In our project dubbed “Banknote of the Future”, we are trying to understand the changes that the currency industry is about to face in the coming years, and what the money of the future should look like.

On these BoW pages, authoritative experts from the global banknote community share their views on the development of the industry.

Hans de Heij graduated from the Faculty of Industrial Design Engineering in Delft University of Technology. He managed the introduction of five new banknotes (25–100 guilders) on behalf of De Nederlandsche Bank (DNB) during the period during the period 1981–1997.

For the Eurosystem De Heij was the manager of Euro design contests in 1996 and 2006. He also took part in preparation and zero production of EUR 200 banknote.

Thanks to him, Dutch guilders got such technical innovation like barcode numbering. He pioneered the inclusion of public (consumer) feedback in banknote designs. De Heij has published several articles on the subject. The colour scheme of the euro banknotes was one of his proposals. He is the inventor of several patents.

In 2008 he started a PhD research to ‘Key elements in banknote design’ at the Delft University of Technology.
1. Which approach to the development of banknotes’ design do you consider acceptable: utilitarian (when first a security complex is defined in which elements are located most conveniently for automatic detection), esthetical (when a banknote’s artistic design prevails and security elements are arranged to match the design) or compromise (looking for golden mean between the two above-mentioned types)?

Your question does not distinguish between groups of users and functions, which is in fact a matrix of different user groups and different banknote functions, in short – the ‘user – function’ matrix. Banknote user categories, according to my definition, are retailers, public, commercial banknote sorting centres, central bank sorting systems, counterfeit deterrence systems and forensic laboratories.

Coming to the functions, in my view there are four main user functions to a banknote: 1) value recognition, 2) handling, 3) authenticity check and 4) communication message. These four user functions can be viewed as ‘design layers’, which are – and this makes banknote design complex – different for each user group.

For a banknote automate an authenticity check is important, while for public it is of more importance that the note’s value is recognized within an instant and that the notes fit properly into their wallets. The key to optimal banknote design is to make a visual attractive solution for this ‘user – function’ matrix. Usually central banks put the authenticity check or the message first. Durability is another popular design policy and is part of the handling function, just like size, orientation (i.e. landscape or portrait) and wet-strength. However, durability is more an objective of the central bank to bring down their costs and is not one of the main aims of a user-oriented approach, except when it focusses on a clean note circulation or durable security features (e.g. preventing a holographic foil from wearing off). By ranking the priorities as done above, a user-oriented banknote design policy is defined, a direction I promote for future banknotes.

2. Is it possible to create banknotes that are entirely protected from counterfeiting?

My answer is definitely yes, for two reasons. The human actions captured by the slogan ‘feel – look – tilt’ could be explored further and secondly there are enough physical and chemical phenomena available that could also be explored further, like colour (spectral signatures), density (low, high), resolution (nano-features) and materials (dedicated DNA structures and other taggents).

Analysis of the human actions will show a strong bias in modern banknotes to tilt and look-through features, while both actions are not favoured by the public. Such features could be reduced and replaced by feel and look-at features. Feel (tactile) features should be developed further as an unfamiliar touch, being the first trigger to inspect a banknote more closely. Introduction of information technology like linking smart phone applications to the banknote is another unexplored area. I am quite sure that the slogan will be extended to ‘feel – look – tilt – smart phone’.

The real problem however is not the human action or technology, but the public perception and attitude towards a security check. People do not look at banknotes in an analytical feature oriented mode – checking the features one by one – but rather in what psychologists call configural or heuristic quality mode. Banknote research should therefore focus first of all on the human perception of the complete banknote and not on details. However, the question remains if people will use them. In the Netherlands people get their banknotes out of an ATM. They are all genuine as a result of the ECB decision on recirculation of euro banknotes in 2010. Bringing these ATM notes to the shops, people receive lower denominations – which are hardly counterfeited – as change. So, why would the general public be interested in public features at all? Instead of this preoccupation with public features, central banks should focus more on the needs of retailers as a first line of defence. There are indications that criminals first plan a trip passing several shops, trying to pass fake notes; counterfeiters do not target the general public. We see a tendency towards a decrease of the counterfeit quality of public features, while the quality of UV features increases.

3. Is it possible to talk about an optimum parity of public and machine-readable features?

Central banks should think much more in advance before they start a new banknote project, they should prepare a Programme of Requirements (POR), listing the requirements from the perspective of the different categories of targeted users. They all need their own specific type of features. One of the preparatory exercises to be done is to create a ‘user – security feature’ matrix listing all user categories, and attribute the number of security features needed per user category. As a rule of thumb 3 ‘independent’ features per category is enough. When three security features are statistically independent from each other and the expected probability on reproducing one feature is 1 in 1,000, the probabil-
ity that all three features are well reproduced is 1 in 1,000,000,000 which is considered as a low probability and thus a safe banknote. With 6 user categories this would lead to 18 to 20 features in a banknotes. In case of public features I can imagine that the central bank would like to incorporate 2 or 3 ‘fall back features’.

4. How design can help to draw attention to security features?

When it comes to the design of public security features, it all starts with raising public interest for the banknote, with evoking positive emotions via attractive design. There are several ways to raise interest and one of them is aesthetics, which is also a link to the user function of an authenticity check. From research we know that people recall more security features if the note is found more beautiful. Positive emotions are also encouraged by introducing some humour, creating a little smile or other ways of self-reflection. In 2010 DNB published a detailed description of user requirements for public security features, like time spent on authentication, easy location, easy to explain and understand, univocal, delicate and striking. Listing and exploring the user requirements should be the focal point of central bank’s research on banknote design. Feature development should be left to the security industry, based on the feature requirements of the central bank. To answer your question, an optimal banknote design matches the POR.

5. High quality imitations of traditional security features have become quite common. Should we reject some of them in favour of new solutions?

Coming back to the "user – security feature" matrix, central banks have to delete a feature if a new feature comes in. This has proven to be very difficult for most of them and as a result many banknotes carry over 30 features. Often central banks do not even know how many features there are in their banknotes. Since the very first European banknote was issued in Stockholm in 1666 watermarks are applied and in the 1960s the see-through register was introduced. Both features are counterfeited but are still kept. Another example is micro-text, introduced around 1860. Did you ever see a retailer checking a banknote with a magnifier? The only one interested in micro-text seems to be the printer. New features are introduced, but old and obsolete features are rarely removed. Combined with the world-wide tendency to reduce banknote sizes this leads to design conflicts. As a result the sizes of denomination numerals on banknotes are reduced and becoming too small for the visually impaired and are even less readable when they are combined with disturbing backgrounds. There is simply not enough space to incorporate more than 20 security features in a banknote, next to all other features.

6. How do you assess the prospects of applying on banknote inks, which special properties are activated under ultraviolet light?

Counterfeits have well-imitated UV features, often even brighter than the ones on genuine banknotes. As a result from research by DNB in 2006 we decided not to promote the UV features anymore, because retailers tend to misjudge the UV properties of both genuine and counterfeited euro banknotes. The product lifecycle of UV inks is at its end. The reaction and tracking and tracing. Coming time and such solutions also do not match with other retail user requirements like discrete and unequivocal validation. UV-features are another example of obsolete features and should be deleted, creating space for other, better features.

7. Are there any tendencies of the public security elements development?

Unfortunately I see more and more complex public security features with what I call multiple levels of nesting; a-feature—in—a-feature—in—a-feature. The most important user requirement to check a security feature is, as said, a limitation of the time needed to authenticate. From research there are some indications that people are willing to spend a maximum of 5 to 6 seconds on authentication. With three public features this would be about 2 seconds per feature. Only a few of the 60 to 70 public security features available on the market match the user requirements mentioned above. Instead of researching their clients, central banks tend to copy features from others, like the colour movement and complex holographic stripes full of features.

Furthermore, contrary to the existing tendency to divide the different classes of features over the front and back of banknotes, for clarity and ease of use all public features should in my opinion be on the front of the note while moving all retail features to the reverse.

8. Are there any prospects for RFID tag integration in banknotes?

From a technological point of view RFID tags would help the banknote industry in many ways, not only from a security point of view, but such tags could also be used for value recognition and tracking and tracing. Coming
back to the 'user – security feature' matrix, an RFID tag could replace the banknote number. The tag’s price can be low, about 5 % of the production cost of a banknote. However, there are two main drawbacks. The privacy aspect of banknotes may be affected; people may perceive banknotes with a RFID tag no longer as anonymous. And secondly, people might fear ‘to be scanned’ by a criminal in a crowd or somewhere else and to be robbed.

However, information technology will definitely affect future banknote designs. Already in 2007 we proposed to print QR-codes on euro banknotes. Scanned with a smart phone, the QR-code would enable linking the phone to the website of the central bank, to show information on the public security features or other relevant information. The provided information is up to date, close to real time. Since the user will be interested in a specific denomination, each denomination would receive its own QR-code.

9. What are the current trends in the development of security elements of level 2? What factors are taken into account in their development?

Using terms like level 1 and level 2 are typically expressions of an authenticity design policy, putting security features first, over value recognition or banknote handling. But even from a security point of view I cannot agree, as said before, with the present focus on the public features. Research has shown that on average retailers accept about 120 banknotes per day and the general public only one or two. Clearly the retailer is key in preventing the spread of counterfeits. To provide the retailer with proper verification equipment is left completely to the market. Suppliers of retail detectors first have to analyse the notes themselves and secondly have to develop their devices. Within the Eurosystem we help by publishing a list of reliable devices. In my view central banks should help the retailer further, by offering a combination of a dedicated retail feature and detection tool for an attractive price (e.g. around 50 euro).

10. How can banknotes evolve in the future? What kind of information can a banknote carry in the future?

Banknotes will only survive when we see and develop this product further as a part of cash payments, including coins. Cash money does have several sustainable advantages over other new means of payments, like privacy aspects and like being a direct, fast and safe payment settlement. On the other hand, cash has several weaknesses, like heavy coins, risk of loss and for retailers the risk on robbing. Cash payments are also often perceived as being dirty. And of course, the costs of cash payments – and as a result their fees – should be equal or lower as the costs of other means of payment.

In my view people will keep using coins and low banknote denominations. Moreover, there will be a need for high, saving denominations (hoarding), which should be developed along other lines as banknotes used for daily payments. The banknotes which will disappear first, if at all, will be the mid-denominations.

11. What is your take on the prospects of the development of common industry standards and certification of banknote security?

Accreditation and certification are normal activities in many industries. Within the Eurosystem we profit from the work done since 1995 to come to standardization of measurement methods on banknotes and other topics concerning quality assurance. Also security regulations and health and safety measurements are harmonized. The next step to be made is to come to ‘green banknotes’ matching with ethical criteria as listed in the Corporate Social Responsibility of central banks, like criteria on emission rates, energy and water consumption, or child labor. In 2007 DNB made a start by issuing the first euro banknotes using about 15 % of Fair Trade cotton and today the paper mills have to include 30 % of sustainable grown cotton.

12. Which substrates for future banknotes will be produced on paper, polymer, or combination (hybrid)?

In the future banknotes will be much used by automat like ATMs and banknote acceptors. From this perspective the banknote automat behave like a user and their user requirements are a single note height, small technical variations in original banknotes and a vertical or portrait orientation. For this use polymer notes seems to behave better than cotton based banknotes. Feeding polymer notes into an automat is easier because such notes are less affected by tears, missing parts and clipped corners. Also from ‘green’ perspective polymer banknotes seem to have better performance when it comes to environmental and sustainability aspects.

Hybrid banknotes are innovative and will lead to new security features and may also have a better performance on the ‘fit for use’ function.

to be continued...