Human factors of first line security

Rudolf L. van Renesse

Conference on Optical Security and
Counterfeit Deterrence Techniques II
San Jose, California, 28 – 30 January 1998
Vol. 3314, pp. 97 – 108

VanRenesse Consulting
Willem de Zwijgerlaan 5
2582 ED The Hague
The Netherlands

Phone +31 70 3540 333
Email ruud_van_renesse@zonnet.nl

Human factors of first line security

Rudolf L. van Renesse

ABSTRACT

Human inspection of security features is based on a cycle of actions: the development and execution of a strategy, and the observation and evaluation of results. These actions aim at establishing the state of the object: genuine or fake. These actions require knowledge, which is either in the head (memorized) or in the world (provided by the object). It is argued that knowledge in the world is most suitable for adequate inspection of first line security features. In contrast, knowledge in the head cannot be relied on, unless standardization is consistently implemented.

From the action cycle five pertinent questions ensue. How easily can the user: (1) determine and understand the function of the device? (2) tell what actions are possible? (3) execute the actions? (4) observe the results? (5) compare the observed results with the expected results? A set of generic design rules is derived, involving the function of the device, the execution of a strategy, and the evaluation of the result.

A number of first line security features is evaluated from this human factors point of view. These comprise substrate embedded features (watermark, windowed thread), features added to the ink (iridescent pigment), printed features (intaglio, small lettering, see-through devices, latent images), and post-printed features (iridescent foils). It is concluded that many current security features do not meet basic ergonomic design rules. However, iridescent optically variable devices tend to have a potential to meet these requirements.

Keywords: document security, first line inspection, public security devices, human factors design, ergonomics.

1. INTRODUCTION

First line inspection of security devices involves the use of the human senses only, without the application of tools like magnifiers, ultraviolet sources, retro viewers, bar code readers, etc. Public security features are of this type. The security device can be considered as a black box that must be operated by a human inspector. As is shown by figure 1, an operand (matter, energy, information) can be transformed from the existing state into the desired state, with the use of this black box.[1,2]

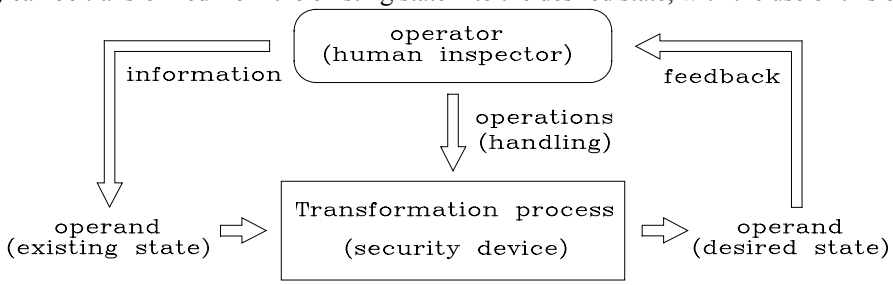


Figure 1 - Functional black box model of the inspection of a security device.

Further author information:
VanRenesse Consulting, Willem de Zwijgerlaan 5, 2582 ED, The Hague, The Netherlands
Telephone: +31 70 3540 333: ruud_van_renesse@zonnet.nl

In this case the operation of the black box by the operator allows transforming knowledge (information) about the required action and its expected effect into (feedback) knowledge about the state of the black box: genuine or counterfeit, respective by the acts of verifying (to prove to be genuine) and falsifying (to prove to be false).[3]
Obviously both verifying and falsifying require an interaction between the operator and the security device that presupposes knowledge or information. Industrial designer Donald Norman points out that this knowledge can either be "in the head" of the operator or "in the world".[4] The first type of information is known *à priori* by the operator, the second type of information is provided by the security feature, without the need of prior knowledge by the operator. Knowledge that is in the head, has been conveyed by various forms of communication, either verbal or written, and is subsequently memorized. In general, the user of security products is almost entirely dependent on knowledge in the head for adequate inspection, because the required information appears not to be provided by the security device itself. Issuers of security documents such as bank notes and cheques, attempt to educate the user about the existing security measures and the way to verify or falsify them. To this end, detailed brochures and posters are issued and even TV spots are broadcasted. Note that brochures and manuals do not bring information in the world, they aim at bringing it in the head. This approach has appeared relatively unsuccessful: the users remain largely unaware of the information they are supposed to store in their heads. This may be due to the enormous variety of valuable documents and the security devices incorporated, as well as the almost complete lack of standardization, within as well as without categories of valuable documents. The task of the user to memorize the required bulk of information appears impracticable.
It may be illuminating to refer to a 1992 investigation of the National Bank of The Netherlands[5] which revealed that, out of the four public security features on Dutch bank notes (watermark, intaglio tactility, see-throughs and small lettering), the public was only aware of an average of 1.5 (1.0 in 1980 and 1.7 in 1997). Needless to say that further knowledge about how to discriminate between genuine and simulation appeared virtually absent.
Summarizing, the problem seems not so much how to produce superb security devices, that can be hardly, if at all, counterfeited. The problem rather is, how security devices can be produced that combine easy inspection with high confidence in their genuineness.

2. HUMAN FACTORS

In order to further elaborate the interaction between the examiner (subject) and the security device (object), we refer to the *action cycle* in figure 2, which is derived of Donald Norman's work.[4] This action cycle compares with the black box model in figure 1. The action cycle comprises two stages: (1) the development and execution of a strategy (input), and (2) the observation and evaluation of the result (output).

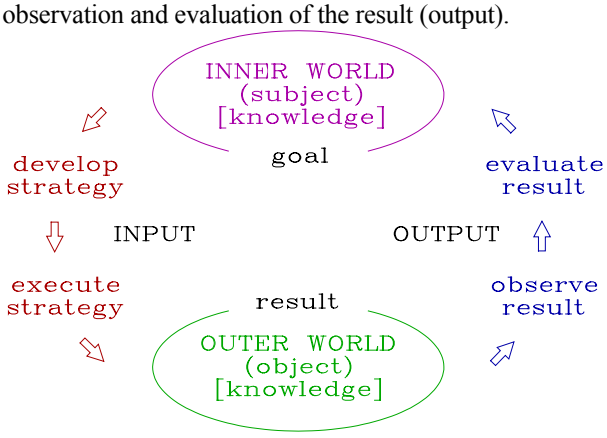
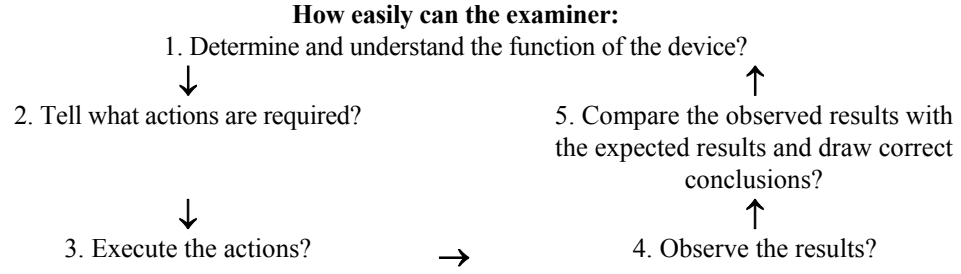


Figure 2 - The interaction between subject and object.

This action cycle is associated with the general theory of industrial product design, and it is extremely relevant as a guide for security designs. In operating a security device the examiner will develop and execute a strategy in order to adequately put the device to use. Subsequently, the result of this action will be evaluated on the basis of what is observed and a conclusion may be drawn with respect to the status of the device. In order to properly operate the security device, the user must have adequate knowledge (information) about the way it functions or else make either errors in operating it or in judgement. Insufficient information may result in cycling through the action cycle several times, possibly without conclusive result. In the worst case of ignorance, the particular security function will not be operated at all. Apparently, the required knowledge is essentially twofold: (1) knowledge about the required action (input) and (2) knowledge about the expected result of that action (output). This twofold information may be either in the world, that is, provided by the product itself (not by a manual or a brochure!), or it may be in the user's head. The latter location, expectedly, is not a probable one.

The structure of the action cycle raises five fundamental questions about the functionality of security devices from a viewpoint of human factors design (ergonomics):[1,6,7]



Based on these fundamental questions and the earlier work by Moser,[8,9] guidelines were formulated, that consider the human factors for the design of security features:[1]

Function

- The security feature must convey a message relevant to the product.
  The feature must obviously belong where it is and relate to the product. On related products, the security features must also mutually relate.
  Security features should preferably be located in standard positions on the product, positions that are exclusively reserved for security features on all products of the line.
- The function of the feature must be obvious and intelligible.
  A feature that remains a riddle for the user does not function. It must be obvious what the device is meant for apart from embellishing the product.
- The functions must be standardized.
  The function of security designs that are very diverse and/or periodically change layout will not likely become understood.

Execution

- It must be evident what too look for and how to inspect it, preferably without a preceding verbal or written communication.
  The information on the "what" and "how" of the feature should preferably be in the world.
- If not in the world, the "what" and "how" of executing the inspection must be easy to communicate and easy to memorize. Standardization is an effective means to this end.
- It should be possible to carry out the inspection in a casual and unobtrusive manner.
  Even a slightly complicated inspection will be considered annoying. The obviousness of the act may further be considered embarrassing and offensive. For these reasons, the inspection will not likely be carried out.

Evaluation

- The effects to be observed must be self-evident; the information will preferably be in the world.
- If not in the world, the information on the effects to be observed must be easy to communicate and easy to memorize. The description must uniquely and unambiguously relate to the specific effects, while the briefness of the description must not result in vagueness.
- The observed effects must unambiguously relate to the expected effects.
  Indistinct signals will cause uncertainty.
- The security feature must unambiguously relate to the overall design.
  The feature must be "in its place". Inconsistent "add-on's" present inadequate or even confusing information.
- The security features must not have existing competitors, which could serve as successful imitations.

3. APPLICATION TO EXISTING SECURITY FEATURES

It is a revealing exercise to try and formulate answers to the above fundamental questions with respect to a few widely used first line security features: the mould made watermark, the windowed thread, the see-through device, various aspects of intaglio printing, small lettering, and iridescent optically variable devices (OVDs). The resistance of these security features against counterfeit is the subject of a separate paper.[3]
As is generally the case, the examiner will not have the possibility to compare the considered security devices with devices

known as genuine; the inspection considered here is of the absolute type.
It is emphasized that no security design, however adequate from an ergonomic point of view, will fulfil its function if inadequate attention is paid by the examiner. Casual or disinterested handling of bank notes will not reveal counterfeits. The number of counterfeits in circulation is not an adequate measure of the success of a security design. This number also depends on other factors, such the appeal of the currency to counterfeiters and the public education provided.

3.1 The mould made watermark

The cylinder mould watermark is present in almost all bank notes and in many other security documents on a world-wide scale. It is a renowned security feature that has been with us since handmade papers were produced in Italy at the end of the thirteenth century.[10] As a consequence it has become a standard. It is regarded by papermakers as the primary and most secure feature, and one of the main barriers against counterfeiting.[11-14]

1. How easily can the examiner determine and understand the function of the device?
Under normal observation the watermark tends to be largely invisible. The examiner must know it is there, and only knows this because it is standard on many bank notes, mostly in an unprinted area. For the same reason the function of the watermark is well known: verifying or falsifying the document by looking for its presence and various typical characteristics in transmitted light.[3]
2. How easily can the examiner tell what actions are required?
Hold the document against the light and look for the image in transmission. This action is not evident, but because of standardization it is well known by the general public. The position of the watermark is mostly indicated by the unprinted area on the note. Subsequently, check for continuous tone, as well as lighter and darker elements of the image. These characteristics are typical for the mould made watermark, but the public is generally unaware of them (not in the head), and neither is this information provided by the watermark itself (not in the world).
3. How easily can the examiner execute the actions?
From a physical standpoint this action is simple, but it is associated with an important psychological drawback: the *embarrassment factor*.[3] "The general public appears to be reluctant to observe and confront, and hence the chances are good that a bank note will only undergo a cursory inspection at the first encounter".[10]
4. How easily can the examiner observe the results?
The characteristics of the mould made watermark are somewhat complicated, so that their observation requires mindful attention and experience. If well designed, the mould made watermark allows unambiguous observation of its typical characteristics. However, many bank note watermarks do hardly display clear and obvious lighter/darker image elements, and, in that case, this observation can hardly be made.[3] Furthermore, in many cases watermarks display portraits that do not combine these characteristics in an ergonomic manner at all, so that their easy inspection is significantly hampered.
5. How easily can the examiner compare the observed results with the expected results, and draw correct conclusions?
The typical mould made watermark characteristics (expected results) are generally unknown and are neither communicated by the device itself. Therefore, adequate comparison of the observed results with these characteristics is generally infeasible. And, even if the device is well-designed and the examiner is familiar with those characteristics, checking for them entails a certain mindfulness.

Summarizing, the value of the watermark for public inspection exclusively rests on its standardization. Its adequate and easy inspection appears significantly limited by public ignorance, psychological drawbacks and, in many cases, by poor design and implementation. It can, therefore, hardly be maintained that the watermark acts as one of the main barriers against counterfeiting.

3.2 Windowed thread

The windowed security thread is a development of Portals (UK) which is applied to bank notes as a security feature (for instance UK, German, Swiss and Czech notes). It is not a standard security feature. The windowed thread has a metallic reflection and is alternately embedded in the paper mass and visible on its surface (with a cycle of about 10 mm). As a result, and contrary to its predecessor the fully paper embedded security thread, the windowed thread is partly visible under normal observation. In transmission the thread appears as a continuous ribbon. Often, the thread is provided with small lettering, visible in reflection as well as in transmission.

1. How easily can the examiner determine and understand the function of the device?
The windowed thread is a security device that must be inspected in normal observation as well as in transmission. Its first line inspection function involves verifying or falsifying the document by looking for its presence and its various characteristics. These characteristics, as such, are relatively uncomplicated but appear diverse. The complete function of the windowed thread is not obvious, and, since the device is not a standard, its full function will expectedly remain largely unknown. The required information is neither in the head nor in the world.
2. How easily can the examiner tell what actions are required?
The required actions are fourfold. Under normal observation check for an interrupted ribbon with metallic reflection displaying legible small lettering. In transmission check for a continuous ribbon, displaying legible small lettering along the complete length of the ribbon. As the function of the device is not clear in the first place, the examiner cannot tell what characteristics to look for and how to inspect them unless *à priori* knowledge is available.
3. How easily can the examiner execute the actions?
This fourfold action is a complex one. Although normal inspection of metallic reflectivity is fast and uncomplicated, by its nature, reading small lettering and judging its legibility requires mindful attention and acute vision. The execution of this action therefore is somewhat inconvenient and time-consuming. Subsequent inspection in transmission is associated with the embarrassment factor and further efforts in inspecting small lettering.
4. How easily can the examiner observe the results?
Inspection of metallic reflection under normal observation, and of its continuity in transmission is a straightforward, easy action. Judging the sharpness and legibility of small lettering is a more or less subjective activity because the extent of sharpness may vary considerably, while the text remains legible. Adequate inspection of sharpness will be fairly difficult (also see section 3.5 on small lettering).
5. How easily can the examiner compare the observed results with the expected results, and draw correct conclusions?
The metallic reflection and continuity of the thread allow easy comparison with the expected result. As set forth above, it will be relatively difficult to compare the quality of observed lettering with the expected quality of the letters, that has to be recalled from earlier experiences (also see section 3.5 on small lettering).

Summarizing, the windowed thread is not a standard, and its complete function is neither simple nor obvious. Complete inspection, inclusive small lettering, is inconvenient, time consuming and associated with psychological inhibitions.

3.3 The see-through device

Precisely registering the printing on both sides of a document allows crating a *see-through device*. It consists of related image elements on each side of the document. If held against the light, the register of front and back image elements is revealed. The see-through device is implemented on many bank notes and is practically a standard. However, not all bank note printers are equipped to precisely register front and back image of the document.

1. How easily can the examiner determine and understand the function of the device?

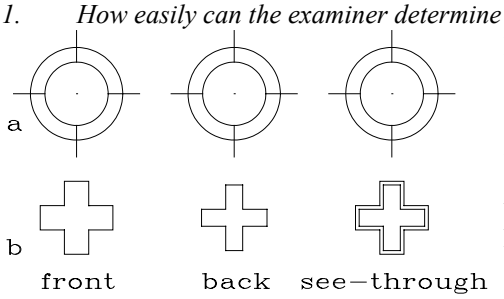


Figure 3 - Inadequate see-through designs.

In reflection only half of the see-through image is visible and this half must convey the function of the device.Front and back elements often consist of complete, abstract geometrical shapes such as circles (figure 3a: old 100 guilder note) or crosses (figure 3b: new Swiss notes). Such complete shapes do not give the examiner the faintest functional clue: verifying or falsifying the document by checking its front-to-back register.[3,15] The examiner must have *à priori* knowledge of its presence, which is generally not the case, although the see-through device is widely used. The required knowledge appears neither in the head nor in the world.

On the new Dutch bank notes the see-through device depicts an obviously incomplete image: only two quadrants (2 and 4) of a well-identifiable, object (a mouse, a tulip, etc.), which, against the light, becomes clearly whole with quadrants 1 and 3 on the back (see illustration in an earlier paper[3]).

This way the knowledge is almost fully placed in the world: the apparent incompleteness of the image invites the user to discover the function of the device without prior knowledge. This quadrant type set-up of the see-through is very well suited for standardization. However, these devices, as such, are neither obvious as a security device, nor is their position on the note obvious. This, though, can be accomplished by positioning standard security features on standard locations, exclusively reserved for security features, on all bank notes. As the public is aware that documents can be inspected against the light for the watermark, an obvious possibility is to combine the see-through with the watermark. This is realized on the new series of Swiss bank notes. It is remarkable, though, that Swiss brochures informing the public about the authenticity tests of their new currency design do neither refer to watermark nor to see-through device. It may be inferred that public inspection in transmission is not considered a viable option by the issuers.

2. How easily can the examiner tell what actions are required?

Hold the document against the light and look for the see-through image in transmission. This action is not evident, but it can be made so by adequate design and standardization. Subsequently, check for front-back register. If the device is well designed, its characteristic front-back register will be obvious.

3. How easily can the examiner execute the actions?

From a physical standpoint the action of inspecting the see-through register against the light is simple, but the embarrassment factor that is associated with this deliberate action forms a certain psychological drawback.

4. How easily can the examiner observe the results?

If well designed, see-throughs allow a fast, easy and unambiguous check of front-back register. It must be noted that simply checking for register tends to be much easier than checking for more complicated characteristics such as that of the watermark and the windowed-thread. Observation of results will be seriously hampered if see-throughs consist of abstract image elements that more or less completely overlap in transmission, so that they do not obviously become a whole. Fully coinciding front and back image elements unduly hamper adequate inspection because they obscure each other (figure 3a).

5. How easily can the examiner compare the observed results with the expected results, and draw correct conclusions?

If the see-through is well-designed, the observed register between front and back image elements can be easily checked for perfectness. Sensing register is not difficult.

Summarizing, the see-through is a valuable security device that potentially allows easy and fast inspection. However, its value for public inspection is yet limited, because it is not standardized and current designs do not adequately convey its function. Furthermore, adequate inspection appears limited by psychological drawbacks.

3.4 Intaglio Printing

The use of intaglio printing is primarily restricted to security printers. Intaglio printing is present on valuable documents on a world-wide scale and, like the watermark, it may be considered a standard security feature. Its characteristics are highly valued by most security printers. The main characteristics of intaglio are the distinct tactility of the printed lines, that stand out in relief on the embossed paper and the crisp appearance of the fine gravure lines.

3.4.1 Intaglio tactility

Apart from other security features, which are inspected with the organ of sight, intaglio printing offers the opportunity of inconspicuously sensing the intaglio relief with the tactile organs. These relief deformations of the paper result from the enormous pressure by which the gravure image is transferred to the paper. Intaglio relief relaxes only slowly with the life span of the note. Otherwise, its first line detection by the public appears not fully reliable.

1. How easily can the examiner determine and understand the function of the device?
The first line inspection function of intaglio involves verifying or falsifying the document by feeling its tactile relief. Although intaglio print is present on almost all bank notes, this function is not obvious and its design is not standardized. Otherwise, the use of intaglio for valued documents appears declining. Consequently, the public is largely unaware of this function. The required knowledge appears neither in the head nor in the world.
On the newer Dutch bank notes intaglio is made very pronounced as an extended matrix of strikingly tactile intaglio elements, present on the left hand side as well as the right hand side of the note. Holding the note between thumbs and index fingers, as is usual, almost unintentionally reveals the presence of the relief. These intaglio elements are differently shaped for each denomination and are explicitly intended for first line intaglio inspection with the fingertip as well as aiding the visually handicapped in denomination recognition. This design exemplifies an admirable endeavor that aims at bringing the information on the function of intaglio in the world as well as making its inspection easier. Also, such patterns can be efficaciously standardized.
2. How easily can the examiner tell what actions are required?
Feel the tactility of the printed design. This requirement is rarely evident, but it can be made so by adequate design (as on the Dutch bank notes) and standardization. Generally, intaglio printing consists of relatively fine lines and its tactility is not easily felt with the fingertip. The relief is best felt (and heard) by lightly scratching the printed line patterns with the fingernail. This inspection method is not at all obvious and, consequently, largely unknown.
3. How easily can the examiner execute the actions?
Holding the note between thumbs and index fingers facilitates sensing the relief in a natural and unobtrusive manner. Well-designed intaglio patterns allow easy and unobtrusive inspection of their tactility with the thumbtip. This is an uncomplicated action. If the paper embossing has taken place with sufficient force, and bank notes are timely withdrawn from circulation, the intaglio print of used bank notes will retain a sufficiently sensible tactility.
4. How easily can the examiner observe the results?
If the intaglio pattern is well designed and located, its tactility can be easily and unobtrusively perceived. However, most bank note designs rather leave it to the examiner to search and find a suitable location for intaglio inspection and do not explicitly facilitate this observation. This hampers easy observation of intaglio tactility considerably.
5. How easily can the examiner compare the observed results with the expected results, and draw correct conclusions?
The tactility of the intaglio pattern varies between notes, depending on their fitness. Therefore, the expected result cannot be the sensation of a certain amount of tactility, but it is the sensation of any tactility at all. This seems not a difficult observation, but it has appeared unreliable in case of untrained inspectors.

Summarizing, intaglio tactility is a valuable security device that can allow easy, fast and unobtrusive inspection, which is not associated with psychological inhibitions. However, its value for public inspection is limited, because most current designs neither adequately convey its function nor is intaglio design standardized for tactile inspection.

3.4.2 Latent image

Several countries, amongst which Austria, Germany and Switzerland, utilize the latent image as a security feature on their bank notes. It is not a standard feature and it seems not likely to become one. The latent image is covert under normal observation and becomes visible under near grazing incidence. Its effect is based on the distinct relief of intaglio printing.[16,17] The observed optical effect is illustrated in an earlier publication.[17]

1. How easily can the examiner determine and understand the function of the device?
The first line inspection function of a latent image involves verifying or falsifying the document by looking, under grazing incidence, for the presence of a light image on a dark background or reverse, depending on the orientation of the document. The observed presence of the latent image offers strong evidence of the presence of intaglio and thus of genuineness.
Because the latent image is invisible under normal observation, it does not give the examiner any clue of its existence, let alone of its function. The examiner must know the device is there and understand its function. This is generally not the case, because it is not a widely used feature. The required knowledge appears neither in the head nor in the world.
2. How easily can the examiner tell what actions are required?
Observe the document under an oblique angle, so that the light source reflects in it and the surface becomes glossy, and look for the appearance of an otherwise invisible image. This action is not evident at all, and it is difficult to imagine a design to which this disadvantage is not adhered. Subsequently, rotate the document in its own plane about an angle of 90 degrees and observe a contrast swap between foreground and background. There is no way the examiner can tell about the necessity of this latter action.
3. How easily can the examiner execute the actions?
Even if having prior knowledge about the presence of the device, observing the gloss of the document under an oblique angle is a demanding action for unexperienced examiners. The action is further hampered if the direction of observation is not along the edges of the note but, for instance, under 45° with the edges, as is the case with German bank notes. Subsequently observing the contrast swap by rotating the document in its own plane under near grazing incidence is time consuming and motorially demanding. Furthermore, this action is so obvious that is strongly associated with the embarrassment factor.
4. How easily can the examiner observe the results?
If the latent image is well designed, its optical effect can be sufficiently obvious. As the effect must be observed under oblique observation, the surface of the document must be sufficiently smooth. Circulated bank notes that have become wrinkled do no longer allow adequate inspection of a latent image.
5. How easily can the examiner compare the observed results with the expected results, and draw correct conclusions?
The latent image presents a simple background-foreground image effect that easily compares with the expected result.

Summarizing, the function of the latent image is not obvious, while its inspection is practically limited to smooth paper surfaces, tends to be motorially laborious, and psychologically inhibited. Moreover, the feature is not a standard. Its adequate and easy inspection is therefore significantly hampered.

3.4.3 Engraved portraits

Of old, engraved portraits, preferably of famous persons, have been applied to bank notes as an anti-counterfeiting feature. The security value of engraved portraits is based on the acknowledged difficulty associated with re-engraving a portrait that exactly looks like the original. This is considered especially difficult, because the human ability to recognize faces is very well developed. Expectedly small deviations in a counterfeit portrait engraving would be relatively obvious, even during casual inspection. This approach has been widely regarded as effectual human factors design and it has resulted in a world-wide application of portraits on bank notes. However, this approach has become increasingly irrelevant since the rise of modern photomechanical and digital reproduction techniques. Currently, counterfeiters rarely make use of the laborious craft of engraving, but rely on offset techniques and the colour copier. With the naked eye, line offset reproductions and colour copies of a gravure can be hardly distinguished from the original even if carefully inspected. The security value of engraved portraits seems long vanished, and what remains is a tradition that is carefully maintained although the ergonomic rationale for it does no longer exist. No investigations or publications appear to be available that provide convincing substantiation for the use of engraved portraits as a security feature. The National Bank of the Netherlands appears to have recognized this state of affairs and currently issues currency of extremely high quality without making use of portraits.

3.5 Small lettering

Small lettering, having a height between about 0.5 mm and 0.8 mm, is present on many bank notes but it cannot be considered a standard. In the Netherlands it is an official public security feature (down to 0.3 mm), although it is not found in a standard location. Under normal observation and lighting small lettering is legible for most people without the use of a magnifier. Lettering having a height between 0.15 and 0.5 mm is generally called microtext or microprinting: a second line feature requiring a magnifier. Otherwise, lettering of 0.5 mm and larger has little security value.

1. How easily can the examiner determine and understand the function of the device?
The first line inspection function of small lettering consists of verifying or falsifying the document by checking its legibility. By its nature, small lettering tends to be unobtrusive in the design and, consequently, the examiner is usually unaware of it. Otherwise, because it is not in a standard place, the non-expert will not know where to look for it. The required knowledge appears neither in the head nor in the world.
Once the small lettering is located in an obvious and standard place, and covers a significant area, its function may be readily determined and understood. The content of the device itself could convey the necessary information.
2. How easily can the examiner tell what actions are required?
Find an area with small lettering. This requirement is not evident, but it can be made so by adequate design and standardization. Subsequently, read the text and confirm if it is legible and sharp. The device itself may convey this information, but, otherwise, for a literate person this action will be obvious. Once the text is observed, an attempt will be almost automatically undertaken to read it.
3. How easily can the examiner execute the actions?
Once well designed and its location standardized, an area with small lettering can be easily found in normal observation. By its nature, reading small lettering and judging its legibility requires mindful attention and sharp vision. The execution of this action therefore is somewhat inconvenient and time-consuming.
4. How easily can the examiner observe the results?
Judging the sharpness and legibility of small lettering is a more or less subjective activity because the extent of sharpness may vary widely. Letters are not either sharp or unsharp and even relatively unsharp lettering may still be legible. This action is unlike that of establishing front-back register, which appears either present or not. Furthermore, the sharpness of small lettering is at the edge of human visual resolution, so that its observation is demanding. As a consequence, observation of the results will be fairly difficult.
5. How easily can the examiner compare the observed results with the expected results, and draw correct conclusions?
Observing the sharpness of the lettering on itself is already somewhat difficult and, therefore, it will be even more difficult to compare this result with the expected sharpness, that has to be recalled from earlier experiences.

Summarizing, the function of small lettering is not obvious and largely unknown. The feature is not standardized and current designs do not adequately convey its function. Furthermore, its inspection is more or less inconvenient, while demanding attention and acute vision.

3.6 Iridescent optically variable devices

Iridescent optically variable devices (OVDs) are either of the diffractive type or of the interference type. The diffractive type is currently coined as *diffractive optically variable image device* (DOVID), while the interference type is conveniently referred to as *interference security image structure* (ISIS).
OVDs are novel developments that are increasingly applied as security features on bank notes and other valuable documents. Examples of DOVIDs are numerous and include the hologram (e.g. American Bank Note Holographics and De la Rue Holographics), the kinegram (Landis & Gyr, Switzerland),[8,19] the exelgram (CSIRO, Australia), the dot-matrix device (e.g. Applied Holographics, UK), and the movigram (Hologram Industries, France).[19] Examples of ISISs are thin film features, such as applied on Canadian bank notes and the British Columbia drivers licence (Identicard, Canada)[18,19] and optically variable ink (OVI from SICPA, Switzerland).

3.6.1 Optically Variable Ink

OVI is an iridescent printing ink based on an interference pigment.[18,19] OVI printing changes colour with angle of observation. It is increasingly used as a security feature on bank notes, but it remains to be seen if it will become a standard in due course.

1. How easily can the examiner determine and understand the function of the device?
The first line inspection function of OVI consists of verifying or falsifying the document by checking for a specific colour change with angle of observation. Under circumstances, the uncommon colour change can be rather obvious and remarkable: the OVI print must cover a sufficient area, stand out in the design and the colour change must be considerable. Colour changes from warm to cool colours, such as a gold to green shift or from one colour into its complementary colour, such as a green to magenta shift are quite favourable. Under these conditions, the optically variable effect tends to serve as 'knowledge in the world' and the function of the OVI feature is easily grasped.
Contrary to the above conditions, we sometimes see OVI used under less favourable circumstances: colour changes are too subtle or the optically variable effect is virtually concealed by background printing. A green-to-black shift, for instance, seems relatively inconspicuous and may be confused with a simulation by a green metallic ink that does not display a colour shift. And, for example, a blue background for a green-to-blue shift will tend to mask the iridescent effect and may be well imitated with a green pearl lustre ink. Under these circumstances the function of OVI may well remain veiled and its use pointless.
2. How easily can the examiner tell what actions are required?
Look for a distinct colour change with angle of observation. A change in angle of observation almost automatically results from the usual handling of the document. As a consequence, if the OVI element is well designed, the iridescent effect tends to be more or less self-evident.
3. How easily can the examiner execute the actions?
The effect is simply observed in reflected light and handling the document while tilting it is a natural act. Therefore, the action seems not associated with significant psychological inhibitions.
4. How easily can the examiner observe the results?
If the OVI printing is well designed and implemented, the changing interference colours attract attention and can be easily observed.
5. How easily can the examiner compare the observed results with the expected results, and draw correct conclusions?
If OVI printing is well designed and implemented, its colour change is so unique and unambiguous, that little doubt can exist with respect to what should exactly be seen.

Summarizing, OVI potentially renders a fairly obvious optical effect that allows easy, fast and unambiguous inspection. Its function can be evident and its inspection is not associated with psychological inhibitions.

3.6.2 Post-printing iridescent OVDs

Post-printed, iridescent OVDs are either pressure-sensitive or hot-stamped DOVIDs and ISISs that are adhered to the document after the printing process. As the optical effects of OVDs are very diverse, their ergonomic aspects can only be discussed in the broadest sense, based on the assumption that ergonomic designs are optimally realized. However, taking many current OVD-designs into consideration, it appears that the latter assumption is not always justified.[1,6,7]

1. How easily can the examiner determine and understand the function of the device?
The optical effects of OVDs can be simple and obvious. Consequently, OVDs potentially allow placing the required knowledge in the world so that their function can be grasped, virtually without foreknowledge.[1]
2. How easily can the examiner tell what actions are required?
As their optical effects unfold by observing OVDs under different angles, the required actions are almost automatically performed by common handling of the documents. Consequently, the required tilt actions can be more or less self-evident.

3. How easily can the examiner execute the actions?
The effect is simply observed in reflected light under normal handling of the document. The action is not associated with the embarrassment factor. Handling the document while tilting it is a natural act, not an obviously deliberate act.
4. How easily can the examiner observe the results?
The changes of image and colour attract attention and can be easily observed.
5. How easily can the examiner compare the observed results with the expected results, and draw correct conclusions?
Changes of colour and image in OVDs can be unique and unambiguous to the extent that no misunderstanding will arise with respect to what should be observed.

Summarizing, the optical effects of OVDs potentially allow easy and unobtrusive inspection. Their function may become obvious by merely tilting the document, which can be done during common handling.

4. DISCUSSION

The ergonomic approach presented in this paper is based on acknowledged rules of industrial design. This approach can be extended to all possible first line features and even to those second line features that require human inspection. It is conceivable that the views, presented above, on specific security features will not be (fully) accepted by all readers. It is, therefore, left to the reader to correct the above, to improve on it and to supplement it. However, in the opinion of this author, the five basic questions about the functionality of security devices and the ensuing guidelines point in the right direction.
Anyhow, it becomes obvious that many of the security features discussed do not nearly meet the fundamental requirements of first line inspection as outlined in this article. This may, but does not necessarily, imply that these features are inferior, it may also be that they are sub-optimally implemented or require unusual handling.
The inherently difficult requirement that a security feature must fulfil, is to make its function obvious and intelligible. It is not always possible to have this indispensable information in the world, and it is therefore paramount to introduce standardization, preferably on an international scale.
It appears that iridescent optically variable devices (OVDs) have a great potential to optimally meet the requirements as laid down in the guidelines of section 2. OVDs derive this potential of the prominent and well definable optical effects they can display. These effects are easily brought about during common handling of the document, so that their function tends to be self-evident. As the optical effects can be well definable and self-evident, the observed results can finally be unambiguously compared with the expected results.
Everybody in the possession of a driving licence understands the basic functions of any car and can operate it without a problem. This is because these basic functions are standardized on a worldwide scale. In contrast, although practically everybody handles bank notes on a daily base, many are not aware of the few basic security features present on their currency, let alone their total ignorance if foreign currency comes into play. The main reasons for this ignorance are (1) the lack of ergonomic design, and (2) the lack of standardization, even within denominations of one single country.
If nobody wants an article of use which is difficult to handle, or which function cannot be simply grasped or remembered, why should we have currency with such attributes? After all, although most people appear unable to easily observe the difference between counterfeit and genuine, they are not compensated by the central banks for the counterfeits that they end up with. It seems demanded that currency becomes equipped with the necessary standard functions that allow people, on a global scale, to ergonomically and with certainty determine its status.

5. REFERENCES

1. Renesse, Rudolf L. van, Security design of valuable documents and products, *Optical Document Security*, 2nd. edition, chapter 2, Publ. Artech House, London/New York (1998).
2. Hubka, V. and Eder, W.E., *Theory of technical systems; a total concept theory for engineering design*, Springer, Berlin (1988).
3. Renesse, Rudolf L. van, Verifying and falsifying bank notes, *Proc. of the Conference on Optical Security and Counterfeit deterrence II*, San José, 29-30 January 1998, SPIE Volume 3314, paper 08.
4. Norman, Donald A., The psychology of everyday things, *Basic Books*, New York (1988).
5. Hey, H.A.M. de, and Koeze, P., Is het geeltje succesvol? - Marktonderzoek bij de Nederlandse Bank, *Tijdschrift voor Marketing*, vol. 26, no. 3, March 1992, p. 6-13 (in Dutch).
6. Renesse, R.L. van, Security design of valuable documents and products, *Proc. Int. Conf. of Security Printers*, Seville (Spain), 15-17 May 1997.
7. Renesse, R.L. van, Security design of valuable documents and products, *Proc. SPIE Conference on Optical Security and Counterfeit Deterrence Techniques*, 1-2 February 1996, San José, CA, USA, p. 10-20.
8. Moser, J-.F., Document protection by optically variable graphics (kinegram), *Optical Document Security*, 2nd. edition, chapter 11, Publ. Artech House, London/New York (1998).
9. Moser, J-.F., Perceptual information from OVD diffraction security devices, *Proceedings of the Conference on Optical Security and Counterfeit deterrence*, San José, 1-2 February 1996, Volume 2659, p. 53-58.
10. *Counterfeit Deterrent Features for the Next-Generation Currency Design*, National Materials Advisory Board, Commission on Engineering and Technical Systems, National Research Council, 1993, Publication NMAB-472, National Academy Press, chapter 5, p. 91.
11. Camus, M., et al, Security papers and special effects, *Optical Document Security*, 2nd. edition, chapter 5, Publ. Artech House, London/New York (1998).
12. Acland, N.A.B., Cylinder mould made paper for non-bank note applications, *Proc. Int. Conf. of Security Printers*, Vouliagmeni (Greece), 6-8 June 1991.
13. Schneider, Walter, New security features and substrates in ID and passport paper, *Addendum to Proc. Int. Conf. of Security Printers*, Lisbon (Portugal), 5-7 October 1995.
14. Hofstetter, Bruno K., Counterfeit protection in the digital age, *Proc. Int. Conf. of Security Printers*, Seville (Spain), 15-17 May 1997.
15. Haslop, John. M., Security printing techniques, *Optical Document Security*, 2nd. edition, chapter 7, Publ. Artech House, London/New York (1998).
16. Renesse, Rudolf L. van, Noniridescent optically variable security devices, *Optical Document Security*, 2nd. edition, chapter 9, Publ. Artech House, London/New York (1998).
17. Renesse, R.L. van, Ordering the order - a survey of optical document security features, paper #2406-33, *Proc. SPIE Practical Holography IX*, February 5-10, 1995, San José, CA, USA.
18. Dobrowolski, J.A., Optical Thin-film security devices, *Optical Document Security*, 2nd. edition, chapter 13, Publ. Artech House, London/New York (1998).
19. Renesse, Rudolf L. van, Iridescent optically variable security devices, *Optical Document Security*, 2nd. edition, chapter 15, Publ. Artech House, London/New York (1998).