Making Bank Notes Accessible for Canadians Living with Blindness or Low Vision

*Carolyn Samuel, Currency Department**

- *The Bank of Canada believes that providing Canadians with barrier-free access to currency is important and is necessary for currency to be most effective as a means of payment. The Bank recognizes the special needs of those who are blind and partially sighted and is committed to working proactively to make bank notes accessible to this growing subset of the population.*
- *The development of Canadian bank notes is based on a continuous process that relies on scientific and empirical research, together with direct feedback from bank note user groups and experts. The Bank consults Canadians living with blindness and low vision, as well as their representative organizations and vision experts, to identify the needs of this community and to explore potential solutions.*
- *Through research, collaborative partnerships, and a focus on continuous improvement, the Bank has transformed a limited set of features into a program offering options for individuals with a range of vision limitations and improving their ability to conduct financial transactions using bank notes.*

Since its establishment in 1935, the Bank of Canada has been committed to supplying Canadians with bank notes that they can use with confidence to carry out cash transactions.

Designing and developing the bank notes that Canadians use every day is complex and challenging. The final notes are the product of continuous improvements involving research, consultation, development, testing, and, ultimately, important public policy decisions and trade-offs.

In deciding which features to include in bank notes, the Bank strives to meet the needs of a wide variety of user groups while remaining focused on the performance of bank notes in terms of security, usability, and cost to society. Although the Canadian general public is the target client, the perspectives of specific subgroups, as well as those of others involved in the use and handling of cash, are also considered. Some of these users include Canadians living with blindness or low vision, financial institutions, retailers, cash handlers, bank note equipment manufacturers, and law enforcement. The Bank must understand the needs of these various groups and must then try to develop notes that meet those needs in the most efficient and effective manner.

This article discusses the Bank of Canada's efforts over the past 30 years to meet the accessibility needs of a specific subset of the population—Canadians living with blindness or low vision. It also reports the findings of expert and user assessments of the suite of accessibility features on the current series of bank notes. The Bank's experience with this group underlines the importance of its relationships with all types of bank note users and the value of understanding their needs and of evaluating how those needs are being met.

* The author would like to thank the members of the Currency Department Strategic Leadership Team and Ben Fung for their contributions to this article. Thanks are also extended to Dr. Jeffrey Jutai (University of Ottawa); Dr. Graham Strong and Dr. Jeffery Hovis (University of Waterloo); Dr. Susan Lederman (Queen's University); Dr. Deborah Gold, Cathy Moore, and Victoria Pearson (CNIB); Mike Potvin (Canadian Council of the Blind); Earl Bryenton (Brytech Inc.); Dr. Sean Pemberton and Dr. Hutch Holton (Canadian Bank Note Company Limited).

Background and Context: Barrier-Free Access to Currency

The Bank of Canada believes that for currency to be most effective as a means of payment, all Canadians should have barrier-free access. The ability to conduct financial transactions using bank notes is crucial to independent living. Yet this can pose significant challenges for individuals who are blind or partially sighted **(see Box)**. The Bank recognizes the special needs of this group and is committed to working proactively to make bank notes accessible to this growing subset of the population.[1] This is also an area of increasing concern and focus for bank note issuers around the world (de Heij 2009 and ARINC Engineering Services 2009).

Improving Access for Canadians Living with Blindness and Low Vision

Over the past 30 years, the Bank's approach to improving bank note accessibility for those living with limited or no functional vision has evolved, as have the solutions available. What started as a limited set of features has been transformed into a program that offers options for a range of vision limitations. In working to provide barrier-free access to bank notes, the Bank of Canada has consulted Canadians living with blindness and low vision, as well as their representative organizations and experts on vision and tactility perception, to identify the needs of this community and to explore potential solutions.

What started as a limited set of features has been transformed into a program that offers options for a range of vision limitations.

The early years

In the late 1970s, the Bank began to review and assess possible approaches to making bank note denominations distinguishable for Canadians who were blind or had low vision. Contacts were established with the principal agencies concerned with people living with blindness and vision loss, promising research and development approaches were pursued, and developments in other countries were studied (Bennett 1982). This early work confirmed a primary objective: personal independence for persons living with blindness and low vision in the day-to-day handling of bank notes.

Birds of Canada series (first notes issued in 1986)

In 1978, during the early development of the *Birds of Canada* note series, the Bank's research team identified several possible approaches to assist Canadians with limited or no functional vision in denominating bank notes. Options included (i) notes of different sizes, (ii) clipped note corners, (iii) denomination numbers printed in Braille,[2] (iv) a hand-held electronic bank note reader, and (v) design enhancements, such as enlarged numerals and stronger colour contrast.

After considerable research and evaluation, the first three options were ruled out. Although different-sized notes are often the first-mentioned choice of individuals living with blindness and low vision, and are found in many major industrialized countries, this change would have substantially increased the cost of handling bank notes for most businesses and individuals. Automated banking machines, cash registers, note-counting/processing equipment, and even wallets would need to be modified or replaced to handle substantially smaller and larger notes than those currently in circulation. Clipping the corners of notes in a pattern so that denominations could be distinguished by touch was also considered. However, clipped corners would cause problems during machine handling and would lead to interpretation difficulties as notes became worn in circulation. Printing a code in Braille on bank notes was also problematic. At the time, it was not possible to produce raised dots that were the height of Braille code with the note-printing processes available. Indeed, research indicated that not all people with vision loss could read Braille. There were also concerns that such dots would wear in circulation.

Even as the list of feasible options shrank, the Bank remained committed to improving accessibility. With promising new technologies on the horizon, the Bank initiated work with a number of research organizations including the National Research Council, Carleton University, bank note printers, and design consultants abroad to research and develop a hand-held electronic bank note reader. This work was facilitated by consultations with agencies that support blind and partially sighted Canadians, including CNIB and CCB

1 The Bank of Canada (like all federally regulated organizations) is subject to the Canadian Human Rights Act (1977 and 1985) and the principle that all individuals should have equal access to the services customarily available to the general public.

2 Braille is a tactile system of raised dots representing letters and numbers.

Defining Vision Loss and Impairment

Vision loss can be described in terms of a range of vision clarity or loss of visual acuity. Visual acuity is expressed relative to normal vision, which in the metric system is set at 6/6 metres (20/20 ft.). This number can be thought of as a fraction of the viewing distance of an object relative to that of someone with normal vision. For example, to see an object, someone with 6/18 (1/3) vision would have to stand at one-third the distance (i.e., 6 metres) of a person with normal vision (18 metres). Those with low vision have visual acuity of less than 6/18 but better than 3/60. People with low vision have difficulty performing common age-related visual tasks in spite of conventional interventions, such as eyeglasses, contact lenses, or eye surgery. Individuals with severe vision loss have visual acuity between 6/60 and 3/60. Even when wearing glasses or contact lenses, individuals with severe vision loss are unable to read ordinary newspaper print or recognize faces across a room. "Functionally blind" individuals have visual acuity of less than 3/60, and their vision cannot be improved by any means (Jutai et al. 2005).

In response to a 2006 Statistics Canada survey, approximately 816,250 (3.2 per cent) of Canadians aged 15 and older reported having some kind of vision limitation, varying from mild (78.5 per cent) to severe (21.5 per cent). The highest rates of vision limitation were found in those 75 years of age and older (13.4 per cent), a group also more likely to have severe vision loss. More women reported a vision impairment than men (58.9 per cent versus 41.1 per cent) but with no differences in reported severity. Approximately 688,975 (5.5 per cent) of Canadians aged 45 and older reported having some kind of vision limitation.

A study completed in January 2007 for the National Coalition for Vision Health projects that over the next 25 years, the number of Canadians aged 40 years and older living with blindness and vision loss is expected to double as the Canadian population ages.

(Canadian Council of the Blind). The final product was developed and produced by Brytech Inc., an Ottawa-based technology firm, with development funded by the Bank.

The *Birds of Canada* note series was introduced in 1986 and featured two enhancements to assist Canadians living with blindness or vision loss: significantly larger denomination numerals printed with greater colour contrast to help people with low vision,[3] and a hand-held electronic bank note reader with bilingual voice output, issued in 1989, that read codes present on all but the $1000 note.

Canadian Journey series (first notes issued in 2001)

Work commenced on the *Canadian Journey* series of bank notes in 1997. As a first step, the Bank reviewed the accessibility features in the *Birds of Canada* notes to identify where improvements could be made.

International best practices were investigated, and consultations were held with experts in the fields of vision and tactility perception and with about 300 Canadians living with blindness or vision loss (with the help of CNIB and the CCB). From this research, the Bank concluded that to be most effective, accessibility features should help the individual to determine the denomination of a bank note quickly, independently, privately, and with the note in any orientation and, to the extent possible, to authenticate the note as genuine. It was subsequently decided that adopting a combination of accessibility features targeting a range of vision loss could greatly improve the situation.[4] Specific areas for upgrading were identified: better features and tools to denominate; the size, font, and colour contrast of the numerals could be improved; and the bank note reader was considered unreliable, too bulky and heavy, and with only voice output, offered limited privacy.

3 Numerals were enlarged from 8 to 14 mm in height and from 4 to 10 mm in width and were printed on a pale background to provide better contrast.

4 For example, tactile features could help blind individuals to denominate, while large numerals and greater colour contrast would help those with vision loss.

To facilitate denominating, two previously considered options were reassessed: different-sized notes and development of a raised-texture tactile feature. Options to further enhance the numerals and to improve the functionality of the bank note reader were also explored. After extensive industry consultations, different-sized notes were again judged to be very costly in terms of their impact on the broader public. Furthermore, the Bank viewed a move to different-sized notes as inconsistent with the trend to more automated dispensing and acceptance of notes in the Canadian market (i.e., ATMs and other note-handling equipment).

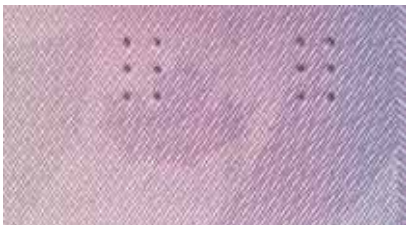
Although the development of a raised tactile feature posed a number of technical hurdles, it was appealing because of the potential to help individuals who were blind to denominate bank notes without using a separate tool. Technical research was undertaken in partnership with key stakeholders and experts to develop, manufacture, test, and evaluate such a feature. Canadian Bank Note Company Limited (CBN), one of the Bank's two Canadian-based private sector security printers, developed the approach and produced samples for testing. The Bank worked with a tactility-perception expert from Queen's University to explore symbol design, aiming to maximize tactility within the constraints of available space, production methods, and limits on note thickness for machine handling (Lederman and Hamilton 2002). Forty-eight possible designs were developed, from which six were selected as having the most potential and were subsequently evaluated by a representative group of Canadians living with functional blindness.[5] The tactile feature chosen is a series of raised-dot patches formed by groupings of six dots separated by a smooth surface that vary by denomination, as shown in **Figure 1**.[6]

To optimize the design of numerals (especially helpful for those with partial vision) the Bank consulted vision experts at the University of Waterloo. Scientific testing was undertaken to determine the optimal numeral size, font, and degree of contrast between the numeral and the background. As a result, notes in the *Canadian*

5 The symbols chosen needed to enable quick and reliable denomination, be easily produced, be durable in circulation, and not generate significant costs for the bank note-handling industry.

6 Rather than being identified as a Braille symbol, the tactile feature is intended to be felt quickly as a patch that feels rough compared with the smoother background of the note. The scientific reasoning behind using the perception of texture is that the sense of touch is better at detecting and discriminating textures than at identifying raised spatial patterns. Thus it should take less time to find a rough patch on the note than to interpret the dots as a specific character. The tactile feature was not designed for those with very poor tactile sensitivity and acuity, for example, people with peripheral neuropathy resulting from severe diabetes.

Figure 1: Raised-dot tactile feature



Journey series feature denomination numerals on the face and back of the note that are about 30 per cent larger than those of the previous note series **(Figure 2)**. The distinct colours used to identify each denomination were also made more vivid to reduce the risk of colour confusion.

It was decided that adopting a combination of accessibility features targeting a range of vision loss could greatly improve the situation.

The Bank also decided to improve the bank note reader, a tool that is especially helpful for blind Canadians living with limited tactile sensitivity (such as that related to diabetes). The bank note reader was given a more ergonomic design and is about half the size and weight of the previous model. It has both tone and vibration output modes (in addition to voice) to address the privacy issue that users had identified and to assist individuals who are deaf/blind.

Figure 2: Improvements in numeral size, font, and contrast

The enlarged numeral is 20 mm in height and is positioned on backgrounds that provide a better contrast. The 20 mm height is estimated to be readable by about 99 per cent of those living with partial vision. The numeral on the front of the note is dark on a pale background, while the numeral on the back is white on a dark background.

The annual cost of the *Canadian Journey* series accessibility program includes the cost of meeting the annual demand for bank note readers (about $0.15 million)[7] and the cost of producing the tactile feature (about 3 per cent of the cost of the annual note order). The Bank also funded the development work for the new bank note reader (about $0.5 million). The enhanced colours and enlarged numerals were incorporated into the bank note design at no added cost.

Assessment of the Accessibility Features in the *Canadian Journey* Note Series

The suite of features and tools introduced for the *Canadian Journey* series was intended to improve the accessibility of bank notes for Canadians living with blindness or low vision. The tactile feature and the bank note reader were aimed at improving access for blind Canadians, while the enhanced colours and enlarged contrasting numerals were intended primarily to help those with partial vision to access information on the notes more readily.

To assess the performance of these features and their impact on those living with limited or no functional vision, the Bank first undertook an informal internal assessment of the tactile feature and later engaged the University of Waterloo to more formally evaluate the suite of accessibility features.

The Bank's own informal assessment of the tactile feature was undertaken about one year after the first denomination in the *Canadian Journey* series was issued. With assistance from CNIB, the Bank obtained feedback from a small group of blind individuals on their ability to detect the tactile feature on a sample of one thousand worn bank notes. The tactile feature was found to be detectable on about two-thirds of the notes. On the remaining one-third, the feature was found to be undetectable owing to the physical wear in the area of the feature and of the overall note.[8]

Expert and user assessment—University of Waterloo

In 2007, about six years after the first note in the *Canadian Journey* series had been issued and prior to starting work on the next series of notes, the Bank engaged vision experts at the University of Waterloo to evaluate the performance of the entire suite of accessibility features. This assessment involved evaluations not only by experts, but also by Canadians living with blindness or low vision, and included identification of potential areas of improvement for the next note series (Jutai, Strong, and Hovis 2008). The primary objective of the assessment was to determine whether the enhanced accessibility features used in the *Canadian Journey* series provided functional benefits and improved the quality of life for people who are blind or have low vision, related to their ability to conduct financial transactions using bank notes.

The study included an expert evaluation of the suite of accessibility features and tools and an assessment of the impact of the changes in those features on quality of life for blind and partially sighted individuals as they carry out cash transactions.[9] The research was conducted in consultation with 64 adults, 18 years of age and older: 64 per cent reported that they had low vision, and 36 per cent reported being functionally blind.

Overall, participants noticed all of the changes to the accessibility features and tools in the *Canadian Journey* note series and felt that the changes were beneficial for a range of vision limitations. Not surprisingly, blind participants were more responsive to features that they could touch (raised dots), while those with partial vision were more responsive to the features that improved their visual perception (enhanced colour and enlarged contrasting numerals). Older people (whose tactile sensitivity diminishes with age) were more likely to notice the changes in numeral size and less likely to notice the raised dots. The colour-related changes were noticed equally by individuals with severely impaired colour vision and by those with normal or slightly impaired colour vision.

Changes in the *Canadian Journey* note series were evaluated as having a significant positive impact on major aspects of cash transactions, including recognition, denomination, note orientation, and, to some

7 Bank note readers are made available free of charge and distributed by CNIB to blind individuals on behalf of the Bank of Canada.

8 Measurements of surface roughness indicated that highly soiled notes had higher overall surface roughness, which could make it more difficult to detect the tactile feature.

9 The Psychosocial Impact of Assistive Devices Scale (PIADS) was used to measure the extent to which the accessibility features promote good quality of life for the user: the extent to which they make the user feel competent, confident, and inclined (or motivated) to use bank notes for financial transactions. "Psychosocial" refers to factors within the person and factors attributable to the environment that affect the psychological adjustment of individuals with a disability. "Internal factors (the core dimensions of psychological well-being, which include independence, personal control, self-efficacy, and self-acceptance (Ryff and Singer 1998)) . . . are essential components of how assistive technologies users define the impact of their devices on their quality of life" (Jutai and Day 2002).

extent, authentication. All of the changes, particularly the enlarged numerals, enhanced the ability of those with low vision to recognize and denominate a bank note and to use it, regardless of the note's orientation. The tactile feature improved the ability of blind participants to denominate bank notes. The raised (intaglio) printing found on all Canadian bank notes was also reported to facilitate authentication for blind participants, as well as for those with partial vision, albeit by only a small proportion of participants.

Changes in the Canadian Journey *note series were evaluated as having a significant positive impact on major aspects of cash transactions.*

The changes in the accessibility features were viewed as having a positive impact on quality of life, although this impact was moderate, since participants felt that the changes made things "just a little bit better" for them. Blind participants tended to give the features more positive ratings than those with low vision, but the difference between the groups was not statistically significant, nor was there a correlation with age or awareness of changes in the features. Scores differed significantly across groups defined in terms of colour vision, however. Those with severe impairment of colour vision reported greater benefit from the changes than those with normal or only slightly impaired colour vision. The changes were felt most in terms of improved functionality and independence.

The impact of circulation wear and tear was also evaluated. Overall, participants felt that their ability to carry out cash transactions was unlikely to be affected by circulation wear. Colour and contrast measurements of new and worn bank notes showed that, although wear and tear produces a "browning" of the notes that reduces the contrast of the numbers, the changes are relatively small. The slight reduction in contrast could be compensated by bringing the note about 5 to 6 cm closer. The objective findings confirmed participant views that normal circulation wear would have only a minor impact on the ability of individuals with low vision to use the notes.

Normal circulation wear had a greater impact on the tactile feature. Although the raised tactile feature is very useful for people with profound vision loss, its usefulness declines as the note becomes worn (a finding consistent with Bank of Canada observations). Participants described the feature as very effective and highly prized, but they observed that it quickly loses its effectiveness and dependability with modest wear and tear. The most common request of participants was enhancement of the effectiveness and durability of the tactile feature. Nevertheless, some participants stated that even if the tactile feature loses its effectiveness over time, a few months of use is helpful. Some individuals try to avoid this problem by requesting only new notes from their financial institution.

The study also confirmed that the bank note reader was particularly useful for people with profound vision loss. Some users reported concerns, however, especially when trying to read bank notes in poor condition and notes in the *Canadian Journey* series compared with *Birds of Canada* notes. This last point relates to design constraints in the *Canadian Journey* series that resulted in changes that allow notes to be read only when the portrait end of the note is inserted into the reader. Notes in the *Birds* series could be read from either end.

In summary, the University of Waterloo study indicated that the features in the *Canadian Journey* series had improved bank note accessibility for Canadians with a variety of vision limitations. The new accessibility features have significantly increased their ability to conduct cash transactions and have enhanced the quality of life for people with all levels of vision loss. The study recommended that the suite of features be retained for future series of bank notes but that improvements be explored in an effort to optimize them. Specifically, there is a need to increase the durability of the tactile feature and to permit both ends of the note to be read by the bank note reader.

The next generation of bank notes

In light of the Bank's commitment to providing barrier-free access to currency and to continuously improving the quality of Canada's bank notes, this feedback from experts and from Canadians living with blindness and low vision is being considered in the development of the next generation of bank notes. The Bank intends to include reading codes at both ends of notes in the design of the next note series and is also exploring options to improve the durability of the tactile feature—at the same time considering and balancing any trade-offs in security, durability, and cost. Thus, the next series of bank notes is expected to include distinct vivid colours, large contrasting numerals, a more durable tactile feature, and improved functioning of the bank note reader.

Conclusions

The Bank of Canada's approach to providing accessible bank notes for Canadians who are blind or have low vision reflects the Bank's commitment to providing barrier-free access to currency. The goal of bank note design and development is, as always, to provide all Canadians with bank notes that are secure, readily accepted, and that can be confidently used to carry out cash transactions. The Bank's objective is that the final bank note design reflects a combination of features and materials that meet the Bank's key performance criteria and also meet the needs of a wide variety of bank note user groups. The development of Canadian bank notes is based on a proactive and effective process of continuous improvement that relies on scientific and empirical research, together with direct feedback from bank note user groups and experts. The cycle is non-stop and clearly focused on the Bank's objectives. Features in the current note series are evaluated, opportunities for improvement are identified, needs are defined, and potential solutions are developed and tested.

Relationships and partnerships with both bank note user groups and experts are important to the Bank and are critical for success. By working closely with its stakeholders, the Bank obtains key information about which features are working well and where opportunities for improvement exist. In some cases, this work leads to collaboration in research and development that helps the Bank to formulate the best solutions in the most effective manner—critical from a public policy perspective.

Relationships and partnerships with both bank note user groups and experts are important to the Bank and are critical for success.

The Bank's experience with the accessibility features in its current note series suggests that while bank note experts can balance the needs of various user groups with the technical limitations of notes (size, printing technology, durability, ability to provide a tactile sensation), it is people living with vision loss, as well as experts who study that loss, who are best positioned to define their specific needs. The Bank has been pleased with the positive feedback from Canadians living with blindness or low vision and has been consulted by several other central banks that wish to learn from our experience, while developing solutions to serve their own communities.

Literature Cited

ARINC Engineering Services L.L.C. 2009. *Study to Address Options for Enabling the Blind and Visually Impaired Community to Denominate U.S. Currency* (July). Available at <http://www.moneyfactory.gov/images/ARINC_Final_Report_7-26-09.pdf>.

Bennett, D. G. M. 1982. "Possible Approaches to Making Banknote Denominations Distinguishable by the Blind and Visually Impaired." In *Bank of Canada Review* (January): 9–16. Statement presented to the House of Commons Standing Committee on Finance, Trade and Economic Affairs, Ottawa, Ontario, 15 December 1981.

Canada. Statistics Canada. 2006. *Participation and Activity Limitation Survey 2006: Facts on Seeing Limitations*. Catalogue No. 89-628-X 2009013.

de Heij, H. 2009. "Banknote Design for the Visually Impaired." DNB Occasional Studies Vol. 7 No. 2. Available at <http://www.dnb.nl/en/binaries/Banknote design for the visually impaired_tcm47-224150.pdf>.

Jutai, J. and J. Day. 2002. "Psychosocial Impact of Assistive Devices Scale (PIADS)." *Technology and Disability* 14: 107–11.

Jutai, J., P. Hooper, G. Strong, L. Cooper, C. Hutnik, T. Sheidow, D. Tingey, and E. Russell-Minda. 2005. "Chapter 1: Terminology, Demography, and Epidemiology of Low Vision." In *Vision Rehabilitation: Evidence-Based Review*. Vision Rehabilitation: Evidence-Based Review Project Team.

Literature Cited (cont'd)

Jutai, J. W., J. G. Strong, and J. Hovis. 2008. "The Canadian Journey Series Bank Notes: Assessment of Accessibility Features for the Blind and Visually Impaired." Revised version prepared for the Bank of Canada.

Lederman, S. J. and C. Hamilton. 2002. "Using Tactile Features to Help Functionally Blind Individuals Denominate Banknotes." *Human Factors: The Journal of the Human Factors and Ergonomics Society* 44 (3): 413–28.

National Coalition for Vision Health. 2007. *Foundations for a Canadian Vision Health Strategy, Towards Preventing Avoidable Blindness and Promoting Vision Health* (January).

Ryff, C. and B. Singer. 1998. "The Contours of Positive Human Health." *Psychological Inquiry* 9: 1–28.