Polymorphic Letters: Transforming Pen Movements to Extend Written Expression

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ABSTRACT

We are developing a digital writing tool, Polymorphic Letters (PL), to investigate hand and pen movements as they may extend and enrich expression in written language. PL recognizes individual letters and associated spatial, temporal and pressure qualities of pen movements. The system maps these features to typography and colour variables, creating lively representations on-screen. Writers will use the tool in learning environments emphasizing the role of personal expressions. We explore *style* and *voice* as they pertain to expressions through hand, pen, and words, and describe the rationale for PL, its iterative design, and next steps based on writers' and readers' experiences.

Author Keywords

Constructionist learning, expressive typography, pen-based interface, multimodal communication

ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation]: User Interfaces – Graphical user interfaces (GUI), Input devices and strategies, Prototyping, Screen design, User-centered design

INTRODUCTION

Constructive learning environments rely on expressive media that may range from string to claymation to Lego blocks embedded with sensors and computer chips [8, 10]. Properties of each material frame a focus on particular ideas: in tying knots people think about spatial relations; in building with gears and pulleys people think about ratios and forces. Learners develop such core ideas through sustained engagement with the material, comparisons of varied productions, and discussions with others.

A pen-based writing tool, Polymorphic Letters (PL), can facilitate reflection and communication within constructive

learning environments. Eventually the system may become a learning tool in its own right, supporting expressions of self and ideas as writers become adept with the tool and develop individualized "voices."

Facilitating reflection and communication

Within the context of a learning environment and the framing of the materials, people can develop the ideas no matter *what* they choose to make or *how* they choose to make it. People can develop understandings of spatial relations whether tying a square knot or a bowline. They may develop the ideas slowly or quickly, individually or collaboratively, deliberately or impulsively. They may form the square knot through discretely alternating two ends of string or continuously winding a single thread. Through the creative process each person reveals something personal. Tools and forms for communication can encourage explicit thinking about the building and enable discussions with others, enriching the social context as well as the learning.

Supporting written expressions of self and ideas

In epistemology, psychology, and education, differences in habits of thought and approaches to learning constitute definitions of "style" – deeply characteristic inclinations to which expressions in different media may "give voice" [16]. In speaking, people control breathing and vocalizations to modulate pitch, range, volume and tempo, in order to augment choices of words and influence listeners. In writing, "style" and "voice" refer to the idiosyncratic ways in which writers express themselves. Yagoda argues that style, or voice, is not simply a set of techniques and devices:

Thinking about voice, my first thought was that it's about identity, recognizability, individuation. But then I thought, no, recognizability is not the point, it's the result—of emotion, movement, kinetic thought, dance, fear, love. It's the result of specific experience filtered through a specific sieve [19, p.214].

In typography choices of size, style, colour and position can make the author's "voice" visible and enhance the meaning of the text [2,9]. Moving the horizontal path up or down can convey a rising or falling pitch. Stretching or compressing a series of individual letters can convey tempo.

We are developing a pen-based writing system that combines the visual richness of typography, the conceptual

range of writing and natural involvements as in vocalization. We consider the pen as an extension of the hand, and movements of the pen as potentially expressive, perhaps comparably to the role of gestures and posture, physical appearance, facial expressions and eye movements in disambiguating our words and adding richness to nonverbal communications [4].

POLYMORPHIC LETTERS

PL extends written expression through recognizing individual letters and associated spatial, temporal and pressure qualities of the pen movements. The system maps these features to typography and colour variables, creating lively representations on-screen (figure 1). Increasing the spatial scope of a movement increases the size of the resultant typographic form. Pressing harder on the screen increases the weight, or thickness, of the form and the warmth of the colour. Thus, your spontaneous or deliberate choices of size, speed, pressure and layout can render your voice visibly augmenting the written expression.

Figure 1. PL transforms the idiosyncratic attributes of your pen movements, such as size of the letters and pressure of the pen on the screen, into colourful typographic forms.

RELATED WORK

Many tools are comparable to aspects of PL: they extend expressive capabilities, support constructive learning, combine multiple media types to enrich the meaning of text, map pen movements in real-time to manipulate visual outputs, address manners of expression along with contents of communication, or encourage awareness of nuances of self-expression. However, we are focusing on writers' awareness of style and development of voice through movements of hand and pen in combination with words.

Full Contact Poetry is a constructive learning environment in which children interpret existing poems and construct their own using the Squeak programming language, and text, image and sound media [3]. Prosodic Font is a computational experiment in designing a font. Letterforms change in shape, size, proportions, and weight in accordance with a speaker's voice signals and words [13].

Cursive is a pen-based system that captures and transforms individual letters and speed and size of pen movements as body gestures of on-screen avatars [1]. Affective computing systems that sense and respond to physiological conditions associated with affective states such as pleasure, frustration or interest, enable interpretation about such states of mind [11]. INNER-active Journal writers construct stories around emotional events in their lives. They then view graphs of skin conductivity and heart rate, to see how their typed text may correspond with these signals [7].

MAPPING PEN MOVEMENTS TO TYPOGRAPHY

Style is a deep and complex set of personal inclinations, so any means of supporting people's voices must be capable of subtle and varied expressions. PL needs to capture and represent many movements in order to achieve fine-grained expressions that both writer and reader can appreciate. This presents a design challenge; for any given input there may be many reasonable typographic responses.

To create an initial set of mappings, we referred to graphologists' systematic study of handwriting [5]. We do not intend PL as an alternative method of handwriting analysis, nor do we intend to make judgments about a writer's character – but we did find some of the handwriting attributes that graphologists have identified to be useful.

PL recognizes several qualities of pen movements (table 1): size (determined by height and width), horizontal spacing (differences in vertical placement), baseline (the horizontal line along which letterforms rest), duration (time taken to write each letter), and pressure (how hard the writer presses on the screen).

Qualities of pen movements		Typographic output
Spatial	Size	Size
	Horizontal spacing	Letter spacing
	Baseline	Baseline, Lightness
Temporal	Duration	Diffusion
Pressure	Pressure	Type weight, Hue

Table 1. PL maps spatial, temporal and pressure qualities of pen movements to characteristics of typographic forms.

Size and horizontal spacing. The size and spacing of your individual letters map, naturally enough, to the size and letter spacing of the resultant typographic forms.

Baseline. The baseline of your individual letters also maps to the baseline of the resultant typographic forms. However, as you input additional letters to a line, the baseline may change – your most recently input letter re-establishes the horizontal line along which the letterforms rest. The result is a playful dynamism as the forms settle into place and a regular, even, appearance that facilitates readability.

Lightness. We retain the writer's natural baseline information – whether ascending, descending or fluctuating – and represent it visually in the light-dark colour value of

the typographic form. The hue of the first letter that you write on each line is pure (50% lightness). As you input additional letters to a line, if the baseline move upwards, the brightness of the resultant form will be lighter, and vice versa. This rationale draws on culturally shared associations of light with high and dark with low.

Duration. As with an ink pen and blotting paper, if you write slowly the edges of resultant typographic forms become diffuse – the "ink" spreads.

Pressure. The pressure of the pen on the screen maps to the weight of the typographic form. As the pen pressure increases so does the apparent heaviness of the type; conversely as the pen pressure decreases the type becomes thinner. Pen pressure also affects the hue of the typographic form. We use a part-spectral colour scale with an indigo-blue-green-orange-red sequence. Drawing on culturally shared associations of blue tones with cool and passive, and red tones with warm and active, pressing harder on the screen increases the warmth, or activity, of the hue. Conversely, less pressure results in cool, passive hues.

As you write the hue may change. Your most recently written letter re-establishes a common hue according to the line's collective pen pressure (figure 2). You see an animated effect as each typographic form changes hue, starting with the most recent form and rippling back.

Figure 2. The pressure of the pen on the screen maps to weight and hue of the typographic form. The collective pen pressure for a line establishes a common hue.

We consider the visual prominence and controllability of hue by applying it line-by-line rather than letter-by-letter. People can read letterforms that vary in character, such as those in handwritten notes, but we have found that hue can be distracting when applied to individual letters. We hope to apply hue word-by-word, which would facilitate writers' deliberate emphases and contrasts.

Implementation
The system runs on a dual processor G5 Macintosh with OS X, a Wacom pen-based pressure-sensitive display screen, Apple Computer's "Ink" handwriting recognition technology, and the Cocoa object-oriented programming framework [6, 17, 18].

INFORMAL OBSERVATIONS
We ran trials to begin considering the system's situation within learning environments and to test the mappings. We emulated communications structures demonstrated to be effective within full learning environments [12, 14]. Our method was participant observation and discussion.

Study 1: writing about juggling
Two girls and three boys, aged 9-14, began learning how to juggle and used PL to correspond with an accomplished juggler about techniques, patterns and tricks (figure 3). The children participated in three two-hour sessions.

PL version 1. Size and spacing of input letters mapped to size and letter spacing of the typographic forms; baseline mapped to baseline; pressure mapped to weight; the time taken to write a letter mapped to the duration of the dissolve. We did not yet regularize the baseline.

Careful printing generated long dissolves that became distracting. We countered by applying a uniform time for the dissolve from input to typographic form. Writers also complained that their tendency to print downward produced an awkward aesthetic and took up too much of the available space. We responded by ensuring that the baseline stays even. In "cleaning up" writers' productions we aim to preserve the idiosyncrasies of handwritten expressions while promoting readability. The challenge is in determining how much regularizing to automate.
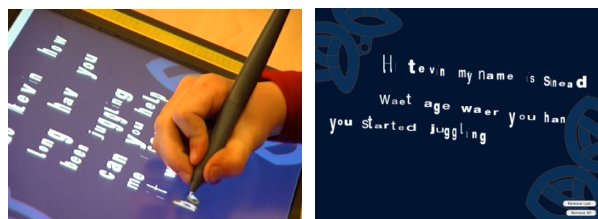
Figure 3. In corresponding about a learning experience, young writers suggested changes for duration and baseline.

Study 2: writing about Dublin past and present
Four male James Joyce literary scholars retraced walks through Dublin by characters in *Ulysses*, and used PL to write reflections on their experiences [15]. Each session involved one walker/writer and lasted a few hours.

PL version 2. Size and spacing stayed the same as for version 1; baseline mapped to a dynamically adjusting baseline; pressure mapped to weight of the typographic form and hue of the entire passage.

Several readers reviewed the writings. Readers were able to distinguish productions of individual writers. In cases where a reader considered both the visual treatment and the written content, there are suggestions of emergent "voices."

One reader pointed out that although two writers produced visually similar writings, their word choices and the spirit of their phrases distinguished the two. One writer took a third-person perspective and used erudite terms. In our conversations, he described his persona as a "tour guide."

> lenehan and m'coy have just viewed tom rochford's invention in crampton court. the event described by lenehan actually occurred in 1905 and is commemorated by a monument on the site in hawkins street [*sic*]

The other writer took a first-person perspective and used lively language. He told us that his entries were influenced

by the walking experience – he described a creative mind-set that gave rise to certain words and mental imagery.

passing close by on the way to trinity following the yellow sucky monster with brushes for teeth eating dublin throw away for grub a few pints and a leery look at summers swaying [*sic*]
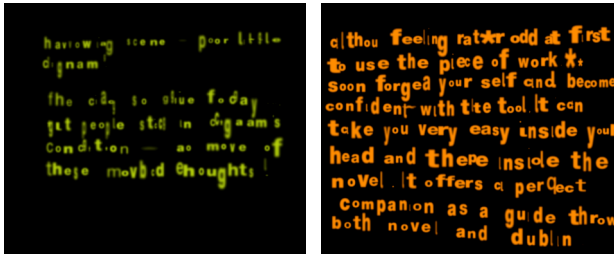
Figure 4. In reflecting on strolls through Dublin, writers established visual distinctions including small vs. large letterforms, generous vs. tight line spacing, slim vs. chunky letterforms, and airy vs. tight letter spacing. Readers also noted some details that were obscure but idiosyncratic, such as relatively larger or bolder letterforms at the start of a word.

The visual consistency across each participant's respective set of writings indicates that writers have characteristic tendencies in their handling of the pen (figure 4). Whether these tendencies would vary with different content or in different situations, we do not know. However, the consistent visual treatments facilitated readers' identifications of various writers, as an initial cue toward recognizing and appreciating style.

None of these writers seemed to experiment with varying their movements to control typographic output. But they all told us how much they enjoyed using the system, and they were thoughtful in formulating their written expressions. In the limited time they had to manage the electronic pen and tablet – which none had used previously – they needed to become familiar with the constraints, affordances and quirks of the system, as well as with the typographic results.

CONCLUSIONS AND FURTHER WORK

Although the system is in early phases of development, uses by children and adults suggest that writers can come to understand how variations in their pen movements help in constructing a progressively rich,wide range of expressions. We anticipate that writers ultimately will develop their own particular styles of expression and readers will come to appreciate nuances in different writers' texts.

Prolonged learning and communication situations will help to generate PL expressions that lend themselves to comparison of writings by different participants. And that enable us, as well as writers, to better understand consistencies that characterize each person's voice.

We intend audible as well as visual mappings of pen movements. Sound, as a time-based medium, would be natural for conveying the temporal qualities of pen movements (speed and duration) and the timing between pen events. In addition to extending expressivity by giving a sense of pace, sound can potentially add "colour" to the writing, heightening the sensations evoked by the form and content of the written expression.

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