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TECHNICAL NOTE

QUESTIONED DOCUMENTS

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The LongPen™—The World's First Original Remote Signing Device*

ABSTRACT: The LongPen™ is a remote-controlled pen and videoconferencing device conceived by Canadian author Margaret Atwood in 2004 and initially intended to bring "live" author signings to far away locations. The LongPen™ allows for individually inscribed long distance signatures and writing while maintaining an original record, written with pen and ink. LongPen™ specimens were compared with control specimens using different speeds, pen pressures, and types of pens. Preliminary indications are that LongPen™ inscriptions can be identified or associated with their author. Size and form are maintained and artifacts are subtle. Some limitations with respect to the capture of long tapered strokes, delicate connecting strokes, and differences in line width were noted. Factors which may impact forensic handwriting examinations include limited amounts of writing, light pen pressure, date of the writing, type of writing instrument, dimensions of the writing, and failure to consider that the device has been used.

KEYWORDS: forensic science, LongPen™, long distance signatures and writing, remote signing, writing automata, electronic writing tablet and stylus, robotic writing arm

The LongPen™ is the first remote signing device capable of producing original signatures and text from any distance over the Internet. The device was conceived by Canadian author Margaret Atwood in 2004 as a means of reaching audiences anywhere in the world with a fraction of the travel time, expense, and carbon footprint of a traditional book tour (1). This article provides a brief overview of the history and technical aspects of the device and includes dates of first demonstration and the public launch. The article also describes the appearance and forensic characteristics of remotely produced original ink signatures and/or text. Forensic document examiners need to be aware of the device and familiar with its capabilities as LongPen™ signatures and writing will inevitably appear in casework.

History and Technical Description

Mechanical writing devices date back approximately four centuries, beginning with the pantograph. Invented by Christoph Scheiner in 1603 (2) and described in his book of 1631, the pantograph consists of a series of moving metal linkages that were used to copy and scale drawings and architectural diagrams. The clockmaker Friedrich von Knaus experimented and produced the first actual writing automata in 1753. His mechanical robot of 1760 was capable of writing 107 words (3). Another device that achieved popularity in its time was the Polygraph, which was invented by John Isaac Hawkins (4). First produced in 1803, it provided for two linked pens and two pieces of paper placed side by side. As one wrote a document with the first pen, the second pen produced an exact copy. Thomas Jefferson purchased such a device in 1804 and wrote over 20,000 letters, always maintaining a file copy and ensuring the excellent archives that exist today (5). Huber discusses the Signo-Graph (multiple pens coupled to a master pen), and the dynamic forensic characteristics of the Autopen, a matrix-based signing device invented by R. M. De Shazo in 1958, have been described in detail by McCarthy and Winchester (6,7). Foley has reported on forensic examination of digital signatures involving the UPS Delivery Information Acquisition Device (DIAD), in use since 1991 (8). Digital signatures have become routine when signing for courier packages and registered mail. Drawbacks of digital signatures include the lack of original signatures and poor resolution copies. The LongPen™ represents a substantial advance by bringing mechanical writing devices into the electronic age while maintaining an original record.

The LongPen™ operates over the Internet to produce long distance, real time, real pen and ink writing and signatures. A typical scenario is as follows: an author based in New York City chats one on one with a fan in London via videoconferencing. Using a stylus, the author writes a personal message on an electronic tablet at the New York City location (Fig. 1). The author pushes the Send button, and an actual pen at the receiving end in London writes the author's message and signature directly onto the fan's book. Both the tablet and a small monitor at the receiving end allow the sender and the recipient to view the text before the Send button on the tablet is pressed. If a change and/or correction is required, the electronic message can be deleted in its entirety and rewritten.

Using a remote robotic arm with an interchangeable pen, the LongPen™ faithfully reproduces whatever the author has written. The receiving station with a detail of the robotic arm and pen is shown in Fig. 2. The device currently allows a writing area measuring 135 by 135 mm, sufficient for a signature and several lines

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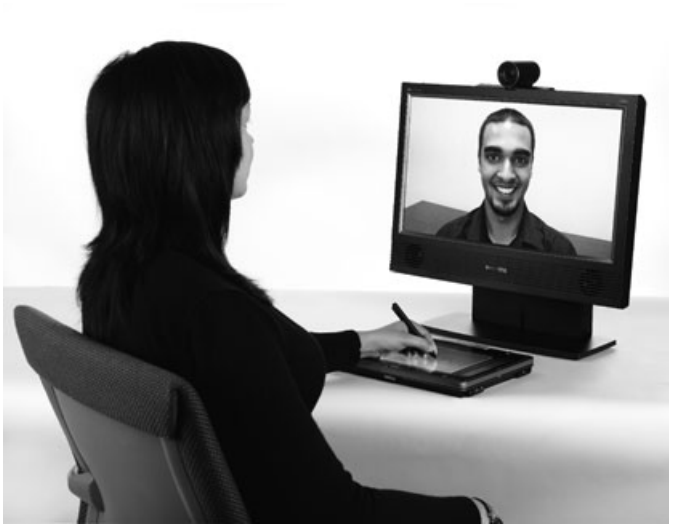

FIG. 1—*Tablet, stylus, and video conferencing station.*

FIG. 2—*Robotic arm with pen writing an original entry onto a book.*

of text. The device is quick and easy to operate. Books are typically signed at a rate of one per minute at LongPen™ signing events.

The LongPen™ has been developed and produced by Syngraphii Corporation, formerly Unotchit Incorporated (Toronto,

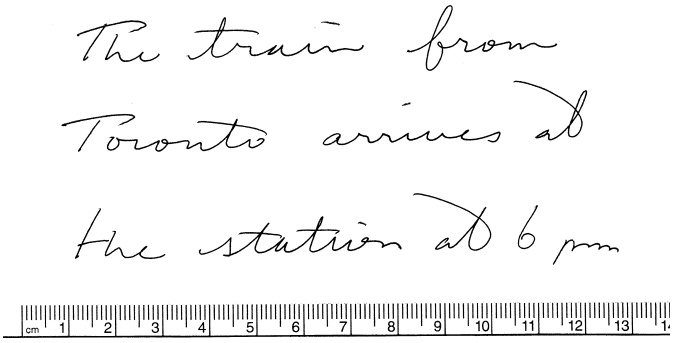

FIG. 3—*Roller ball pen specimen written with the LongPen Kiosk, normal speed, normal pen pressure.*

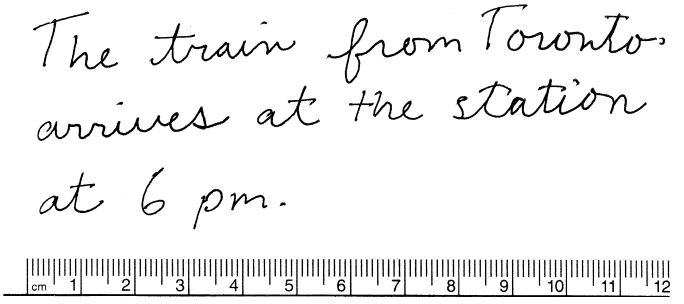

FIG. 4—*Roller ball pen specimen written with the LongPen Kiosk, slow speed.*

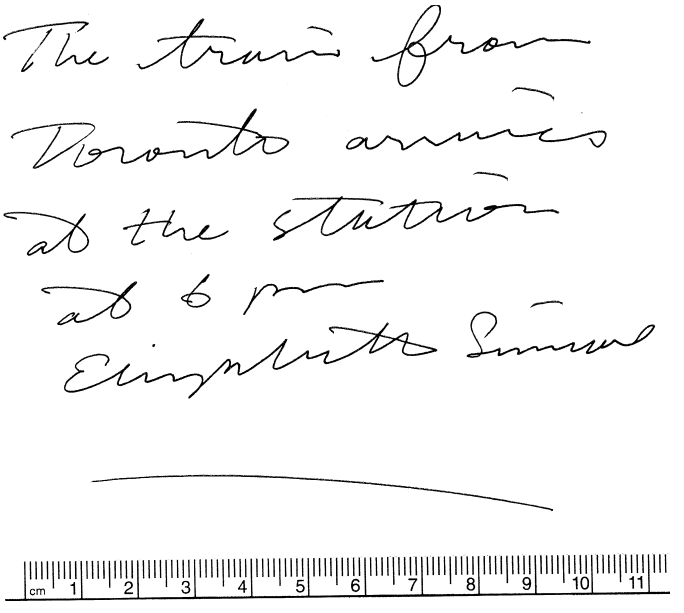

FIG. 5—*Roller ball pen specimen written with the LongPen Kiosk, fast speed.*

Canada). The first prototype was successfully demonstrated at Toronto in November 2004 (private invitation to members of the publishing industry). Further testing was conducted in late 2005 and early 2006 when *c.* 200 signatures were transmitted between Washington, Ottawa, and Toronto. The first public transatlantic signing took place on September 24, 2006 when author Kate Mosse signed books from London, England to The Word On The Street book festival in Toronto, Canada (Don

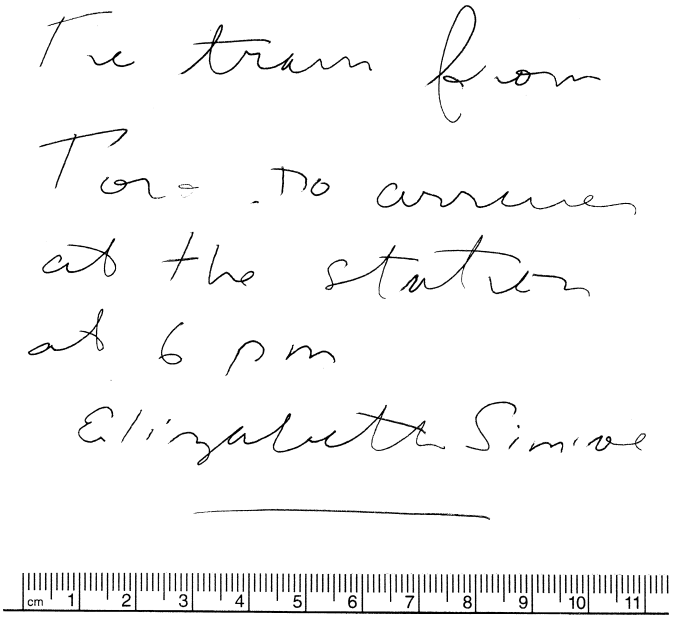

FIG. 6—*Roller ball pen specimen written with the LongPen Kiosk™, light pressure.*

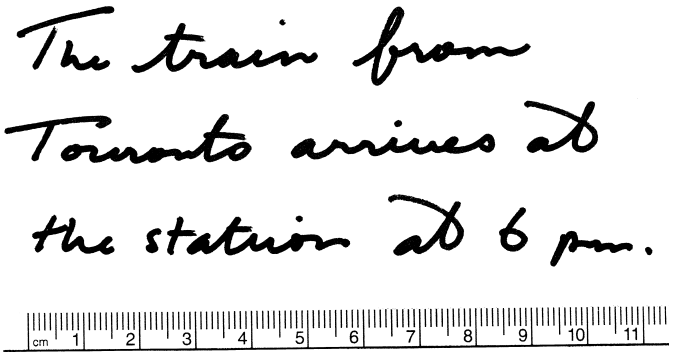

FIG. 7—*Fine point permanent marker specimen written with the LongPen Kiosk™, normal speed, normal pressure.*

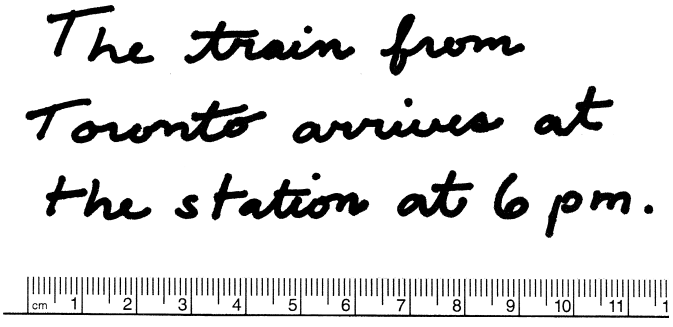

FIG. 8—*Fine point permanent marker specimen written with the LongPen Kiosk™, slow speed.*

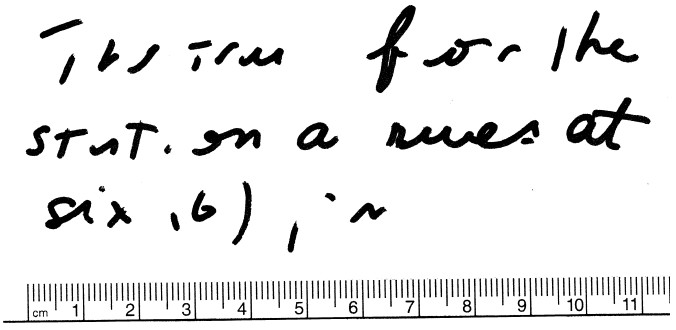

FIG. 9—*Fine point permanent marker specimen written with the LongPen Kiosk™, light pressure.*

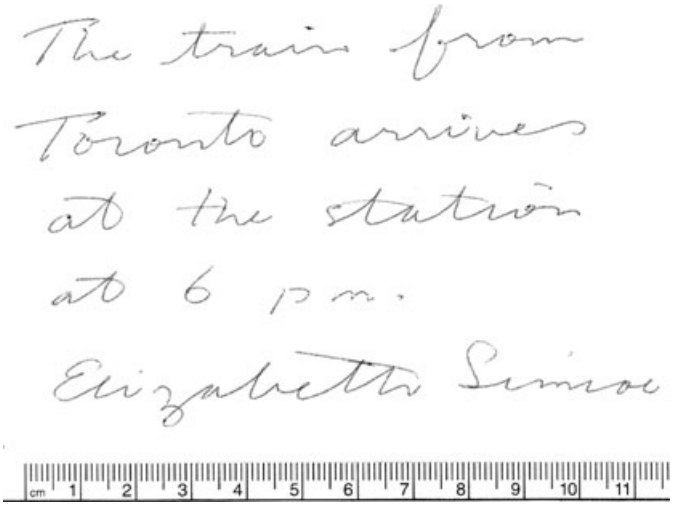

FIG. 10—*Ball point pen specimen written with the LongPen Kiosk™, normal speed, normal pressure.*

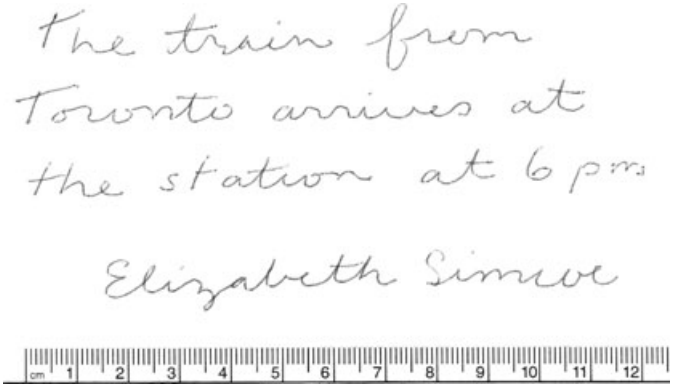

FIG. 11—*Ball point pen specimen written with the LongPen Kiosk™, slow speed.*

Marshall, President and CEO, personal communication; Unotchit Inc., October 22, 2007).

The device moved into production in October 2006. It was first made available in a large kiosk format. The smaller BusinessWriter™ (width 86.36 cm, depth 58.42 cm) has been on the market since 2007, and a portable briefcase-sized model is available as of January 2009 (John Wiltshire, personal communication; VP Technology, Unotchit Inc., January 15, 2009).

Applications have broadened from the initial focus on the publishing industry. The LongPen™ can be used in conjunction with either individual or template forms making it ideal for business, banking, law, and government. The Government of Ontario is currently using a LongPen™ in its Cabinet office. Justice applications include quick and simple signing of original affidavits, warrants, and court orders without costly transportation and delivery time. Election applications are pertinent, particularly for states which

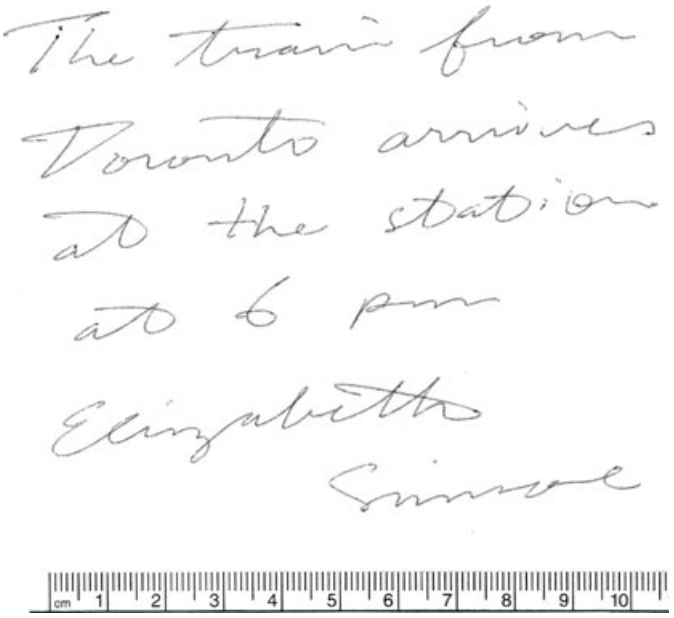

FIG. 12—*Ball point pen specimen written with the LongPen Kiosk™, fast speed.*

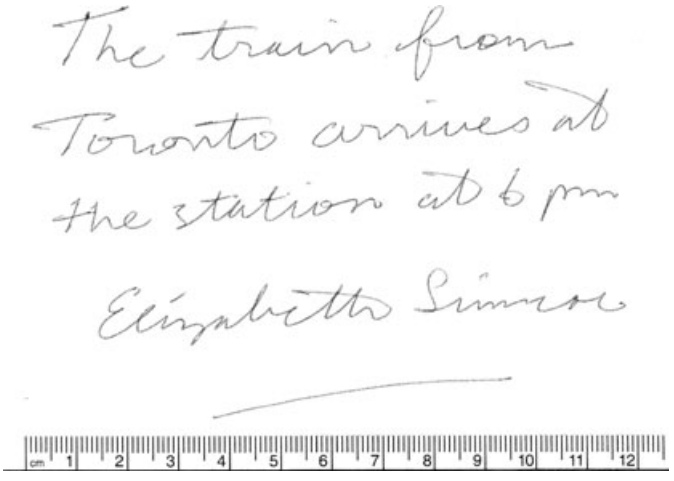

FIG. 13—*Ball point pen specimen written with the LongPen Kiosk™, heavy pressure.*

require original signatures to be filed. Medical doctors can sign original prescriptions for remote communities, eliminating the 2–3 days it would normally take to get the original prescription to far away locations. Posted military personnel and off-shore workers can continue to conduct normal transactions. High-level executive officers and politicians can be reached anywhere in the world at any time. Original documents can be signed in a matter of minutes.

The device is normally installed on a one to many basis; that is, the head office of a corporation typically maintains the receiving station and staff in the remote locations are issued small electronic tablets. There is no restriction to the number of tablets that can connect to one receiving station, and this keeps costs reasonable. The equipment can also be leased for special events.

Transmission is 24/7, from anywhere with a functioning high-speed Internet connection. A symmetrical bandwidth of 150 kb/sec is required for sending the signature data, whereas a higher symmetrical bandwidth of 534 kb/sec is required for optional video-conferencing. Data transfer is highly secure with a combination of

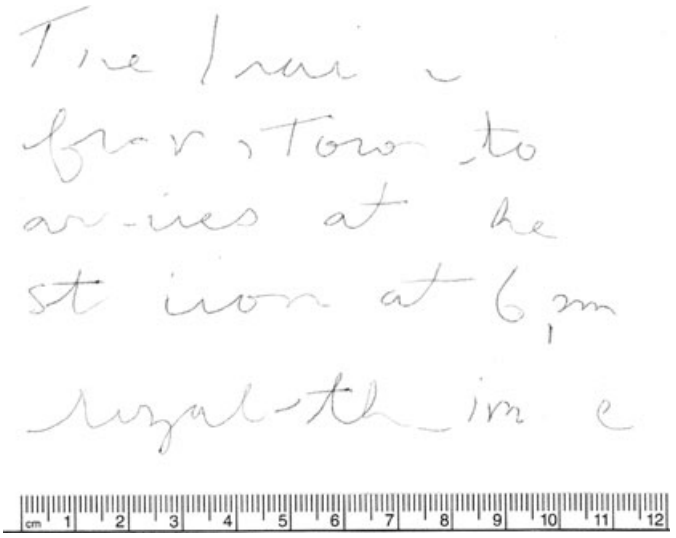

FIG. 14—*Ball point pen specimen written with the LongPen Kiosk™, light pressure.*

cryptographic protocols, including Secure Sockets Layer, Internet Protocol Security, Triple Data Encryption Standard and Advanced Encryption Standard (John Wiltshire, personal communication; January 7, 2009).

The LongPen™ offers fourfold signature security and verification as follows:

- The LongPen™ produces legally valid, original ink signatures. Users do not have to face issues involved with the proof of non-original signatures, nor are there archival problems that relate to long-term storage of digital records such as when signatures are captured in electronic form.
- The writer is video recorded during the signing process. For example, when the law firm or bank has an actual video record of the agreement or contract being signed by the client or when a fan has a video clip showing the baseball player chatting with the fan and signing a ball.
- The digital fingerprint of the signatures (i.e., stroke path and approach, pen lifts, velocity, pressure, and acceleration) is captured and stored for comparison with other standards if required. Each writer has a unique digital "fingerprint." Tytell as well as Plamondon and Lorette (9,10) have written extensively on devices that capture the biometrics of handwriting for the purpose of writer verification.
- Once the LongPen™ has produced an original signature, that exact signature cannot be written again with the robotic arm. This is an important security feature that prevents misuse of the LongPen™.

The LongPen™ is sensitive to writing speed and acceleration. If the author writes slowly, the LongPen™ writes slowly. If the author writes quickly, the LongPen™ writes quickly, up to a present top velocity of 125 mm/sec. The size of the writing is maintained. Pen angle is fixed with a slight right slant. The robotic arm moves along *x*, *y* axis (parallel to the paper plane) and along the vertical (perpendicular to the paper plane). Yaw, roll, and pitch have not been incorporated. Should the right pen angle be a concern, e.g., a left-handed writer with a left slant pen position, the equipment can be adjusted (John Wiltshire, personal communication; September 24, 2008).

The LongPen™ also captures pressure information. This is the function of the force exerted on the stylus, not pressure on the

tablet. This allows the writer to comfortably rest his or her hand on the digital tablet while signing.

As of April 2009, LongPen™ signatures and text in the public domain have only been written using roller ball pens (John Wiltshire, personal communication; April 24, 2009). During this study, fine point permanent markers and ball point pens were also tested to determine how this might impact on the signatures and writing. Permanent fine point markers are often used when signing glossy photos, CDs, baseballs, clothing, and other celebrity memorabilia. Pencils were not tested as the application or use would more likely be limited.

Materials and Methods

A short passage "The train from Toronto arrives at the station at 6 PM." and the signature "Elizabeth Simcoe" were written using a 0.7-mm (Fine) uni-ball® Vision™ (Newell Rubbermaid, Inc., Atlanta, GA) roller ball pen at normal speed and normal pen pressure on a sheet of copy paper (75 GSM). The text and signature were then written with different writing speeds (slow and fast) and different pen pressures (heavy and light). In each instance, the sheet of paper used for writing was placed on top of 10 sheets of paper, providing a soft writing surface. This process was then repeated with a fine point permanent marker (Sharpie® Fine Point; Newell Rubbermaid, Inc.) and a ball point pen (BIC® Round Stic™ Grip Fine; BIC USA, Inc., Shelton, CT).

The passage and signature were then written using the LongPen™ stylus and electronic tablet with different speeds and pen pressures. The robotic arm of a LongPen Kiosk™ was fitted and tested with each of the three different writing instruments. In each instance, the sheet of paper used for writing was placed on top of 10 sheets of paper, providing a soft writing surface. The control specimens were then compared with the LongPen™ specimens.

Results and Discussion

The appearance and forensic characteristics of the LongPen™ specimens when compared to the control specimens are presented in Tables 1–3.

Early indications are that LongPen™ inscriptions can be identified or associated with their author. The LongPen™ produces very natural signatures and text under normal writing conditions using any of the three types of pens tested. Size is maintained and the artifacts, that occasionally occur, are subtle. There is still some

TABLE 1—*Roller ball pen specimens written with the LongPen Kiosk™.*

Variable	Observations
Normal speed and pressure	The writing was surprisingly fluid and natural, with good line quality and evidence of tapered commencement and terminal strokes and some differences in line width and depth. Artifacts include occasional areas of slight and isolated tremor and occasional tic marks at base of single letters (Fig. 3). Indentations were a little more pronounced than the control specimen.
Slow speed	The writing reflects what typically happens when writers slow down the speed of their writing. There is a tendency to revert to copybook forms; there are fewer flying starts and tapered terminal strokes, there is more tremor, thicker lines and deeper indentations (Fig. 4). Indentations were a little more pronounced than the control specimen.
Fast speed	The writing reflects that which typically occurs when a writer deliberately writes with increased speed. Letter forms become more stylized and abbreviated; there are more flying starts and tapered terminal strokes, finer lines, lighter indentations, and increased length of writing. Overall line quality is good but hairline strokes are not fully captured. One artifact noted is a tendency to have some of the *i* dots dragged a little longer than the control specimen so that they appear like dashes instead of dots (Fig. 5). Indentations are a little more pronounced than the control specimen.
Heavy pressure	The writing generally reflects what occurs when a writer uses heavy pen pressure. There are fewer flying starts and tapered terminal strokes; there are deeper indentations and thicker lines. It was noted that overall the appearance of heavy pen pressure is less apparent than the control specimen. This is because of capture limitations in the tablet and stylus.
Light pressure	Extremely lightly written signatures and text render incompletely when using the LongPen™. This is primarily because of limitations with the tablet and stylus technology. If one writes too lightly, the signal is not picked up and is consequently not transmitted for processing. This results in a broken and patchy writing (Fig. 6). Indentations are little more pronounced than the control specimen.*

*In the event of a writer who is frail or has an illness or a condition that does not allow them to write with normal pen pressure, e.g., Parkinson's disease, multiple sclerosis, etc, the LongPen™ software can be adjusted to be more sensitive to light pen pressure to ensure a successful signing (John Wiltshire, personal communication; January 23, 2008).

TABLE 2—*Fine point permanent marker specimens written with the LongPen Kiosk™.*

Variable	Observations and Discussion
Normal speed and pressure	The LongPen™ produces natural looking signatures and text when a fine point marker is used at normal writing speed and normal pen pressure (Fig. 7). Line quality is good. There is some variation in line width but fine and delicate strokes are not completely captured. Artifacts are minimal. As expected, there are no indentations.
Slow speed	The LongPen™ replicates much of what occurs when a writer writes slowly with a fine point marker. Tremor increases, line thickness increases, there are blunt commencement and terminal strokes. As with the control specimen, there is bleed through to the underlying page (one of two instances in the study). There are no indentations (Fig. 8).
Fast speed	LongPen™ signatures and text written quickly with a fine point marker are more abbreviated and stylized similar to the control specimen. There are more flying starts and tapered terminal strokes. Line quality is good. Fine and delicate strokes are not fully captured. There are no indentations.
Heavy pressure	As with the roller ball pen, the output partially reflects what occurs when a writer uses heavy pen pressure. There are fewer flying starts and tapered terminal strokes and less gradation in line width. The writing does not fully capture the line thickening that occurs with the control specimen. As with the control specimen, there is a touch of bleed through to the underlying page. There are no indentations.
Light pressure	As with the roller ball pen, extremely lightly written signatures and text render incompletely attributed to tablet limitations. The writing is broken and patchy and is not quite as delicately nuanced as the control specimen (Fig. 9). There are no indentations.

TABLE 3—*Ball point pen specimens written with the LongPen Kiosk™.*

Variables	Observations
Normal speed and pressure	The LongPen™ writing was excellent, with good line quality and some evidence of tapered commencement and terminal strokes and variation in line width and depth (Fig. 10). Artifacts include occasional areas of slight and isolated tremor and skips, and occasional tic marks at base of single letters. Indentations are consistent with the control specimen, except that fine and subtle differences in pen pressure as between upstrokes and downstrokes are not fully captured.
Slow speed	The writing is very similar in appearance to the control specimen. There is a tendency to revert to copybook forms; there are fewer flying starts and tapered terminal strokes, there is more tremor, thicker lines and deeper indentations (Fig. 11).
Fast speed	The writing and signatures reflect what occurs when a writer deliberately writes with increased speed. Letter forms become more stylized and abbreviated; there are more flying starts and tapered terminal strokes and there are thinner lines and lighter indentations. Overall line quality is good. Long tapered strokes and hairline connecting strokes are not fully captured (Fig. 12).
Heavy pressure	The writing partially reflects what occurs with the control specimen. There are fewer flying starts and long tapered terminal strokes; there are deeper indentations and thicker lines. As previously noted, the overall appearance of heavy pen pressure is less apparent than with the conventionally written specimen. The writing does not fully capture the line thickening that occurs with the conventional writing (Fig. 13).
Light pressure	Extremely lightly written signatures and text were rendered incompletely when using the LongPen™ with a ball point pen, similar to what occurred with the roller ball pen and the fine point marker (Fig. 14).

room for improving the capture of long tapered strokes, delicate connecting strokes, and normal differences in line width. Indentations are generally a little more pronounced than those produced by the roller ball and ball point pen control samples.

The LongPen™ specimens written with fast speed and slow speed generally reflect the control specimens except for some capture issues with very light, fine strokes. Some of the i dots were also observed to be longer than in the fast speed control specimens.

The LongPen™ is not normally set up for writers who apply extremely light pressure to the writing instrument. Without special adjustments, writing produced under these conditions will appear patchy and broken. Tablet technology also has some capture limitations with respect to heavy pen pressure, but they are not as pronounced as those attributed to light pen pressure.

Factors which may affect the outcome of handwriting comparisons include limited text, light pressure, the number and type of artifacts, the type of writing instrument, the date of the writing, the dimensions of the writing and failure to consider that the LongPen™ has been used to produce the writing.

Unlike earlier signing devices that utilize fixed signature matrices (7) or DIADs (8), the LongPen™ allows unique signatures and extended writing to be transmitted to locations virtually anywhere in the world and still be original records, written with pen and ink. Future technological improvements will result in fewer artifacts and new applications. Handwriting produced with the LongPen™ may well prove to challenge forensic document examiners.

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