads can be found in the use of United States banknotes. United States banknotes contain small red and blue fibers littered throughout the note for visual

identification. For the security of notes greater than 10 dollars, a polymer security thread was laminated into the substrate. A polymer security thread is a synthetic thread that is only visible when held up to a light and cannot be duplicated in photo-copiers or printers (“Paper Currency”).

Other countries have different security standards for banknotes. Australia’s banknotes are printed by Note Printing Australia (NPA), a subsidiary of Commonwealth Bank, which was established in 1913. For 75 years, the NPA has been printing paper currency for Australia and in 1988 the NPA introduced the first polymer banknote technology (“Banknotes”). In the 1960’s Australia was struck by a massive counterfeit attack of the $10 note. These notes were very high quality and difficult to identify. In response, the NPA introduced the idea of printing on a polymer note. A polymer note is one that uses a synthetic substrate instead of one that is composed of natural fiber. The NPA decided that the polymer substrate would be more difficult to duplicate because the technology did not yet exist in Australia.

There are many arguments for the use of polymer notes being a more secure currency substrate. Polymer notes provided a smoother, reduced-texture surface, compared to paper notes, allowing for the introduction of micro security printing (“Banknotes”). The polymer substrate also allowed for more security features such as a clear window with a picture and a registration star. According to NPA,

> Polymer substrates provide a platform for new and additional security features with durability, quality and cost efficiency. It is a valuable addition to the arsenal of technologies available to note issuers for ensuring the integrity and quality of their

currency. With the growth of digital printing technology, counterfeiters can reproduce paper banknotes with little knowledge or experience. Polymer banknotes are a deterrent to the counterfeiter, as they are much more difficult and time consuming to reproduce. They are more secure, cleaner, and more durable than paper notes (“Banknotes”).

Polymer notes are effective banknote solutions because of their versatility. NPA indicates, “The traditional printed security features applied on paper can also be applied on polymer, including intaglio, offset and letterpress printing, latent images, micro-printing, intricate background patterns, see through registration, visible and invisible fluorescent features, and the use of metallic, metameric, or metachromic inks” (“Banknotes”).

Planchettes are another security device that involves the substrate of a banknote. According to Warner, “Planchettes are tiny paper dots that are embedded during papermaking and are not reproducible by scanning, photocopying, or printing” (Warner 44). Planchettes can be fluorescent, which can only be viewed under UV radiation or non-fluorescent, which can be removed from the paper surface (Warner 44). Furthermore, there are chemically reactive planchettes that change color when in contact with an alkaline solution. There are also thermochromic planchettes, which cause the planchettes to change color when heat is applied to them (Warner 45).

SECURITY INK

The next stage in securing banknotes involves the pigment needed for imaging. There are two main types of ink associated with security printing. The first is anti-duplication ink, and the second is anti-alteration ink. “Anti-duplication inks are designed to prevent unauthorized copying or duplication of documents” (Warner 49). These types of inks use covert security techniques such as UV fluorescence to authenticate. “Anti-alteration inks provide overt indications of tampering, such as discoloration upon exposure to water or chemicals or destruction to the background” (Warner 49).

Ultraviolet Inks (UV) are frequently used in U.S. banknote printing. These inks “cannot be seen with the human eye under normal lighting conditions” (Warner 54). To see these inks requires light from UV radiation. The U.S. $20 banknote uses a form of UV ink known as invisible UV-fluorescent ink. These types of ink are special because they are invisible under daylight, but “glow different colors under UV illumination” (Warner 55). This ink offers a covert security feature by not being detectable without the proper short-wave, or long-wave UV illumination (Warner 55).

Color-shifting inks are used exclusively in the printing of U.S. banknotes and are an example of both anti-duplication ink as well as anti-alteration ink. They are considered an optically variable device (OVD) and are used in the $5, $10, $20, $50, and $100 banknotes. This high-tech ink feature, “prints the denomination numeral in the lower right-hand corner on the front of the banknote” (Warner 53). When the bill is tilted forward or backward, the ink actually changes color from black to green or copper to green depending on when the note was printed (Warner

53). Another example can be found on the use of a €5 (Euro) banknote in which a section appears black at one angle and yellow at a different angle (Warner 14).

An OVD is a device that alters the appearance of printed material in many ways. For example,

> OVDs change in appearance to the observer when the viewing angle between the device and the observer is changed, when the angle between the device and the light source is altered, when the device is rotated, or when the color temperature or dominant wavelength of the light source is changed (Warner 14).

It is not surprising that OVDs have become, "a cornerstone for document security applications" (Warner 14).

There are many other security ink techniques that are not currently used for the printing of banknotes, but might be in the future. One fascinating example is the use of electrochromic ink, which is a new development by Dow Chemical Company, USA (Warner 59). This special ink, "changes color when stimulated by an electric current" (Warner 59). Currently, this type of ink is used for packaging applications, but could prove to be an effective option for authenticating banknote printing in the future.

LITHOGRAPHY

Lithography is a popular printing process that is based on the principle that water and oil do not mix. In today's lithography, an image is photochemically transferred to a plate, which accepts ink in the image areas and repels ink with a water based fountain solution in the non-image areas.

Security printers use lithography in a fundamentally different way from commercial lithography printers (Renesse 112). Security lithography involves creating images by using a line structure formation and altering the colors along this line. Simulated 3-D effects are achieved with this type of lithography and are an essential component in preventing an easy replication from a counterfeiter. With lithography, it is possible to print a smoothly changing color along a single printed line. This technique is called *rainbowing* and is beneficial because it produces an enhanced colorful effect that cannot be separated into individual color components. Thus, "The counterfeiter using the camera [counterfeit] process has to spend a large amount of time hand-retouching the negatives to obtain a satisfactory plate" (Renesse 114).

The genius of lithography security printing is the precise ability for registration of individually colored printings. This is done through the use of duplex or triplex patterns on the face of a document. Multiple color patterns prove to be a very effective security measure because, "if counterfeiters separate these colors they have to ensure that the small areas are perfectly sharp to retain pattern integrity and also are perfectly fitting from each printing to get color harmony" (Renesse 114).

One last security technique that lithography offers for currency printing is the see through effect, which relies on refined registration. With lithography it is, "possible to create a combined image from elements printed on both sides of the document" (Renesse 114). This is done by generally printing the outline of a shape on one side of the document and the solid shape on the other. When the document is held up to light, the solid shape fits perfectly into the outline shape on the other side.

INTAGLIO

The intaglio printing process requires precise work, as images must be carefully engraved into the printing surface, or plate. Once the image is engraved, the plate is coated with ink. A tremendous amount of pressure is used to print the image from the cylinder on to the substrate. The intaglio printing process is used frequently in security printing and traditionally provides the main visual security on the document. Intaglio printing is produced by plates on which images are recessed, much like gravure printing which is the commercial term for this type of printing. However, intaglio security printing requires, “Thick paste inks with hand-engraved plates using high printing pressures” (Renesse113). Moreover, intaglio security printing “has the distinctive variation in depth of image and this variation in tonal range” (Renesse 113). As a result, “The intaglio engraver constantly looks for juxtapositions of shade and tone” (Renesse 116). This process ensures the portrait on a banknote is easily recognizable and very hard to counterfeit through the camera process because fine detail is lost or the solid areas fill in. Intaglio printing also produces a three-dimensional structure print. This structure “can be used to conceal a message that is only readable from a specific direction” (Renesse 117). The message can be read when the document is held towards the light at an oblique angle.

Intaglio printing is the primary printing process used to create U.S. banknotes. Intaglio printing is used because its ability to produce extremely fine detail that remains legible under repeated handling and is difficult to counterfeit (“Paper Currency”). The U.S. understands the importance of quality when printing money and strives to minimize flawed prints. There are many inspections that occur during the printing process, which involve the raw materials, inks and substrate.

LETTERPRESS

Letterpress is another widely used security technique by the currency printer. Letterpress is one of the oldest printing techniques based on Johannes Gutenberg's invention of moveable type. Metal plates with raised images are inked and pressed against the substrate. It is a legal requirement for each banknote in the U.S. to have an individual identification number. This requirement is carried out through the letterpress process (Renesse 118). Letterpress uses a numbering box that rotates with the press and allows for the unit digit in the box to automatically advance and print. Letterpress is effective because, "any number can be built up and printed in perfect alignment" (Renesse 118). Counterfeiters have an extremely tough time to reproduce these numbering patterns because the design of the numbering is not available commercially. This type of number security can be further enhanced using special inks including two colors, fluorescence, magnetic, or other types of special ink (Renesse 119).

MICROPRINTING

Microprinting is a common security printing technique that refers to printing microscopic letters that are, "too small to see without magnification" (Warner 68). At a normal viewing distance, these characters look like a very thin line, however microprints contain much more legible information. Microprinting is difficult to counterfeit because it is virtually impossible to reproduce the print accurately with only the use of photocopiers (Warner 68). Microprinting is commonly used in banknote printing. For example, on the new $100 bill there are two instances of microprinting, where "USA 100" appears within the lower left corner, and the words, "United States of America," which are spelled out on the lapel of Franklin's coat ("Paper Currency").

Other variations of microprinting on the new $100 bill include concentric fine lines behind Franklin's head and behind the image of Independence Hall ("Paper Currency"). These lines are very fine and almost impossible for copiers or printers to replicate without producing a blended background ("Paper Currency").

MACHINE READING

Banknotes are mainly designed as a tool for humans to exchange goods and services with on a daily basis. Banknotes "incorporate a range of tactile and visual security features" (Renesse 119). Machine reading is the use of a machine to authenticate the legitimacy of a document. There are two main features of machine reading. The first types are features are known as teller-assisted features, which help inspectors to authenticate documents. The second types are automated features that are used to activate the acceptance of a document. Fluorescence lighting would be an example of the former type of machine reading, and a machine sorting system would be an example of the latter. Automated machine sorting systems have to be very restricted in their discussion. According to Renesse, "often only the currency printer and personnel at the central bank know that a document possesses such a feature" (Renesse 121). As such, the following discussion of machine reading components apply strictly to teller assisted features.

Invisible fluorescent printing is a component of machine reading technology. With invisible fluorescent printing, "an image is printed with an ink that contains a fluorescent pigment that has similar visual optical properties to the ink vehicle…Thus, the image that appears under a UV source is not directly associated with the visible printing" (Renesse 120). The counterfeiter has

no inclination that this image is apparent unless a UV source of lighting is used to illustrate the image. Hence, the invisible printings provide an enhanced level of security.

The American one dollar bill uses a different type of teller-assisted feature that involves magnetic detection. The dollar bill uses a magnetic pigment, which is mixed with the black ink on the front of the document (Renesse). Handheld devices are used to, “detect the magnetic field when rubbed over the surface of the document” (Renesse 120). This type of teller-assisted feature is known as magnetic detection and has been, “extended into numbers, signatures, and the intaglio of other countries banknotes” (Renesse 120). The drawbacks with this are that darker hues are more effective for magnetic detection, thus making it difficult to use in conjunction with lighter hues. For example, “magnetic pigments are dark in nature and hence a good signal cannot be achieved from say, a bright red ink” (Renesse 121). As demonstrated, magnetic ink can be a very effective security measure against counterfeiters, despite minor limitations with versatility.

DURABILITY

Durability is relevant to every type of security document. When making a security document such as a banknote, there should always be thought as to how this document will be handled during its lifetime. For example, “the handling environment of a security document plays a large part in determining what security features can be incorporated and what type of crime it is exposed to” (Renesse 121). Banknotes are a unique type of document because they are first supplied by a central bank and then circulated through the economic waves of society. For example,

> There is no specific environment that the banknote must be contained within. Hence cultural and social climate dictates whether the document is in a wallet, bill-fold, pocket, or just held next to the skin. Exposure to hazards is high as the document is handled under all conditions, from banks, offices, ships, markets, and bars. Under these conditions, it must represent its value and not change color or nature (Renesse 122).

The author of *Optical Document Security*, Rudolf L. van Renesse, illustrates banknotes are a unique document because of the highly complex handling they encounter on a daily basis. Extreme handling can diminish the strength of the note and make it unusable in a relatively short period of time. Hence, some countries use polymer notes, which provide a stronger substrate for their banknotes. Over time, banknote security features may diminish so that they are no longer detectable. For example, a banknote may be exposed to certain chemicals that wash away its fluorescent threads, which cause it to appear illegitimate. Banknotes must be durable to ensure that the security devices used in their production last for the entire life of the banknote.

FORGERY PROTECTION

Counterfeiting is a way of copying documents to make a fake look as genuine as possible. This should not be confused with forgery, which is making alterations to a genuine document. Forgery is a tricky problem because it deals with an authentic document in which the security features are still present. For example, “successful alteration of a document leaves the bulk of the genuine authenticity features unaltered and facilitates acceptance of the document by authorities”

(Renesse 123).

Sometimes, a forgery attempt will include using bleach or other solvents to try to remove ink. A security component to deter this activity is the addition of fugitive inks. Fugitive inks are, "special inks that are formulated in vehicle systems that allow sufficient drying to provide a document that can be handled yet will react when attacked with either aqueous or organic solvents. Often the ink color disappears when the bleach or oxidative type ink eradicators are used" (Renesse 124). The use of fugitive inks are a great protection against forgery because they remove the original printing pattern and make it hard to reproduce precisely again.

DESIGN EFFECTS

It is critical for a secure document to be both aesthetically pleasing and well designed. This way, people will be more likely to treat it as a secure document. For example, "Aesthetics can greatly increase users' awareness of a genuine document and reveal departures of style caused by counterfeits" (Renesse 125) Security designers must combine fine artists with the skills of a forensic scientist (Renesse 125). If security designers do not make this combination of design skills and science skills then they will be significantly less secure against counterfeiters and forgers.

An effective design for a secure banknote will give the impression of authority and security from the country they represent. On the contrary, "If a banknote gives the impression that it is a bus ticket, it will be treated as such" (Renesse 126). It is critical to understand that banknotes are an important representation of a country. Many times, a banknote is the first document that a

foreign traveler will see when visiting a different country and thus will be the first impression of a countries stature. For instance, “by their nature, security documents [including banknotes] often reflect the stature and culture of a nation” (Renesee 126).

There are many techniques used in the security printing of banknotes. Furthermore, in each technique there is usually more than one related component, which further enhances the security of the banknote. With so many techniques available for banknote printing alone, it can be difficult to determine which ones should be incorporated. In general, the more security features a document has the harder it is to counterfeit or forge. Thus, a great number of security features are present in the banknotes that are used today. When a person handles a banknote, often times they do not realize the vast amount of technology and security features that are present in the palm of their hand. It is simple to take these features for granted but one should remember the reason for this heightened level of security: “One of the most frequently used currencies is also the most counterfeited one—the U.S. dollar. No other currency is involved in as many seized counterfeits world wide” (Renesse 1).

III - Research Methods

The evolution of security printing techniques has been effective in making it nearly impossible for the counterfeit production of banknotes. However, counterfeiters are also evolving to a more sophisticated level. Consider the recent activity of *state sponsored counterfeiters*, where a government with capital and resources funds the practice of counterfeiting. This is what happened in North Korea, where simulated $100 U.S. banknotes were printed by a government agency using the same cotton fiber substrate and intaglio presses that the United States Bureau of Printing and Engraving uses (Modern Marvels). These $100 banknotes are termed “supernotes” and are very high quality counterfeit documents. Alarmingly, they appear nearly identical to a genuine U.S. $100 banknote.

When nations begin to counterfeit another nations currency, they are severely crossing ethical boundaries and acting from an absence of morality. Currency is a symbol of sovereignty, discipline, and represents a country in a number of significant ways such as gross domestic product, economic condition, and overall success of the citizens. State sponsored counterfeiting is an infringement upon these principles and a demoralizing act to the citizens of the United States of America. The more protection in currency the more a government can maintain the integrity of their nation. As a component of this protection, security printing techniques must properly be used to deter counterfeiting at all levels. Research methods in banknote security printing techniques are relevant to discovering which techniques are most effective against counterfeit banknotes and ultimately protecting the currency of the United States of America.

In order to conduct an effective research assessment, a formalized research method must be used. There are several formalized research methods that are considered acceptable to use for formal research. However, this research assessment on banknote security printing techniques used elite and specialized interviewing and content analysis. These formalized research methods are the best suited for a study on banknote security printing techniques because they penetrate the most important and knowledgeable people involved in banknote printing. Banknote printing demands change in security techniques to maintain the security of the document over time. This change is best described by experts in the industry and is the reason elite and specialized interviewing is used in this study. Elite and specialized interviewing, along with content analysis provided the most current type of research from industry experts.

ELITE AND SPECIALIZED INTERVIEWING

Elite and specialized interviewing is research applied outside of the scientific realm. It is simply interviewing successful professionals and executives. This is different from standard questionnaires and interviewing because it, "involves a more complex situation because such individuals often see themselves as experts and important people, and are resistant and sometime impatient with standard questionnaires" (Levenson 22). Nonetheless, elite and specialized interviewing can provide valuable information as well as a rewarding experience. In this study, elite and specialized interviewing focused on the current elite stakeholders involved in banknote printing.

Manubu Yamakoshi (Japanese Government), Larry Felix (Director of Bureau of Engraving and Printing) and Catherine Yates (United States Government Printing Office) were interviewed.

Since these individuals have different backgrounds, the general questions asked depended on the individual. However, the main idea was to try to answer three focus questions. The first is, what are the most effective security printing techniques for banknotes today? The second is, what type of security techniques continue to be used as new techniques are being introduced? The third is, how does your experience in security printing relate to the security printing techniques used for banknotes? These are not the specific questions asked, but will served as a guide to the conversation as elite and specialized interviewing should not be a structured interview with a list of questions, but rather a constructive conversation.

Manabu Yamakoshi is an employee of the National Printing Bureau of Japan. He is conducting research at California Polytechnic State University, San Luis Obispo located in California. Mr. Yamakoshi is a valuable source of information on banknotes (yen) that are printed in Japan. Furthermore, his experience with security printing techniques provided information about banknotes in Japan as well as an opportunity to compare the two types of currency.

Larry Felix is the Director of the United States Bureau of Engraving and Printing. He has appeared in many publications including, *Money*, a Modern Marvels documentary about the money making process in America. His leadership involvement and experience with the United States Bureau of Engraving and Printing made him an ideal candidate to interview.

Catherine Yates is a California Polytechnic State University alumnus and currently is the technology program manager at the U.S. Government Printing Office. She provided information

about banknotes as well as other security printing techniques that may influence American banknotes in the future.

CONTENT ANALYSIS

Content analysis is a research technique that aims to quantify qualitative information, which is usually gathered from elite and specialized interviewing and descriptive research. Content analysis is, “often used in combination with other research methods in developing results and drawing conclusions.” (Levenson 27) The final component of research will be content analysis, which will analyze the data from elite and specialized interviewing. A thorough content analysis depends on four components of analysis. These components include objective, systematic, quantitative, and manifest.

Objective refers to having, “different people analyze the same content and get the same results.” (Levenson 27) This is important in this study because most of the research is based on categories such as security substrates, security inks, intaglio, lithography, letterpress, microprinting, machine reading, durability, forgery protection and design effects that are involved with banknote printing.

Systematic means, “that the selection of content to analyze information must be based on a formal, predetermined, unbiased plan.” (Levenson 27) For example, some of the research cannot be favored because it fits the hypothesis. Instead, all of the research must be analyzed equally. Elite and specialized interviewing are two distinct forms of research and must be examined equally and thoroughly for a proper content analysis.

Quantitative means that, “the results of the analysis are usually expressed numerically in some way.” (Levenson 27) In this study, the research will be quantified and put into a tabulation list which will numerically illustrate which banknote security printing technique is considered the most effective based on the research.

Manifest means, “the systematic analysis involved in content analysis is ordinarily of a fairly direct and simple kind” (Levenson 27). This refers to the language of how the research is conducted. For example, often times slang and jargon is used in an industry such as the printing industry. A proper content analysis will interpret these jargon terms literally and determine if each person interviewed is using their preferred form of jargon.

Elite and specialized interviewing provided significant data about banknotes. The data were organized through the use of categories, which represented all of the themes or topics that were discussed. All of these themes were counted and documented in a content analysis tabulation list. The list is organized so that the theme or topic of discussion is on the left of the paper, and to the right of each theme or topic is the number of times each theme or topic was referred to. After the content analysis tabulation list was compiled, content analysis clusters were developed. Content analysis clusters are based on the frequency of each theme or topic discussed. The first cluster is high focused and contains the theme or topics that were referred to the most. The second content cluster is intermediate focus and contains all the themes or topics that were referred to with an intermediate focus. The third cluster is low focus and contains all the themes or topics that were referred to the least. From these clusters conclusions were reached that reflects the highest,

intermediate and least effective security features for banknotes. The most frequently mentioned categories from elite and specialized interviewing provided the best explanation as the most effective security printing techniques for printing banknotes.

IV – Results

The interview with Manabu Yamakoshi was an insightful experience. Mr. Yamakoshi was able to articulate his knowledge of security printing of banknotes and provide valuable information for this study. In addition, the interview carried a multicultural tone, as Mr. Yamakoshi was able to elaborate and draw comparisons on Japanese and US banknotes.

The first question of the interview was about Mr. Yamakoshi's reasons for conducting research in the United States. He responded by stating he is here researching the topic of artifact metrics. Artifact metrics is the study of authenticating for artifacts in documents using their intrinsic characteristics. It could very well be the future of security printing for banknotes and other important documents.

When asked what are the most effective techniques for banknote security printing, Mr. Yamakoshi responded clearly and effectively. He said there are three main criteria for security printing of banknotes. The first is the use of a watermark, either a multi-tone or a basic watermark, the distinction not as significant as the presence of the watermark itself. The second is the tilting effects banknotes offer, such as optical variable ink and holograms. Specifically referring to optical variable ink (OVI) for US banknotes and holograms for Japanese banknotes. The third is the texture or touch of a banknote, which is a product of a specialized substrate and intaglio printing process.

In his concluding remarks, Mr. Yamakoshi said that security printing for banknotes must consider basic human functioning when designing and developing banknotes. Again he referred

to the three criteria for banknotes and concluded with the reasons they are the most effective. These three criteria are the most effective techniques to prevent counterfeit because they are the easiest to detect and require no machine reading or light source to authenticate.

The interview with Larry Felix was a learning opportunity from the first word. His eloquence and erudite manner made for a very effective interview. The first question of the interview was about Mr. Felix's opinion to state sponsored counterfeit, which is a critical opponent to Mr. Felix's organization. Mr. Felix did acknowledge that supernotes are a problem and a threat to the US economy, he touched on the realities of counterfeit today. He said, "The reality is you can never eliminate [counterfeit], it is a fundamental basis of our society." With this said, Mr. Felix then continued to talk about some prevention strategies.

This interview was unique because Mr. Felix brought forth a broad spectrum of prevention ideas. He started with focusing prevention on getting over certain hurdles, such as narrowing the focus of counterfeit prevention, law enforcement, and controlling factors higher up the supply chain. When asked what are the most effective techniques for banknote security printing, Mr. Felix responded broadly by stating it is a combination of elegant design, effective public education, and effective law enforcement used together that really make an effective banknote security device. Furthermore, from a printing perspective, he described the use of layers of overt and covert features, such as various line layers, different colors, fabrics, security threads, and microprinting. He summed up this question nicely by saying there is a family of interdependent and dependent factors that must work together to effectively prevent counterfeit.

In, addition Mr. Felix stated an interesting comparison between supernotes and credit card transactional fraud. It turns out that supernotes are a loss of about 30 million dollars, while credit card transactional fraud is over 100 billion dollars. Nonetheless, it is still a top priority for Mr. Felix's organization to protect the American dollar. Put simply, "We [Bureau of Engraving and Printing] spend more money to maintain the integrity of the United States dollar than the actual loss of the counterfeit itself." This explains that the United States is concerned with state sponsored counterfeit not only for the monetary losses it creates, but more significantly for the negative image it places on United States currency. Mr. Felix explained that this is an issue of image because if the American people believe that counterfeit is taking place without any government effort to stop it, the dollar will lose its value drastically.

The interview with Catherine Yates was a great experience. The first question of the interview was about what Ms. Yates does for the Government Printing Office. Her position as the technology program manager makes her responsible for security documents such as passports. Still, Ms. Yates' occupation with the GPO allowed her to provide general information about security printing of banknotes.

When asked what are the most effective techniques for banknote security printing, Ms. Yates responded by saying that document security is measured by three levels. Level one include the overt features, such as optical variable ink and watermarks. Level two include the covert features and require tools like a microscope to authenticate. Level three include the most complex, such as markers in a printing ink and must be authenticated by forensic agencies like the secret service. Banknotes incorporate all three levels in order to use the most effective security features.

Furthermore, Ms. Yates was stern in stating that banknote security rests heavily upon layering overt and covert features.

In addition, Ms. Yates also stated that the intaglio printing process is a crucial element in banknote security. This is due to the raised ink surface that intaglio leaves on the substrate as well as the elegant design that is used for banknotes. This surface provides for a unique texture to the banknote that is very difficult to reproduce.

Results: Content Analysis Tabulation List

The following is a tabulation list that contains all of the banknote related themes or topics that were discussed during the interviews. The list is organized so that the theme or topic of discussion is on the left of the paper, and to the right of each theme or topic is the number of times each theme or topic about banknote security printing was referred to. This list is significant in determining content analysis clusters, which are based on the number of times each theme or topic was referred to.

Combination of techniques Layers of different colors, fabric, threads, etc Overt and covert features used together	9
Watermark	4
Tilting effects Optical variable ink Holograms for Japanese Banknotes	5
Touch and feel The tactile feel of ink on banknotes due to the nature of intaglio printing	5
Prevent counterfeit at higher up the supply chain	1
Narrow Focus Specify what kind of counterfeit to be targeted and prevented against	1
Law Enforcement	1
Elegant Design	3
Effective Public Education	2
Microprinting	3

Results: Content Analysis Clusters

The following are content analysis clusters derived from the tabulation list. The first cluster is high focused and contains the theme or topic that were referred to the most. The second content cluster is intermediate focus and contains all the themes or topics that were referred to with an intermediate focus. The third cluster is low focus and contains all the themes or topics that were referred to the least.

Cluster 1 – High Focus

Combination of techniques
Layers of different colors, fabric, threads, etc
Overt and covert features used together

Cluster 2 – Intermediate focus

Tilting Effects
Optical variable ink
Holograms for Japanese Banknotes

Touch feel
The tactile feel of ink on banknotes due to the nature of intaglio printing

Watermark

Elegant Design

Microprinting

Cluster 3 – Low focus

Effective public education

Law enforcement

Prevent counterfeit at higher up the supply chain

Narrow focus

V – Conclusions

The results of the study indicate that the most effective security printing for banknotes are the use of a combination of techniques. This involves using layers of different colors, fabrics, and security threads. Also, the use of interlaced overt and covert features that work together as an effective security feature. An example would include not only the use of a watermark but also the use of ultraviolet threads, which are layered over the area of the substrate that the watermark is located. This is a clear example of an overt security feature used in conjunction with a covert feature to provide the most effective security printing for banknotes.

Of a lesser importance are the intermediate security features that contribute to security. These include the use of optical variable inks, which have tilting effects and holograms used in Japanese banknotes and also an elegant banknote design. Other features in this category include the tactile feel of the banknote substrate, which is unique due to the intaglio printing process and the use of a watermark. It is true that these features are significant in producing effective security techniques for banknotes, however they are not good enough deterrents of counterfeit when used alone. It is absolutely critical that they are used in banknotes but also that they are dependent on each other's presence for maximum effectiveness.

According to the results, the least important features for the security of banknotes have a broad focus. These features include, effective public education, law enforcement, prevent counterfeit higher up the supply chain, and to narrow the focus of counterfeit prevention. Theoretically,

these features are critically important because they are relevant to a functioning society. For example, an effective public educational system will set most people up for success and give them the tools they need to succeed. However, there will always be an unfortunate number of people who do not succeed. It is these individuals that may resort to counterfeiting currency to make ends meet. These security features are generic in that they can apply to many different aspects of life, not just for banknotes specifically. Therefore, they are of the least importance to the banknote document itself. Nonetheless, they are still important considerations to consider for the effective security of banknotes in general.

Of all the security printing techniques used for banknotes it is logical to assume that the more techniques used in a document, the more secure it will be. This is reaffirmed by the results of this study. However, the bigger issue with counterfeit prevention is not about how many features a document has but instead in the minds of the people. As Larry Felix stated in his interview, "The reality is you can never eliminate [counterfeit], it is a fundamental basis of our society." To refute this quote, our society will have to refocus our counterfeit prevention efforts into a broader spectrum; namely by improving society so more people are set up for success.

Bibliography

"Banknotes." *Noteprinting.com*. Note Printing Australia. n.d. Web. 10 Oct. 2009.

"Paper Currency." *Madehow.com.* Advameg, Inc. 2009. Web. 10 Oct. 2009.

Renesse, Rudolf L. van. *Optical Document Security*. Massachusetts: Artech House, INC., 1994. Print.

"The World Standard in Security." *Noteprinting.com*. Note Printing Australia. n.d. Web. 10 Oct. 2009.

Warner, Richard D., and Richard M. Adams II. *Introduction to Security Printing*. Pennsylvania: PIA/GATF*Press,* 2005. Print.