RESULTS OF DETECTION TESTS CARRIED OUT BY THE BANCO DE ESPAÑA

How training affects the authentication of banknotes

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1. Executive summary

The Cash and Issue (Cal) Department is involved in a variety of activities including training different groups of people in relation to banknotes and, especially, to broadening knowledge about security features, with emphasis on the ability to detect counterfeits and authenticate genuine banknotes.

During this training, Cal discovered the opportunity to conduct a detection test among 166 participants with three main goals: a) improving the quality of the courses; b) measuring changes in the ability to distinguish fakes from genuine banknotes and c) detecting changes in security features used before and after receiving the training.

The National Analysis Center (NAC) Spain usually participates in the training sessions and it was tasked with developing a suitable detection test to quantify the improvement. The tests developed are based on Detection Theory, using selected participants and unsophisticated technology (4 minutes is the maximum time to analyse a pack of 10 banknotes: 4–ES2-50€-Genuine; 4-ES1-200€-Genuine; 1-ES2-50€-Inkjet counterfeit; 1-ES1-200€ offset counterfeit).

The main findings are that training increases the total number of hits, mainly in the identification of genuine banknotes, while the gestures employed to analyse the banknotes changed significantly with the acquisition of new habits and the consequent increase in time needed.

2. Possible combinations based on detection theory

Detection theory gives four possible scenarios for each stimuli – response. Regarding the detection of fakes, multiple factors can influence capacity of recognition: quality of the fakes, soiling, fatigue, previous knowledge, background, etc. All of them are reflected in the final decision.

The following figure reflects four possible combinations or scenarios:

Figure 1
COMBINATIONS OF STIMULI - RESPONSE

b. Genuine banknote considered fake Failure **False alarm**	**a. Genuine banknote accepted** Hit **Genuine Hit**
c. Fake detected Hit **Correct rejection**	**d. Fake accepted as a genuine** Failure **Miss**

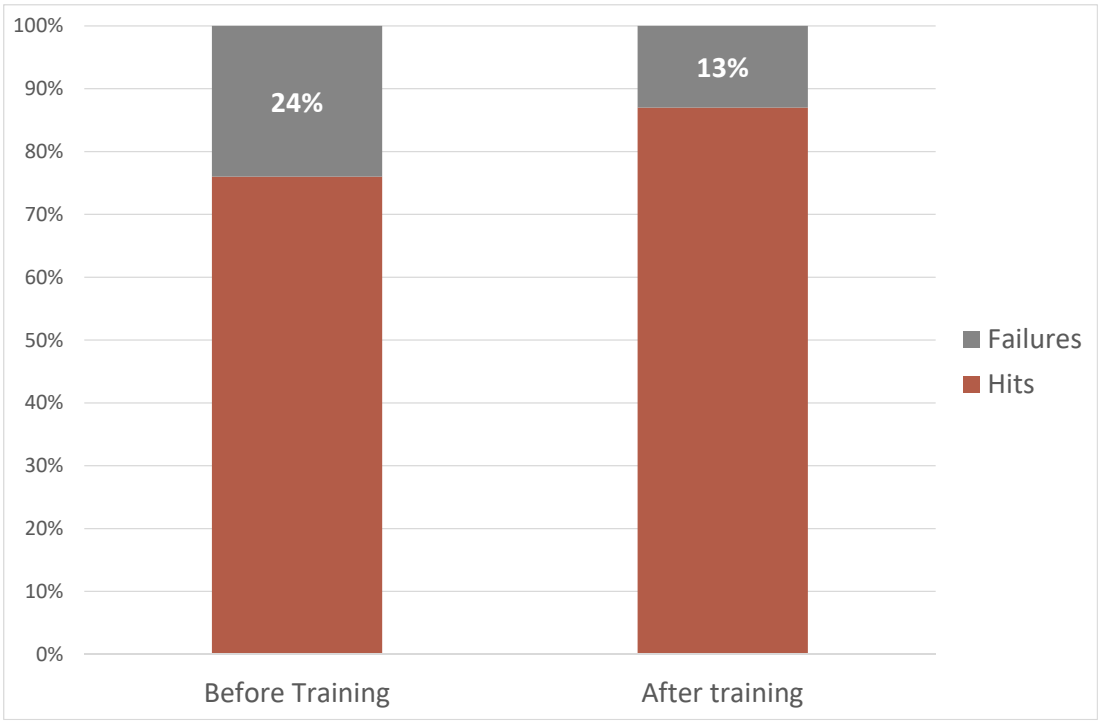
a. Genuine Hit: a real banknote is accepted (light brown). It represents the most common situation in real life. After a commercial transaction, a genuine banknote is used for payment and accepted.
b. False alarm: a genuine banknote is rejected (light grey) because its authenticity is considered suspicious. During a transaction, the seller is suspicious of the customer, and/or the environment and/or the banknote and rejects the banknote.
c. Correct rejection: a fake is detected. The banknote catches the attention of the seller and is rejected (dark brown). Some aspects of the banknote (printed background, tactility or other security features) trigger a process which end with the counterfeit being rejected.
d. Miss: a fake is accepted as a genuine banknote (dark grey). This case represents the worst scenario as the counterfeiter has achieved the goal of placing a counterfeit in circulation.

Background color is used from chart 2 to 4 for better understanding. Grey reflects failures and brown reflects hits, while the intense colors represent an action relating to fakes.

3. Results

3.1 Banknotes grouped into hits/failures

Chart 1 represents the simplest grouping of decisions: hits vs failures before and after the training for all types of banknotes.

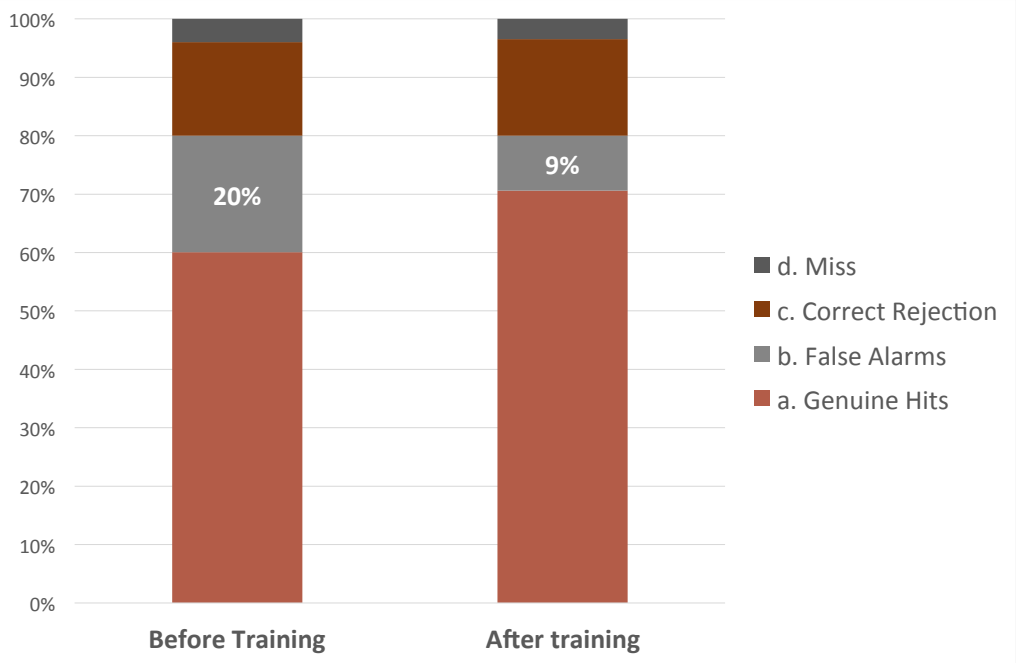


The total number of hits was 76% before the training and 87% afterwards, an increase of 11%. Failures decreased by 46%, from 24% to 13%.

As expected in advance, we can obviously conclude that training improves the general hit rate.

3.2 Banknotes grouped by cases

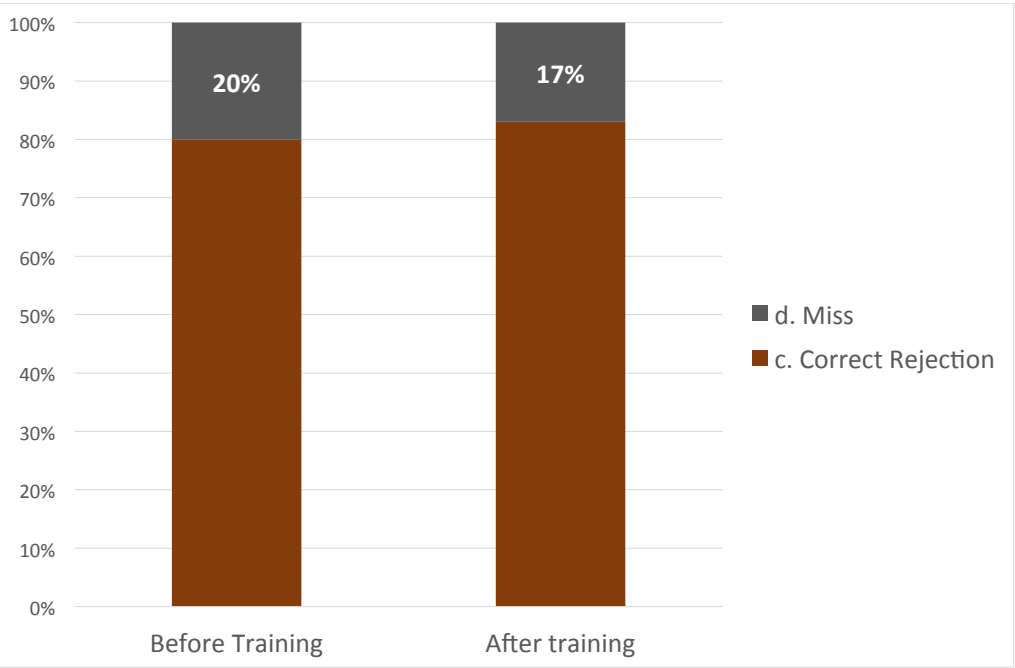
Chart 2 shows changes in the four possible cases explained in Table 1.



Based on the possible combinations described in Detection Theory, it is worth noting that the counterfeit hit/acceptance ratio remained practically unchanged. However, the genuine hit/rejection ratio dropped substantially (by 11%). This could mean that after training, participants mainly improve the ability to authenticate genuines but slightly the ability to detect fakes.

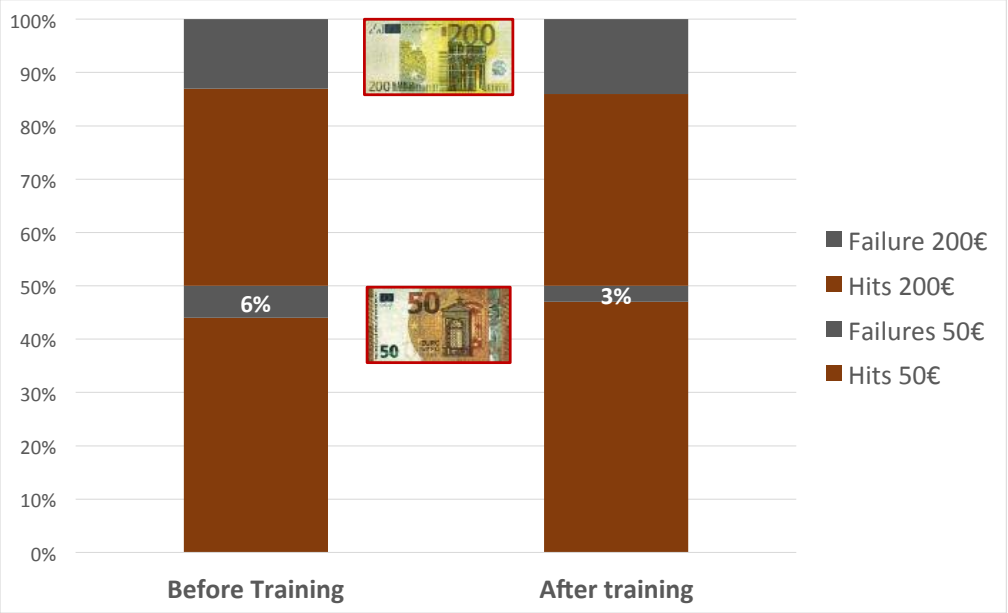
3.3 Banknotes. Focusing on counterfeits

This section focuses exclusively on fakes, only taking into account the top of the previous chart. It would appear that the relationship between genuine rejection and miss remains virtually unchanged after the training. Only a minimal reduction of 3% in total is observed, which in relative terms represents 15% of fake acceptance reduction.



3.4 Banknotes. By denomination (or quality of fakes)

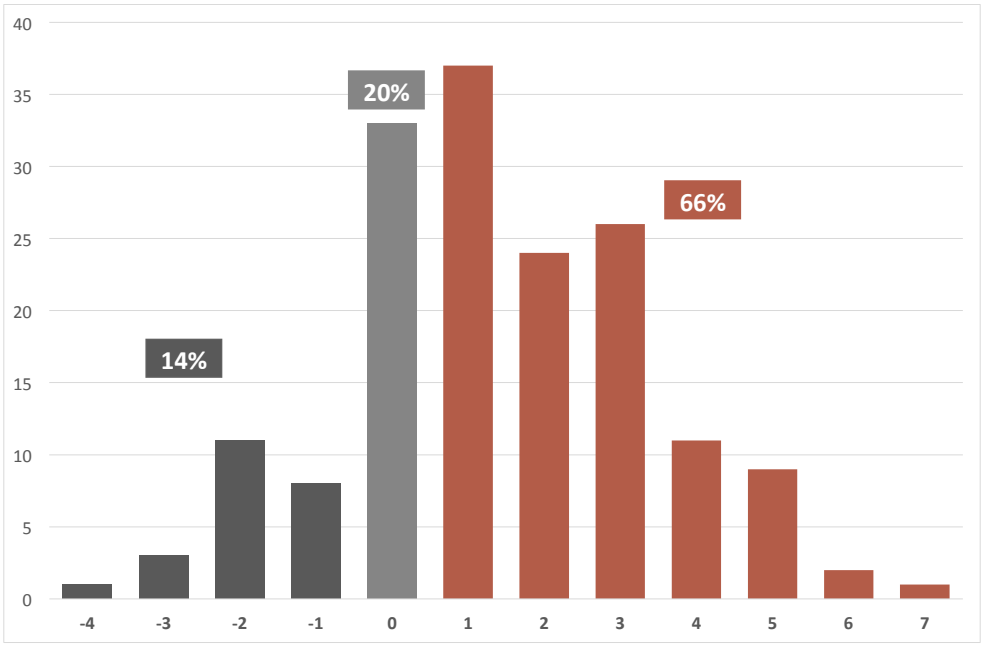
The following chart shows the influence of counterfeit quality on detection ability before and after training. As was explained in section 2, two types of counterfeits were selected. The first one is high quality (offset copy), and the second one is medium quality and widespread (Inkjet copy).



While €50 counterfeit banknotes are easily spotted after training, detection of high-quality banknotes remains stable. This is probably because many of the participants belong to the group of students and the training is not focused on high-quality counterfeits but on more general concepts relating to banknotes.

3.5 Participants. Distribution of changes in total hits

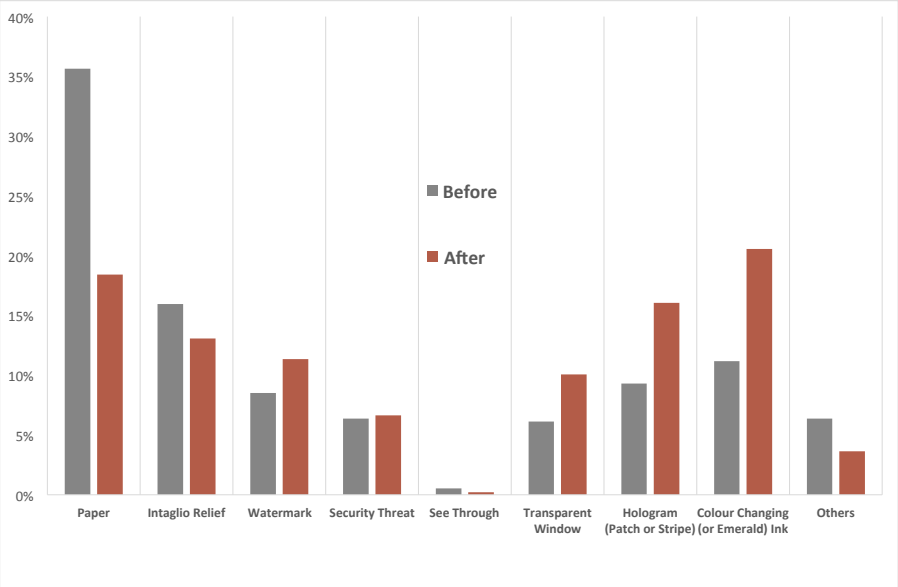
Considering the distribution of changes in hits by participants, the number of people who have improved their initial marks is shown in the chart below. For instance, 37 out of 166 participants improved the number of hits by one. 66% of the participants improved, 14% worsened and 20% remained stable.



The average value of the distribution is 1.4. It is concluded that the training leads to improvement in 2 out of 3 participants.

3.6 Security features (SFs) used for counterfeit detection before and after training

Security features used to assess banknotes were analysed before and after the training. During the first step, the most used SFs were paper and intaglio relief, which are probably the most subjective and intuitive ones. After the training, most participants used prominent security features based on tilting the banknotes (holographic features and colour-changing inks). An intermediate position relates to "look" SFs (watermark, security thread and transparent window).

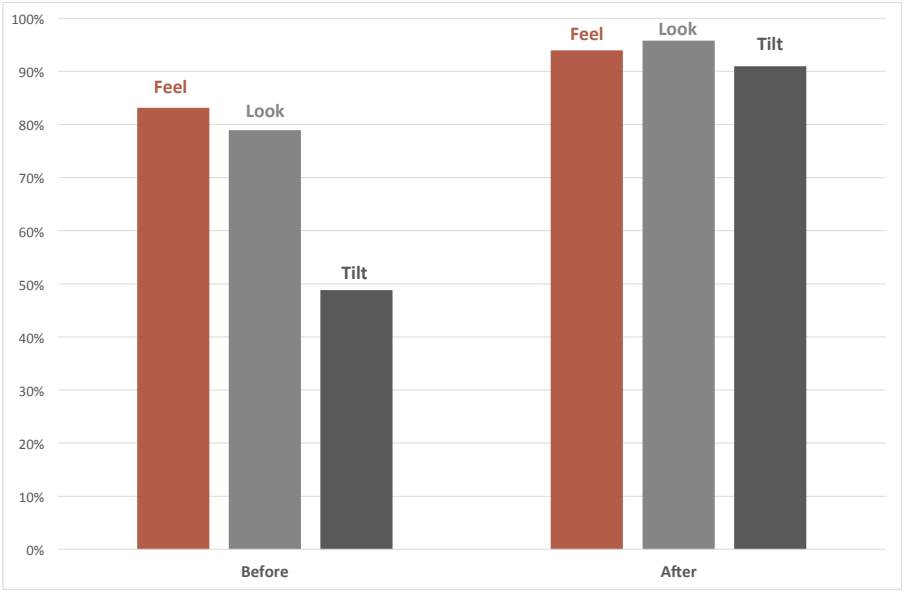


The see-though number was seldom employed before training and afterwards it was almost missed because this SF is only used in half of the banknotes selected. Contrary to the initial expectations of the NAC expert, the transparent window was used more often than expected before training and achieved a usage of 10% afterwards.

In summary, training has drastically modified the SFs used for detecting fakes and authenticating genuine banknotes mainly by decreasing subjective SFs and increasing those based on movement.

3.7 Gestures used for all cases

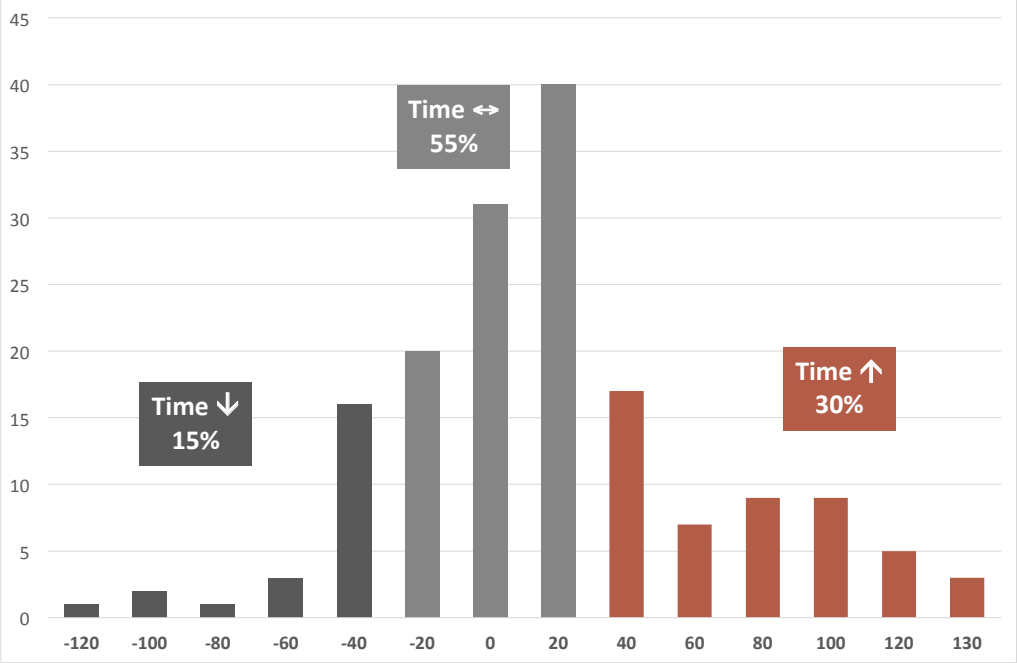
he "Feel, Look and Tilt" (F-L-T) method is covered as part of the training courses following the steps recommended on the ECB's website. As expected, a significant change in the gestures was observed.



Before training the most common gesture was “feel” (used by 83% of participants), followed closely by “look”, while “tilt” was known and used (poorly) by only around 50% of the trainees. After training, the gestures used changed, and “look” was more used than “feel”. However, the highest increase was in the “tilt” gestures, from 48% to 91%. The number of F-L-T gestures increased individually around 70%. Finally, the percentage of participants using a combination of the three gestures in a single banknote rose from 45% to 89%.

3.8 Distribution of changes in time required (expressed in seconds)

As initially expected, the time required to examine a banknote increased.



As explained in the methodology section, the maximum time was set to 4 minutes for checking the entire set of ten banknotes (on average 20-25 seconds per banknote). 55% of the population did not sustancially change the time needed to check the ten banknotes (or did so slightly). 15% required less time to analyse the banknotes and 30% required longer. This extra time was probably needed because many trainees added the “tilt” gesture to check the banknotes.

4.0 Conclusions

The following conclusions and interpretations can be inferred from the data, charts and previous experience on the matter.

1. Training increased the total number of hits on banknotes, mainly regarding the identification of genuine banknotes, while the detection of counterfeits only improved slightly, owing to the difficulties in detecting offset copies and the impact of the number of students on the study.
2. Fake acceptance decreased slightly and mostly affects medium quality counterfeits.
3. Participants improved their total number of hits on average by 1.4 (on a 0-10 scale), the most common being between 0 and 3, mainly reflecting the reduction of genuine rejection.
4. While paper and intaglio relief was the most used SF for detection before training, most participants improved the use of watermarks and security threads, although the main improvement was observed in colour changing inks and holographic features. By far the less used SF was the see-through number, which even worsened after the training.
5. Training significantly changed the use of “tilt” versus “feel”, although “look” ended up being the most commonly used gesture. Eighty-nine percent of participants employed the full F-L-T combination after the training.
6. Most of the participants needed more time for their analysis after the training, mainly owing to the addition of the “tilt” step.