A Glitch Pedagogy:
Exquisite Error and the Appeal of the Accidental

Ernesto Peña
Kedrick James
&
the Digital Literacy Centre[1]
Department of Language and Literacy Education
University of British Columbia

Abstract:
By experimenting with computer glitches as provocation of accepted norms of user interactions with digital technologies, this paper extends and radicalizes Dewey's (1934) pedagogical principle of "consummatory experience," observing computational error, logical accidents, and procedural glitches as creative and productive forces in the lived curriculum. We hold that this troubling of expected outcomes, this disruption of programmed processes which, as a result of incommensurable informational input, result in unique (and educational) by-products, is fundamental to understanding our digital humanity, and that these irregularities convey the same learning potential that learning from mistakes and fortunate accidents do in the arts, sciences, and within the broader context of lifelong learning.

Keywords: glitch, creative pedagogy, automation, machine learning, John Dewey, consummatory experience

Introduction: Accident and Error

It is not difficult to see the overwhelmingly negative stigma that is attached to accident and error; the irony of appreciating such mishaps seems almost comical. We are taught from an early age to experience embarrassment and humiliation when we make mistakes, but good teachers know how to work with our mistakes and activate our learning by engaging with those results rather than inculcating our fear of errors. The commonplace myth that children learn languages easier than adults arises from the freedom that very young children feel to make errors in speech. Adults indulge and might try to understand a child, where a fellow adult is judged accordingly. So we internalize the reluctance to try new things as we grow older, afraid of not being good at something. All learning relies on the ability to try, within a communicative context, to comprehend and express oneself strategically, whether through a golf swing, growing a garden, making a Vine video, or reading the spectrogram of a star. Error is at the base of logic, as logic is the attempt to reduce and control forms of error, and here logic is pattern recognition on the part of an observer. The keener the background knowledge of the observer the more precisely error can be identified. When processing any kind of familiar pattern of input data, whether organically through the senses, mechanically, or digitally, error alters the rate of activity of the processor. It does not slow it down; it greatly speeds it up. A computer hard drive running error messages starts to overheat.

Errors can cause the entire system to fail. We might wonder how something so seemingly insignificant as a missed quotation or colon or missed DNA pairing can have such dramatic outcomes. That is because all controlled or coded events (which is all creative phenomena) entail both a goal, sometimes quite a simple goal, and a very complex series of constraints that are like gatekeepers to achieving that goal. Those programs running differential software such as Bayesian and Markovian algorithms make highly proficient (indeed intelligent) pattern recognition machines. As such, they work on calculating *probabilities* from a wide range of known and unknown variables, trained on achieving a particular goal. Key here is the notion of probabilities, and that probabilities are guestimates within a sea of error. Stuart Armstrong (2015), for example, explored the difficulty of training artificial agents to make decisions based on values instead of facts. With utility (ease, speed, efficiency) as a coefficient, "constructing a well behaved value selecting agent immune to motivated value selection—one that is capable of learning new values while still acting on its old ones, without interference between these two aspects – is an important unsolved problem" (p. 19). Using the Sophisticated Cake or Death problem, a logistical challenge, results in a lot of Death. The point here is that even artificial agents need to learn from their errors to make good decisions.

Errors in the age of industrial mechanization lead to bad accidents, but other than human miscalculation, errors were initiated by irregular input in automated manufacturing. If the goal was to produce a certain type of lamp, for example, it was possible to mass-produce all the intricate parts in a manner that removed humans from the process almost entirely. One type of machine could be made that produces filaments, another bulbs, another metal housings, another wooden shafts, another insulated wire, another plugs, while another cuts and glues felt shades and so on. Once each job is standardized, sequenced, and mechanized; mechanical automation promised to eradicate those pernicious faults of human error. However, humans, even at the height of industrial mechanization, remained vital to manufacturing to solve the conflicts of non-standard materials to be fed into the machines. Where a carpenter, seeing an unusual warp in wood around a knot might decide to work with the knot and bring out its irregular beauty, the same piece of wood going into a joinery machine could damage or destroy the machine. In contrast, it has never been possible to fully automate the shoe industry. Lamps could be mass-produced because from year to year, the materials remain relatively constant. If however, owing to the changing designs and materials of the fashion industry, every year you needed a new machine that could work with leather to produce a stiletto, then another to make boots with snakeskin, then another to make sneakers with textiles, then another to make gumboots with rubber, then another to make flip flops with plastic, the cost of automation would never be recouped (Bright, 1958). Moreover, your company would always be one year behind the current market, given that by the time the machinery was produced, the trend would have moved on.

All this teaches us about the role of error and accidental input from a technical point of view. However, it is not from industry that our understanding of error and accidental beauty arises, but from art. During the era of the rise of industrial automation and concomitant human vs. mechanical agent conflict (Noble, 1986), America was also in the golden age of jazz music. What spotlighted jazz as particularly significant for music enthusiasts was the way top players of the genre would embrace improvisation (Menezes, 2010). Often the improvisor would feed off other players and/or members of the audience. While they retained a common goal, they also embraced the possibility of irregular input and unusual results. Supporting findings by Pressing (1988), Menezes describes improvisation "as a skilled performance with error-correction capabilities (a closed-loop feedback system) coming from the real-time comparison between intended and actual output" (p. 11). Players would adapt and support each innovative gesture, expanding musical possibilities into expressive probabilities. Improvising musicians "view errors as a motor of creativity" (p. 57). Music is by no means the only art form that employs error to accelerate creativity.

Improvisation is also central to explorations of glitch. Because this research focuses on provoking unpredictable outcomes from routine processes, it requires invention, imagination, and improvisation within a series of imposed technical constraints. Improvisation is a form of inquiry with skill. When still at basic stages of learning routines, errors can be corrected according to a known set of goals and parameters. When moving past the basic goal of acquiring patterned expression to a new goal (e.g., expand the listeners' aesthetic parameters, both known and unknown), then errors are more difficult to distinguish from exceptional results; errors initiate new learning, inspire adaptation, are skilfully integrated as a new fundament, and used to demonstrate mastery of the (art) form. Hence, with basic learning complete, improvisation as a methodological technique enhances speed and dexterity by which the artist incorporates error-as-learning cycles and turns mistakes into a form of innovation and beauty.

This process of transforming error into learning and then transmuting it into metaknowledge is at the base of what John Dewey anticipates with the concept of consummatory experience, which he theorizes in *Art and Education* (1934). According to Dewey, engaged inquiry in the processes of achieving an outcome is as significant, or more significant, to learning than the product that is produced at the end. Likewise, Dewey's insistence on processes of learning being emphasized over product was a central tenet of the Process Writing movement, which sought to introduce to the teaching of writing the notion that multiple states and processes were typically undertaken when any given piece of writing was composed (Elbow, 1981; Emig, 1971). The goal, obviously, was to write something in a particular style and genre, but the constraints were many, some known (formal genre properties) and others unknown (audience reception, even exhaustive knowledge of the topic). Formal experimentation with processes could lead to better writing as the writer learns by experimenting with the compositional process.

Inquiry and Technology

Dewey understood inquiry as an unavoidable, pervasive human activity: "[inquiries] enter into every area of life and into every aspect of every area. In everyday living, men examine; they turn things over intellectually; they infer and judge as naturally as they reap and sow, produce and exchange commodities" (Hickman & Alexander, 2009, p. 170). Dewey's notion of inquiry has been qualified as democratising, a breakout from the dominance of theory over practice that classical philosophy contributed to disseminating and that has ruled the mindset of western civilization (e.g., Schön, 1992). For Dewey, inquiry is not a merely intellectual process but a hands-on approach to questioning in which the value of tools of thought (theories, concepts, constructs, etc.) does not rest on their accuracy, but in their ability to convey further knowledge; that is, knowledge obtained from inquiry is a tool for inquiry itself (Chunn, 2014). The emergence of digital technology and its increasingly protagonistic role in education has sparked several new discussions, but it has also opened the possibility of re-examining others that could have been considered settled from a new perspective. Dewey's thought has not been the exception. The space that digital technology would allegedly take in Dewey's theory of inquiry has been discussed since at least the early nineties (i.e., Hickman, 1990), although more recent accounts have problematized this role by bringing another Deweyan concept to the discussion, a pedagogical principle known as *consummatory experience*. According to Dewey (1934) a consummatory experience is understood as the interplay of the means and the ends as a condition towards a culminating, valuable experience, even if that experience is not necessarily fulfilling or pleasurable. The coinage of this concept also reflects the critical stance that Dewey had on the culture of his time for alienating processes from products (Tiles, 1990). These *consummatory experiences* are the kind of experiences that should emerge as a direct outcome from teaching (Oral, 2013). These two concepts: *inquiry* and *consummatory experience* are inextricably connected, as it is allegedly through reflexive inquiry that an experience can ultimately be consummatory in Dewey's terms.

Scholars like Eric Mullis (2009) have denounced the use of proprietary digital devices and applications for educational purposes because such use puts the concepts of instrumentalism and consummatory experience at odds. Even when these devices can be used as effective tools for inquiry, their proprietary nature is oriented to the fulfillment of its intended purpose by hindering the underlying processes, and by doing so, circumstantially preventing a consummatory experience by blurring the means for inquiry. In other words, by dealing with the *whats* without addressing the *hows*. This statement might be debatable in cases in which there is no analogue version of an activity (computer language coding, for instance) that a digital device is emulating. The use of these devices and proprietary applications has been promoted in western education models as a practice towards the acquisition of *digital literacy* (e.g., Johnson, 2011; Leonard, 2013; TeachThought Staff, 2014) to the degree of having institutions holding conferences on the use of certain mobile devices for educational purposes (e.g., http://www.tlipad.com/). The criticism and drawbacks (Murphy, 2014) of using proprietary technologies primarily focuses on economic and logistical challenges of the extensive implementation of such devices and not on the pedagogical outcomes of their use. This potentially occlusive aspect of technology was foreseen by other influential voices in education and pedagogy such as Ted Aoki. Back in the late eighties, Aoki (1999) warned about the dangers of an overconfidence in computer technology insofar as it only accounts for a limited *standing reserve* of manifestations of *the real*, instead of revealing other possibilities:

> we must seek the true by understanding computer technology not merely as means but also as a way of revealing. As a mode of revealing, computer technology will come to presence where revealing and unconcealment can happen, i.e., where truth can happen....Hence, what endangers man, where revealing as ordering holds sway,

> is his inability to present other possibilities of revealing. In this, it is not computer technology that is dangerous; it is the essence of computer technology that is dangerous. (pp. 170–171)

Here, we do not try to engage in a discussion about the pedagogical value of proprietary digital technology or *computer* technology in general; instead, we contend that digital devices can be used as teaching and inquiry tools while preserving the consummatory experience and the potential to reveal alternative realities to some extent by adopting the concept of glitch as a prompt for inquiry.

Glitch

According to the Oxford English Dictionary (OED), the noun *glitch* started to be used among astronauts to refer to a momentary electrical spike over which there is no control. An early use of this word in this context reads: "A *glitch* is a minute change of voltage in a wire which is enough to trigger another system out of proper sequence" (Stimson Jr., 1961, p. 232). This notion of lack of control can be seen as well in the verb *to glitch*, originally defined broadly as to "meet unexpected problems" ("glitch, v.," n.d.). Since the early sixties, the term has evolved to encompass unforeseen behaviours within a system, particularly—although not exclusively (e.g., Willis, 2007)—to computer systems, and has been mobilized to other fields, such as video gaming (e.g., Krapp, 2011) and art (e.g., Menkman, 2011) among the most prominent. In the realm of computers, the rhetoric around glitches inclines towards an understanding of undesirable occurrences and errors, where glitch is sometimes used as a euphemism for *bug* (e.g., Krutz & Lutz, 2013). However, unlike its understanding in relation to computers, in gaming and art-related popular media, a glitch is seen as a serendipitous event, privileging unexpectedness over failure (e.g., Hernández, 2012). Moreover, in the specific case of glitch art, it has been argued that the lack of control is, more than a circumstance, a desirable ontological condition (e.g., Menkman, 2011). A glitch can only be so if there is no control over the result. These dispositions towards the phenomenon of glitch resonate with us and our proposal in regard to proprietary digital technology, although we are aware that precisely because of the proprietary nature of many devices and applications, the room for glitching is limited to the affordances of the tools and to the previous experience of the witness of the glitch. In other words, a glitch requires a norm to digress from, and it is possible to assume that a glitch could be understood, predicted, and ultimately become a norm. It is also possible to assume that what is a glitch for one person might be a norm for another, depending on their previous knowledge. It is because of this that in our own understanding, a glitch is a *non-moralizable*, contextual event.

Although we acknowledge the dual character of glitch as a product and a process, our approach to glitch is that of a product instrumental to the understanding of its own process, a sort of reverse engineering in which the goal is not to reproduce such processes but to shed enough light on them to make them tools of inquiry. We would argue that glitches can serve to interrogate not only the underlying processes that lead to the glitch object, but would also disrupt the *standing reserve* of realities that Aoki denounced (1999). Moreover, glitches could help to interrogate the very definition of collaboration, agency, authorship, intentionality, and so on. Consider for instance the following questions: Who is the author of the glitch as digital artifact? Is it the user of the proprietary device when producing the glitch? The programmer of the algorithm that the user intends to disrupt? Is it the device itself? All of the above?

Method: Cases, Experiments, Protocols, and Provocations

Although the concept of glitch as we present it here could be understood as a mere theoretical tool, we envision it as a hands-on form of inquiry. Glitch is not only something that should be thought about or observed. Glitch is something to be provoked, even performed, and as such, glitch is also provocative of methodological innovations.

In order to illustrate the arguments here exposed, we present four cases of the use of glitch as a tool for inquiry. The first three cases deal with different technologies, methods, and formats, respectively static imagery, automated literacy, and language translation protocols. The fourth case applies a recombinant process that utilizes the above three methods to produce a distinctive artifact that has been glitched at each stage of production. These cases should be taken as mere examples of the potential of the adoption of glitches—unexpected products of purposeful disruption—as pedagogical and reflexive tools. It is important to point out that all these resources are available in most of the current devices and operating systems. These cases are: provoked panoramic camera mistakes (referred to here as *stitch-skipping*), automated voice-to-text fuzzy interpretation (*voice-vaguing*), and natural language machine translation errors (*glot-swapping*). These particular kinds of glitches are based on either open or native applications commonly available across computer platforms.

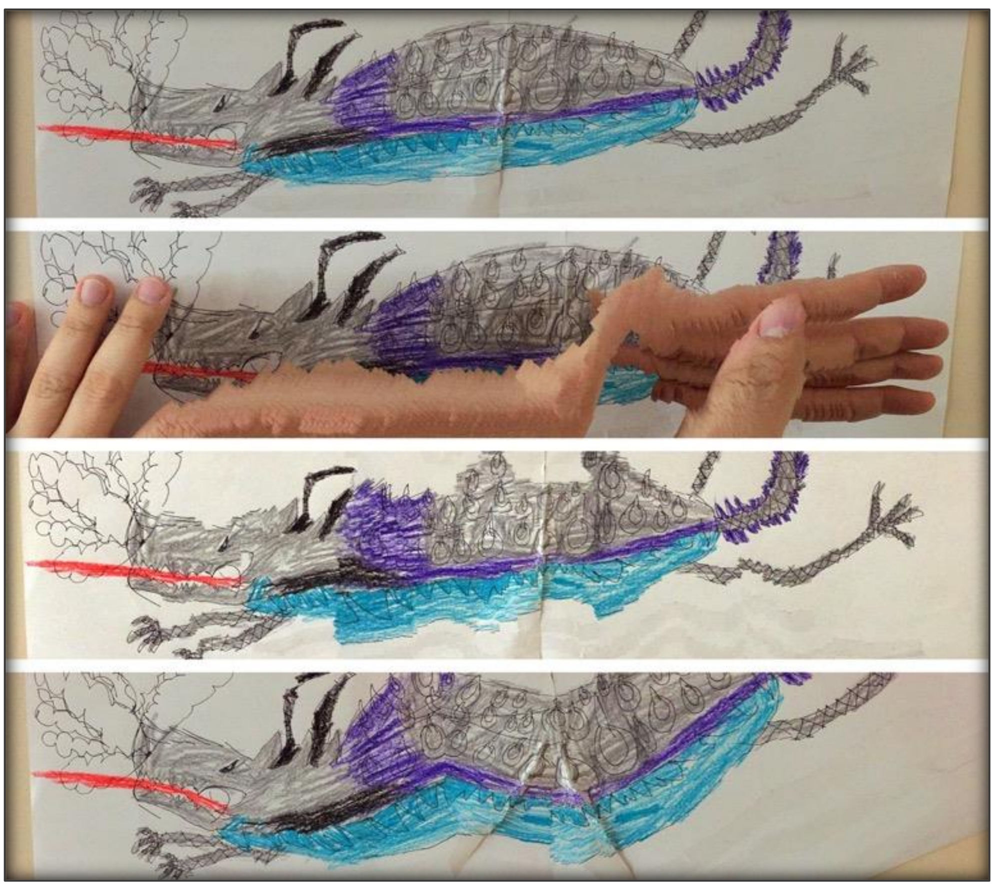
Case 1: Stitch-Skipping

Typically, artifacts designed for specific purposes provide—or should provide—information about their use. Possibilities for action or *affordances* are often related to physical objects and are ideally inferable from even very basic designs (Bransford, Shaw, & Minnesota, 1977; Norman, 1988). The notion of noticeable hints of the use or interaction possibilities of an artifact is referred to as *perceived affordances* (Gaver, 1991). For instance, by virtue of their shape, the affordances of objects such as hand axes, hats or spoons should be clear enough to require no further explanation. The concept of *affordance* has been also applied to digital interfaces, usually mediated by other semiotic resources. Sometimes this mediation is done subtly through interface metaphors, for example, where the affordances of artifacts familiar to the users are insinuated in the interface. Sometimes this mediation is as obvious as with skeuomorphic design, where the general aspect of an object is mimicked in the interface. In these information environments, explicitness of affordances makes *intuitiveness* a highly desirable feature. It can also occur that the affordances of an object or an interface are not perceivable but *hidden* (Gaver, 1991). In those cases the operation of the artifact would require explicit instruction, unless the function of artifact is to make the user discover those affordances, as with some video games.

Glitches can be provoked by acknowledging and willingly disrupting the perceived affordances of an object or system, or by receiving explicit instruction on how to interact with such an object or system and going against such instruction. Stitch-skipping consists in glitching panorama pictures by purposefully digressing from the protocol for their creation. These images display an elongated view of the selected scene that would be impossible to capture in an analogue photographic format. The process of creation of these kinds of images varies between devices and systems. However, it is possible to assert that, in general, in mobile devices–at least in the two currently leading operating systems (International Data Corporation, 2014)—the process of creation of these kinds of images requires the user to perform a relatively stable *sweeping* movement across the scene using the device's camera software. Mobile devices with panoramic picture capabilities usually provide basic instructions or indications of the procedure for production of a *canonical* panorama. Although it could be assumed that the available ways to disrupt the standard procedure for the production of panoramas vary on each system, these procedures of production would be the first aspect to be disrupted due to their accessibility, as the pervasiveness of both intentional and accidental panorama glitches in social media seems to prove ("Get Glitchy with Your Phone's Panorama Function," n.d.; Lowe, n.d.; Neff, n.d.), to the extent that it is relatively easy to find online tutorials for glitching panoramas. In these tutorials, the expected result of a photographic panorama is disrupted by the movement either of the camera or of any of the elements in the scene while the picture is taken. This implies that the norm for the creation of panoramas requires objects and subjects within the scene to remain still during the capture. Failing to comply with this condition, disregarding the systemic requirements of the software employed, results in a glitch.

The starting point of our inquiry was an attempt to understand the role of movement in the occurrence of glitches in panoramic photos by purposefully moving the camera, the subjects, and objects in non-normative ways. The first step consisted in creating a reference image in compliance with the *norm* or the expected outcome of a panoramic photo. After that, using conditions as similar as possible to those of the first shot, subsequent images were

in which either the camera or the elements in the scene were intentionally moved. The result was a normative image and a set of glitched versions of it. The first image was then compared with the set of glitched images to observe the differences and devise possible explanations.



Samples 1 & 2 (Top to Bottom):
Canonical Panorama; Moving Subject; Horizontal Motion; Vertical Motion.

Panoramic images break the ergonomic conventions that many optical devices such as cameras or displays have. These conventions (landscape orientation with a given proportion, either 4:3, 16:9, etc.) are arguably based on the distribution of the human eyes in the face (Skopec, 2004). Panoramic pictures extend the perception of a person beyond what can be perceived within a normal gaze and by doing so, alter the common narrative capabilities that regular photographs have (Nelson, 2007). Panoramas are created by assembling a sequence of pictures based on the similarity between the edges of the contiguous images (a process known as stitching). Considering the infinite number of factors and parameters that would play a role in determining when two images are contiguous, the stitching program allows for a generous margin of error, and it is within this margin of error that glitches emerge. Typical of glitches found on social media, the glitching agent is a person or an animal that moved during the take. In these images, the glitch reveals this movement, and by doing so, it reveals that panorama pictures are constructed from a sequence of discrete images, meaning that, in particular conditions, a glitch could denote time and sequence—features alien to standard photography. In addition to working with movement within the frame, we also experimented with provoking a glitched image by irregular movement of the camera while shooting. By choosing to not comply with the steady sweeping motion, the stitching process of the algorithm is swamped with incoherent data. The resulting product ends up being a visualization of the camera movement, as long as it follows a particular course; in other words, as long as the camera's motion has a modicum of coherence. In both cases, the resulting glitches are visualizations of the sequential processes that went into their making.

By doing so, the taker of the photo is formally represented in the resultant image, even though they do not appear as subject. This makes the malleability of representation much more obvious to the observer encountering a glitched image that captures something of the intention of the photographer. Typically, such representations remain indexical, pointing toward an assumed external reality from which the photographer, as the symbolic agent, remains absent. The invisibility of the photographer, the media, or the distribution network, hampers the learner's ability to develop and utilize critical thinking skills in regard to the politics of representation. This visual glitching process disrupts the illusion of reality conveyed by representational media, enhancing sensitivity to the processes underlying the creation of narratives of truth and fact.

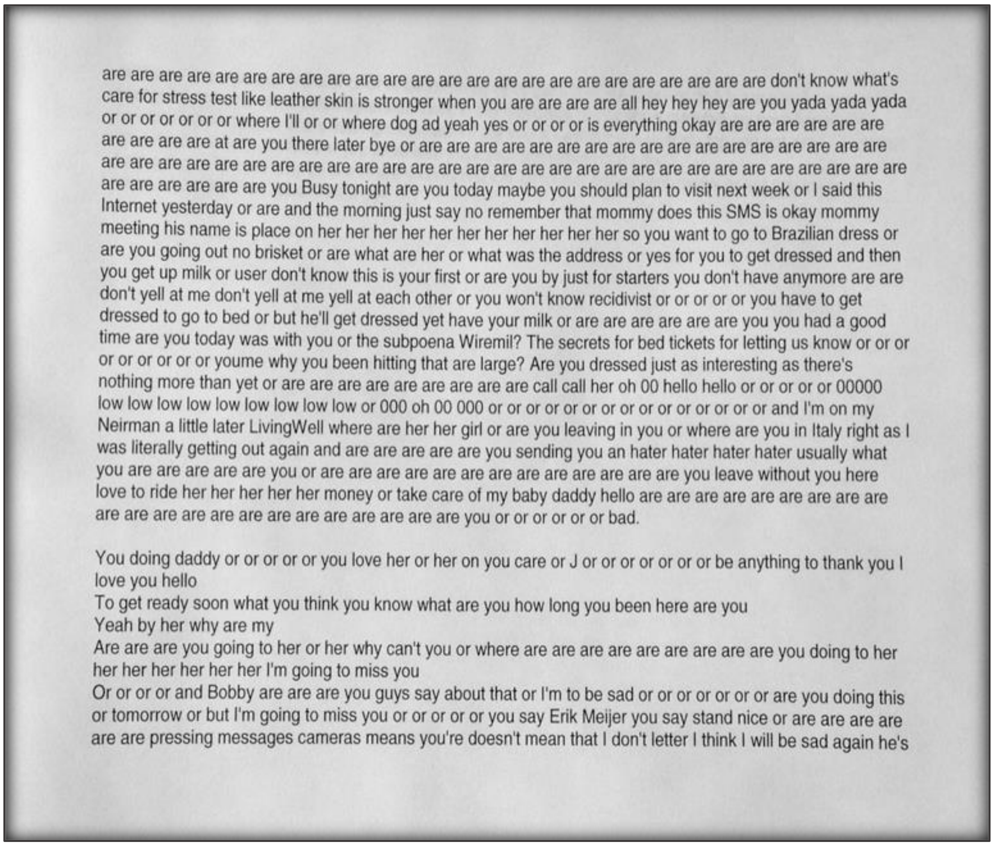
Case 2: Voice-Vaguing

Building on work that began in the 1930s (Huang, Acero, & Hon, 2001; Juang & Rabiner, 2006), the outstanding achievement of automated speech recognition or speech to text (STT) software symbolizes the ability to program machines to overcome challenges similar to those that "humans face in understanding language: linguistic analysis of input (deciding what was actually said); semantic processing of the input (interpreting what the input means); pragmatic processing of the input (decisions on how to respond to the input)" (Rost, 2011, p. 99). In order to achieve these goals with a level of dialogic fluency, computers require both substantial background knowledge (training) and robust computational tolerance for variations of acoustic input, the latter requiring far greater memory and processing capacity than is required for processing print text which benefits from discrete orthographic tokens and units. Speech, on the other hand, is continuous and does not distinguish homophones (e.g. there, their, they're) except through context. Automatic processing of natural language is "now used for a wide range of applications such as information extraction, machine translation, automatic summarization, and interactive dialogue systems" (p. 99). Recent advances in mutual processing by machine-learning algorithms have culminated in the development of neural net and deep learning models of speech processing programs that have helped speech recognition become a standard human-computer interface option. This development alerts us to the fundamental changes that will be brought about in many fields of education, and in particular to language and literacy education.

Deep learning algorithms are capable of successful word recognition across a broad spectrum of voices in many languages and dialects, and, moreover, are not voice-dependent in their training (Larson & Jones, 2012). Gone is the comparison of each vocal sound in real time to a standardized linguistic unit. Deep learning algorithms consider larger clusters of speech-sound, predicting the expression by spectral analysis based on a deep knowledge of underlying oral language structures currently in use by referencing big data rather than matching frames of utterance (Rost, 2011) to sounds made by an idealized speaker. In other words, these algorithmic systems have learned how to listen, understand, and in the case of artificial voices, to speak fluently in a so-called *natural* language through deep listening to billions of human utterances; they are deep learning in so far as they aggregate big data to increase tolerance of variation and accuracy of transcription, and have the ability to retrieve information that originates in human to human conversation as computer data based on their programmatic instructions. Since the nineties, for example, the U.S. National Security Agency has used voice recognition to scan phone and audiovisual networks for keywords, non-normative communications, and voice-prints of persons of interest (Froomkin, 2015); conversely these technologies are used in modern language education to assist humans to acquire and correct speech. By the nineties, commercially viable speech recognition software had reached a public with smaller average vocabularies than that recognized by the software. This discrepancy between individual human speech pattern recognition and that of deep learning algorithms has grown exponentially since 2010 (Deng, et al., 2013), to the point where it is even possible to scan transmissions of distorted or barely discernable conversation.

Development of natural language processing software is so rapid that if David Pogue (2010) was correct and "the keyboard isn't going away in our lifetime...99.9 percent accuracy is darned good—but until it reaches 100, speech-recognition technology [will] still [be] plan B" (p. 40), his prediction will have more to do with the intractability of habit than with the capacity of intelligent algorithms. Nonetheless, errors in interpretation abound even with sophisticated software, and without normative pronunciation or regular syntax, algorithms can no longer accurately predict utterances and are slower to compose. Our intent is to enhance understanding of current limits of deep learning speech recognition systems using voice-vaguing to exploit creative and pedagogical potential by increasing the ambiguity of language being input into the processor. The processor analyses incoming speech by filtering the waveform in layers, feeding in slowly adapting knowledge of linguistic patterns in the target language, and making predictions based on previous words spoken and current words to anticipate what the speaker will say next. This is a multi-tasking, feed-forward system of analysis that greatly speeds up the process of comprehension and emulates human linguistic processing, as we often guess another speaker, *putting words in their mouth*. This feature of anticipating linguistic expression is now standard in mobile phone technologies where words are both suggested in the process of being typed and changed instead of corrected; popular social media sites like www.damnyouautocorrect.com feature particularly funny or egregious predictive mistakes. Speech recognition failures are now also becoming popular entertainment as well. It is not necessary to understand the technical details of language recognition software in order to utilize these tools in a manner that is both entertaining and alerts learners to the broader implications of their use of mobile information and communication technologies.

We began researching speech recognition from the perspective of glitch pedagogy, by using improvised and extended vocal technique to create ambiguity and il-logical interference in the input data (voice-vaguing). This involved several stages in the generation of a textual artifact, one in which both human and artificial voices were used to vary input to the speech recognition software. Although proprietary, use of this software enabled access to deep learning algorithmic responses. Following an iterative remix process useful in developing critical media literacies (James, 2015), a selection of online videos featuring infants babbling (in their sleep, in conversation as twins, and playing on the phone) were input for voice recognition. Age extremes are an admitted weak spot in voice recognition software (see http://atmac.org/speech-to-text-dictation-software-for-os-x), which struggles with young voices (due to distribution of formants and fundamental resonances in the waveform). Because voice recognition software uses spectral analysis which filters out midrange tones and correlates low frequency resonances with co-efficient high pitches, one is relatively assured, with infant dictation to voice recognition software, of creating glitches. Regardless of the cultural group or language background of the infant, voice recognition reduced complex babble to one word, mainly "are," "or," or "her". What is particularly startling about these results from the humanist perspective is that even though the infants' babble sounds like speech with inflections and pauses modeled on adult language, the results are typically monosyllabic. For the example given in *Sample 3*, the introduction of other linguistic items primarily results from noise or adult voices in the background. Results for children up to the age of five continued this trend with very little accuracy even when it is relatively easy for a human adult to decipher the child's meaning. The baby-babble text resulting from this experiment became our data source for further iterative glitch experiments.



are are are are are are are are are are are are are are are are are are are are are are are are are don't know what's care for stress test like leather skin is stronger when you are are are are all hey hey hey are you yada yada yada or or or or or or or where I'll or or where dog ad yeah yes or or or or is everything okay are are are are are are are are are are at are you there later bye or are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are are you Busy tonight are you today maybe you should plan to visit next week or I said this Internet yesterday or are and the morning just say no remember that mommy does this SMS is okay mommy meeting his name is place on her her her her her her her her her her her her so you want to go to Brazilian dress or are you going out no brisket or are what are her or what was the address or yes for you to get dressed and then you get up milk or user don't know this is your first or are you by just for starters you don't have anymore are are don't yell at me don't yell at me yell at each other or you won't know recidivist or or or or or you have to get dressed to go to bed or but he'll get dressed yet have your milk or are are are are are are you you had a good time are you today was with you or the subpoena Wiremil? The secrets for bed tickets for letting us know or or or or or or or or or youme why you been hitting that are large? Are you dressed just as interesting as there's nothing more than yet or are are are are are are are are are call call her oh 00 hello hello or or or or or 00000 low low low low low low low low or 000 oh 00 000 or or or or or or or or or or or or or or or and I'm on my Neirman a little later LivingWell where are her her girl or are you leaving in you or where are you in Italy right as I was literally getting out again and are are are are you sending you an hater hater hater hater usually what you are are are are you or are are are are are are are are are are are are are you leave without you here love to ride her her her her her money or take care of my baby daddy hello are are are are are are are are are are are are are are are are are are are are you or or or or or or bad.

You doing daddy or or or or or you love her or her on you care or J or or or or or or or be anything to thank you I love you hello
To get ready soon what you think you know what are you how long you been here are you
Yeah by her why are my
Are are are you going to her or her why can't you or where are are are are are are are are are you doing to her her her her her her her I'm going to miss you
Or or or or and Bobby are are are you guys say about that or I'm to be sad or or or or or or or are you doing this or tomorrow or but I'm going to miss you or or or or or you say Erik Meijer you say stand nice or are are are are are are pressing messages cameras means you're doesn't mean that I don't letter I think I will be sad again he's

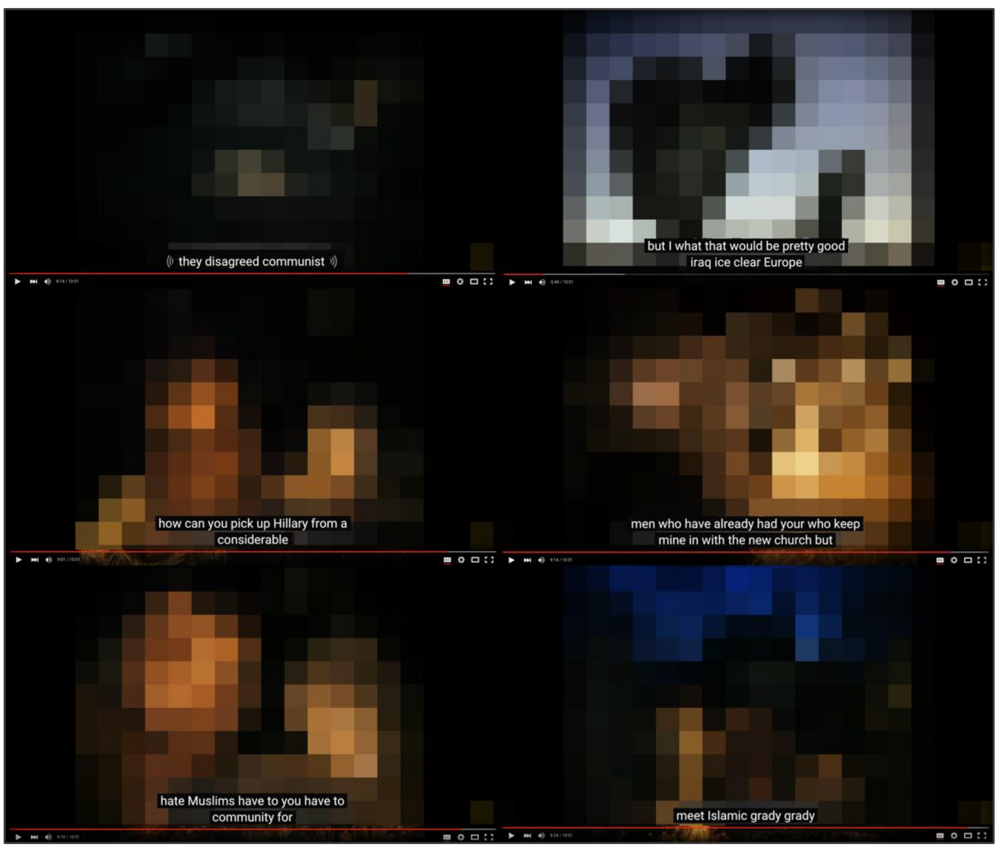
Sample 3. *Baby Babble Text.*

Case 3: Glot-swapping

Glot-swapping trades the vocal sounds of one language with another, such as expecting English diction to be captioned in Swahili. Typical uses of auto-captioning software include subtitles for persons with deafness or environments that require the sound on televisions to be muted. For our purposes, auto-captioning was activated in English to caption video versions of non-English children’s stories. The software combines both speech recognition and language translation algorithms which multitask as learning entities embedded within deep neural networks (Yu & Deng, 2015), just as someone learning a second language must do. As a glitch pedagogy experiment, we misrepresented input, challenging the translation/captioning process, whereby the software must homophonically translate the spoken words into an English equivalent.

Compared to the babble text, with adult voices the language classifier had more success at producing a diversified textual output, formulating probable English utterances from Russian, Spanish, and Hungarian source material. What is most remarkable about these examples of homophonic auto-translation is the frequency of words pertaining to corporate entities and national and religious identity (see *Sample 4*, Ёжик в тумане (*Hedgehog in the Fog*, Norshteyn, 1975) closed-captioning of https://www.youtube.com/watch?v=_Rugwd8ZNHY). A critical lens on the concomitant texts might focus on the dominant presence of corporations such as Facebook and Google in Big Data—perhaps a value-motivated skewing of the artificial agents—and inspect the nationalistic and imperialistic overtones of the probability-generated phrases, which are made that much more perverse as mis-readings, or glitch-readings, of children's stories. Seeing the bigger picture of language-use allows the glitch pedagogue to extend their lesson-based experiments with captioning software to examine how our computerized interlocutors can make errors and how these can be inherently biased, which potentially results in unwarranted accusation or suspicion.

From a critical literacy perspective we would emphasize that while the algorithms learn from us, we are learning from the algorithms. In fact, from our brief experiments, one might say that such auto-captioning software drawing on big data as stored on United States-based servers is a tad xenophobic. Xenophobia in algorithms, or at least a sense of cultural bias in the programming of such algorithms, has been explored by researchers working on automated language assessment for international literacy testing items and evaluation protocols (Maddox, 2015) and in the analysis of Google's technologies and algorithms (Noble & Roberts, 2016). Recent glitch-tweeting escapades of Microsoft's racist, drug-smoking, teenage-girl, Artificial Intelligence chat-bot garnered unwanted international attention for adopting these very human traits (Gibbs, 2016). One does not think of artificially intelligent systems, robots, or international testing items as having cultural or racial biases, but there are clearly indications that they represent biases inherent to the discourses of dominant user groups. Once again, there is room here for critical literacy scholars to take a much closer look at these instrumentalised paradigms of automated language processing as governments and large institutions increasingly rely on computer generated, artificially intelligent interpreters.

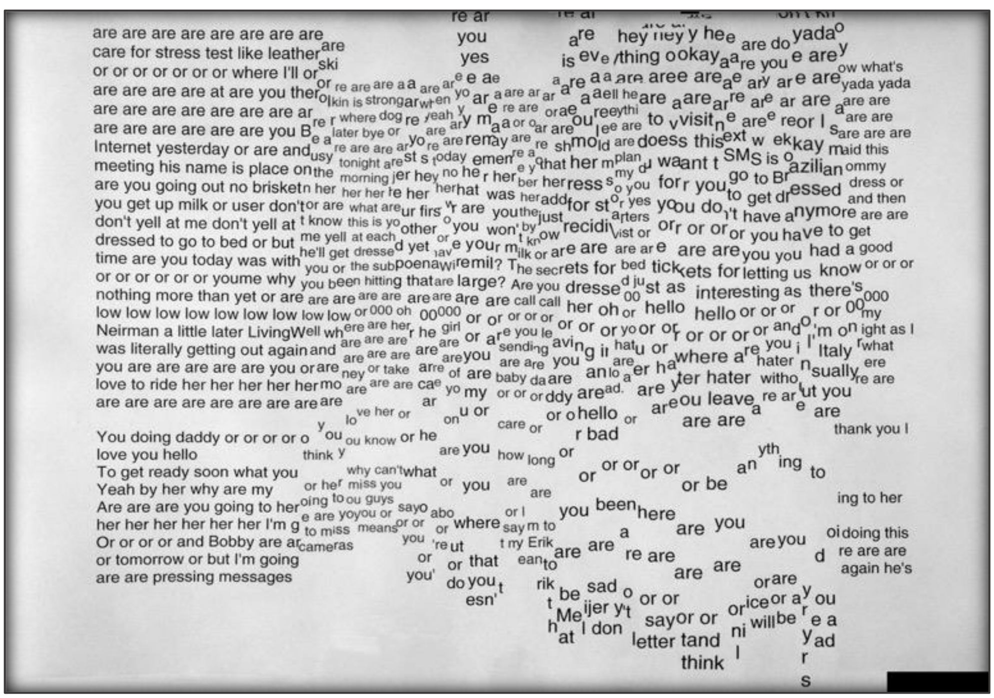


Sample 4. *Ёжик в тумане (Hedgehog in the Fog).* Closed captioning.

Case 4: Toward Iterative Glitch

Along with glitch artists, we posit a perverse desire to witness deformity in the becoming of digital objects, so that we might see this object anew and awaken our senses to the appeal of the accidental, the beauty of errors in processing. In the same way that a child amazes the adult with uncanny yet poetic and wise utterances, we seek to be enlightened and entertained by unexpected outcomes. We fast-track our learning and engage at the level of consummatory experience with the otherwise mundane or routine software applications implicated in daily literacy practices. Continuing in this autodidactic glitch pedagogy, we undertook the production of texts that would combine all the previous elements—voice-vaguing, stitch-skipping, glot-swapping, using text-to-speech artificial voices to read multilingual texts to voice recognition systems, a *code-bending* practice which brings Optical Character Recognition (OCR) and Google's translation software into the recombinant error-prone process of iterative glitch-text generation. Owing to the unpredictable outcomes of the increasingly complex tasks set for probabilistic calculation, we are repositioned as learners, even while teaching with glitch pedagogies.

For this recombinant case in which an iterative method of provoking errors in human-computer semiosis was employed, the text was generated with speech recognition software trying to recognize the vocalizing babble of children, from infants to five-year-olds. The resultant script (see *Sample 3*) was printed out on standard letter format white paper, and a glitched photo panorama was taken using a mobile phone. Saved as an image file, the graphic text (which resembled concrete poetry, see *Sample 5*) was uploaded to a free online OCR program. The OCR recognized the distorted and recombined graphemes as letters and ideograms from a broad cross-section of languages. It was enjoyable from a pedagogical point of view, to have languages specialists in our academic department deciphering this multilingual polyglot text (see *Sample 6*). Running the computer's text-to-speech program identifies the unicode character before speaking it, which gave us a way to true our predictions, turning this process into a highly educational glot-swapping game.

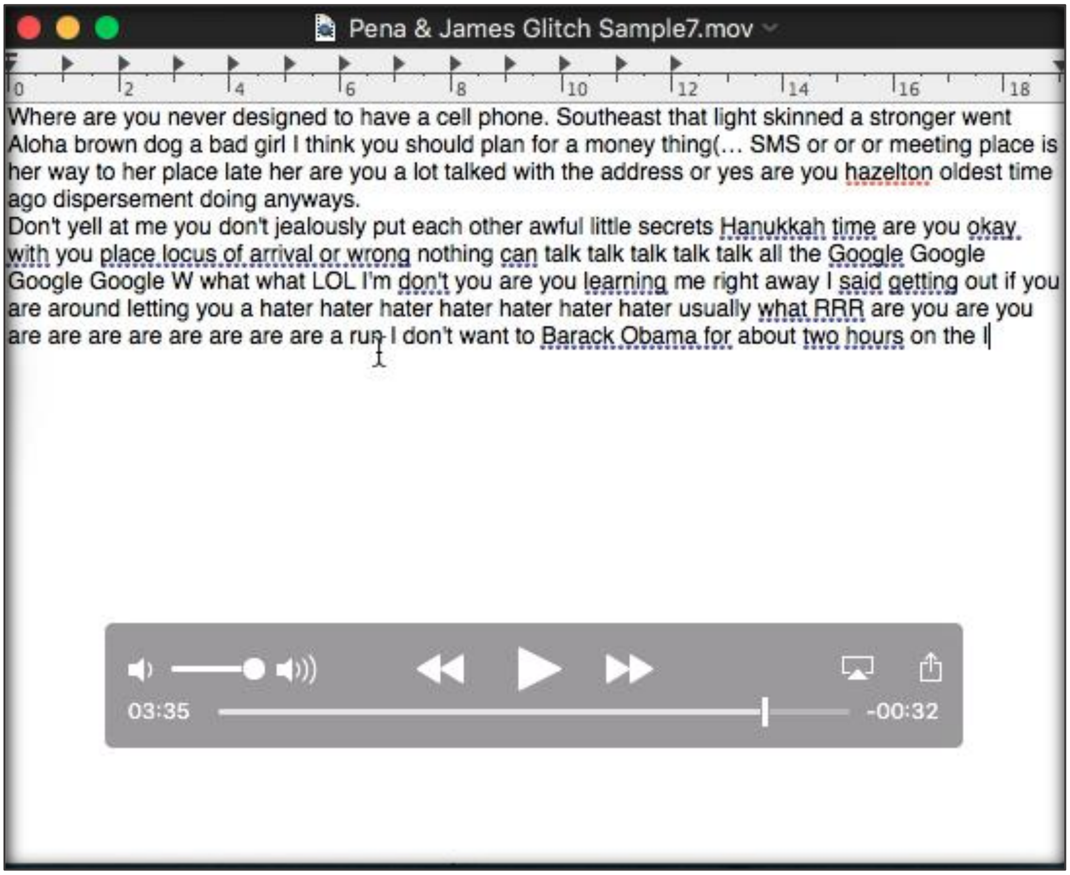


Sample 5. *A Glitched Panorama Photograph of Sample 3.*

ℒΘ af ご ○項 ~ E von i u twi i
-1 i V-2 on O !!!!!!!!!ំ yOU are hey'rey y hee afe doyo, 蠶 驚 蠶 test 獻 驚 yeS is eve/thing ookayaa: yOU e afe,
What's Of Or Where 鬣 re are are a a are 韇 ae . 蠶* areao ay are areyada yada are are are are at are yout
osolkins Strongarwhen y a臂獸 afe ar o a oel heare aarearse are ar are ᗣ.8 € are are are are are are are ar.
orae ..reeythi
where dog re yeah, y m OU to VVisitne areo reor are are are are are are are are you BGK bye of \, are að "aas
earare9^sée are ^ vV*$"n Sare are are
i. ext Internet yesterday or are and se areare ayo: aerenày: reshmoida edoess this: w ekkaym:
e a - - - - ក្ំ : ប៊ា្ Wahatherm# waantt SMS is ឧziញ្ំ - 驚麒he獻rhe噶蠶需 you3° t05'j dressor are you going Out no
brisketn her her hese her herhat was O y to get dresse
- her O and then you get up milk or user don'tor are what areur firs or are 濾轟or St; 鷺 yCou dont have
asysmore are are
l i - - , , . cistϴ
don't yell at me don't yell at theំ ឡ Yon? OW recidi' of Osr or Ofor you have to get n
dressed to go to bed or but he'll get Gressed yet awo your m: are are are are are areyou you had a good
time are you today was with you or the subpoenawisemil? The secrets for bed tickets for letting us know OY Ol
OY
or or or or or or youme Why you been hitting thatare large? Are you dresses: as interesting as thereṣood
nothing more than yet or are are are are are are are are are call call 0 her |O Or 0 low low low low low low low
low low oro OO999 or or or or of oh or hello hello or or r Or o ímy
- - -- - Or aՈր̀ ·́ --, -, Ո i Neiman a little later Livingwell where or he girl e you e o or or yoor of or or or or *dom
oojght as
Or - - was eay:hao areosendingoog ou of e you Italy'what
afe r
are are OՄ Where a afe arey 0Մ afe hater ΘfΘ you are are are are are you orarejî, ortake arrej ars, 'j°'° Ｙ ha n
lo , ef - sually - baby daare as 10 a er hater witho fΘ afΘ love to ride her her her her hermo are are are 覽 Y9 my
or or 蠶 aread, are y! (ut you
fΘ af are are are are are are are area" we her, * u or nello areo: leave," "e afΘ lo or OΠ Care OY O Or arΘ afΘ
hank | - y Or bad thank you You doing daddy or or or or o ou ou know or he OՄ f Oa yth love you hello think y
are you how longo" OY OY an ing To get ready soon what you r "...whate, afe Or or Or be to Yeah by her why
are my of 蠶 yOU are Or ing to her Are are are you going to her: sayo abo or you beenhere her her her her her
her I'm go...ss meang or or where saym * a are you 6, oidoing this Or or or or and 黯 are acameras *...* ut th
"...are are re afe arey. fΘ aYΘ afΘ or tomorrow or but I'm going | or tna to afe again he's are are pressing
messages " do yout rik, sad afe Orafe y esn' t be ijer 號 OY Ol orice? 臀 OՄ Me 蠶° §âyo! o! ı will be 'e a at
letter tand | yad think s

Sample 6. *OCR Interpretation of Sample 5.*

In addition, an improvised musical recording of a live vocal performance of the baby babble source text accompanied by amplified analogue and synthesized soundscape was produced. This audio file was also played to a computer running speech recognition software so that a comparison could be made between textual products of analogue and digital glitch experiments. In comparison, the computer-generated textual remix of the children's voices is highly complex and sophisticated. Stitch-skipping produces distortion at a graphemic level. By comparison, the noise distortion factor of voice-vaguing with musical interference in data for speech processing of spoken words results in a more visceral text with corporate/political overtones, referencing Google several times, and current U.S. President Barack Obama (neither of which is present in the *song* form, see *Sample 7*). These results correspond with similar observations made in the Case 3 glot-swapping experiment. This comparison of results between graphically glitched and sonically glitched source texts provokes further stages for research needed to explore the potential for transmediation across sensory domains.



Sample 7. Screen-Capture Video of Voice Recognition Software Interpreting a Pre-recorded Performance of Sample 3 Text. **Note:** To view this video, open the supplemental file to this article from the table of Contents of this issue of JCACS (Volume 14, Number 1) or visit https://vimeo.com/188163815.

Once a text begins its iterative journey, it is never finished or complete; indeed, through selective editing, recycling, and re-processing, the text takes on a variety of different r*eadings*. From an educator's perspective, this is precisely what we hope to encourage in students when teaching critical digital literacies. In addition, we puncture the superficial application of computers to witness the extrusion of deep layers of data available to device-level intelligence, thereby engaging creatively with the algorithmic, deep learning characteristics of contemporary language recognition software. We acknowledge the artificial intelligence entities who, once trained, begin *ipso fact*o to train the user, to interpret them and reflect back the interpretation as search results, or word suggestions, or formatting expectations, or in response to a command based verbal dialogue. Programs begin to write the user, making many formal operations of textual production and delivery first facile and then redundant. The more digital automation does for the user, the less the user is aware of what the automation is doing, how well or how poorly it is doing it, and to what ends, other than the most superficial aspect of serving an (inter)personal communication.

Conclusion

Glitch pedagogy helps the learner to gain an overview, even if very partial and with all manner of bias, of the big data substrate on which contemporary voice and visual recognition systems have taken root. Through myriad network/media channels, this substrate is brought to the surface, recycled by the users who are grown on that substrate of global sociolinguistic behaviour, conditioning language use and awareness of the youngest populations, as we increasingly turn toward digital devices like computers and tablets to entertain, educate, and otherwise babysit biological offspring. As Schaff and Mohan (2014) claim,

> parents are using their digital devices as pacifiers or babysitters...as a global society we are exposing children to digital games at a very young age. Infants in strollers are l*earning* content and skills using the devices provided by their parents...it would be logical to assume these children would grow up craving the same learning delivery method they used as an [sic] infants. (p. 16)

The point at which the computer application becomes agentive in not only the product but also the production and assembly of communication and cognition, or semiosis and psyche, a strong and peculiar bond is formed between the artificial other and the individuals it serves. In this sense, the prescriptive programming of social algorithms has the same force as genres do, as Schryer (1999) states, "because they exist prior to their users, [genres] shape their operators; and yet their users and their discourse communities constantly remake and reshape them" (p. 81). This reshaping process involves misappropriation of socio-cultural/algorithmic norms. Glitch pedagogy can be used to interrogate that relationship between served and server, between used and user, dialogically and creatively. It opens the parameters of our own understanding, offering surprising resonant clusters of meaning, expression made possible only through collaborative expression between human and robotic semiosis. This way, poetry grows through the cracks in intended meaning enlightening us as to the nature of our discourses.

In another sense, these experimental discourses with algorithmic familiars is a game. Digital gaming is frequently put forward as a way to motivate learners "in a safe virtual environment where failure is a powerful learning experience without the serious consequence or stigma of real-life mistakes...in the traditional classroom, students make mistakes and they are marked down, lose points, or they fail" (Schaff & Mohan, 2014, p. 17). Glitch pedagogy not only instigates the game-sense of learning but celebrates mistakes and processing errors as central to creativity, inquiry, invention, and discovery of processes underlying knowledge construction and mobilization in the twenty-first century. We provide the following manifesto of glitch pedagogy as a provocation to curriculum thinkers and designers and to instigate a new method of educational inquiry. With it, we hope to instigate a different vision of the educational affordances of digital devices that play so significant a role in contemporary learning and understanding.

Manifesto of Glitch Pedagogy

1. The movement of Glitch Pedagogy recognizes accident and error as inherent to all learning processes.
2. Glitch is understood to be the formative source of learning; glitch-free environments repulse rather than attract curiosity and inquiry.
3. Glitch is particularly effective as a means to convey meta-knowledge of systems and systems-thinking.
4. Glitch is caused by incommensurable input which is improperly digested by logical processes. The input is thus recombined and reconstituted irregularly producing new or unexpected results.
5. Glitch arises on a backdrop of programmatic consistency. It is therefore stigmatized.
6. Glitch interrupts the industrialist and the fascist. Glitch then interrogates power without cruelty or revenge.
7. Glitch is non-conformity.
8. Not until digital technology dominated the socius did glitch become paradigmatic and utilitarian.
9. Glitch provokes the hipster revolution. Without exemplary inconsistency, character is barren. Inconsistency gives character to ideas, charges them, puts them in motion.
10. Glitches are inherently amoral; they are neither good nor bad, but rather are the product of natural law in information environments.
11. Without glitch there is no evolution and no innovation. Glitch pedagogy is the best preparation for life.
12. Einstein's maxim that problems will not be solved by the same thinking that created them is our central tenet.

Sample 8. *Manifesto of Glitch Pedagogy*

References

Armstrong, S. (2015, January). *Motivated value selection for artificial agents*. Paper presented at the 2015 AAAI Workshop, Austin, TX. Retrieved from http://www.aaai.org/ocs/index.php/WS/AAAIW15/paper/viewFile/10183/10126

Aoki, T. T. (1999). Toward understanding "computer application." *Counterpoints*, *70*, 168–176.

Bright, J. R. (1958). *Automation and management*. Boston, MA: Harvard Business School.

Chunn, E. (2014). *The technological humanity of John Dewey* (Bachelor of Arts honors thesis). Portland State University, Portland, Oregon. Retrieved from http://pdxscholar.library.pdx.edu/honorstheses/31

Deng, L., Li, J., Huang, J. T., Yao, K., Yu, D., Seide, F.,…Acero, A. (2013). Recent advances in deep learning for speech research at Microsoft. In *2013 IEEE International Conference on Acoustics, Speech and Signal Processing* (pp. 8604–8608). Vancouver, BC. Retrieved from http://doi.org/10.1109/ICASSP.2013.6639345

Dewey, J. (1934). *Art as experience*. New York, NY: Balch.

Elbow, P. (1981). *Writing with power: Techniques for mastering the writing process*. New York, NY: Oxford University Press.

Emig, J. (1971). *The composing processes of Twelfth Graders*. Urbana, IL: National Council of Teachers of English.

Froomkin, D. (2015). The computers are listening: How the NSA converts spoken words into searchable text. *The Intercept*. Retrieved from https://theintercept.com/2015/05/05/nsa-speech-recognition-snowden-searchable-text/

Gaver, W. W. (1991). Technology affordances. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 79–84). New York, NY: ACM. Retrieved from http://doi.org/10.1145/108844.108856

Photojojo. (n.d.). *Get glitchy with your phone's Panorama function.* Retrieved from http://content.photojojo.com/inspiration/photo-projects/how-to-make-phone-panorama-glitches/

Gibbs, S. (2016, March 30). *Microsoft's racist chatbot returns with drug-smoking Twitter meltdown.* Retrieved from http://www.theguardian.com/technology/2016/mar/30/microsoft-racist-sexist-chatbot-twitter-drugs

glitch, v. (n.d.). *OED online*. Oxford University Press. Retrieved from http://www.oed.com.ezproxy.library.ubc.ca/view/Entry/78999

Hernández, P. (2012). *It's not a glitch. It's a feature. It's art. It's beautiful*. Retrieved from http://kotaku.com/5933722/its-not-a-glitch-its-a-feature-its-art-its-beautiful

Hickman, L. A. (1990). *John Dewey's pragmatic technology*. Bloomington: Indiana University Press.

Hickman, L. A. A., & Alexander, T. M. M. (Eds.). (2009). *The essential Dewey: Ethics, logic, psychology* (Vol. 2). Bloomington: Indiana University Press.

Huang, X., Acero, A., & Hon, H.-W. (2001). *Spoken language processing: A guide to theory, algorithm, and system development*. New York, NY: Prentice Hall.

International Data Corporation. (2014, February 24). *Android and iOS squeeze the competition, swelling to 96.3% of the smartphone operating system market for both 4Q14 and CY14, according to IDC*. Retrieved from http://www.idc.com/getdoc.jsp?containerId=prUS25450615

James, K. (2015). Mapping critical media literacy onto iterative remix practices. In P. Schmidt & A. Lazar (Eds.), *Reconceptualizing literacy in the new age of multiculturalism and pluralism: A tribute to Peter Mosenthal* (2nd ed.) (pp. 125–150). Charlotte, NC: Information Age Publishing.

Johnson, B. (2011, October 31). *Teaching and learning: Using iPads in the classroom*. Retrieved from http://www.edutopia.org/blog/ipad-teaching-learning-apps-ben-johnson

Juang, B., & Rabiner, L. R. (2006). Automatic speech recognition: A brief history of the technology development. *Encyclopedia of Language & Linguistics* (2nd ed.) (pp. 806–819). Oxford, England: Elsevier.

Krapp, P. (2011). *Noise channels: Glitch and error in digital culture*. Minneapolis: University of Minnesota Press. Retrieved from http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10519768

Krutz, D. E., & Lutz, M. (2013). Bug of the day: Reinforcing the importance of testing. Publications from the *2013 IEEE Frontiers in Education Conference (FIE)* (pp. 1795–1799). Retrieved from http://doi.org/10.1109/FIE.2013.6685147

Larson, M., & Jones, G. J. F. (2012). Spoken content retrieval: A survey of techniques and technologies. *Foundations and Trends in Information Retrieval*, *5*(4–5), 235–422. Retrieved from http://doi.org/10.1561/1500000020

Leonard, D. (2013, October 24). *The iPad goes to school*. Retrieved from http://www.bloomberg.com/bw/articles/2013-10-24/the-ipad-goes-to-school-the-rise-of-educational-tablets

Lowe, J. (n.d.). When panorama photography goes wrong. *HUH Magazine*. Retrieved from http://www.huhmagazine.co.uk/8050/when-panorama-photography-goes-wrong

Maddox, B. (2015). Inside the assessment machine: The life and times of a test item. In M. Hamilton, B. Maddox, & C. Addey (Eds.), *Literacy as numbers: Researching the politics and practices of international literacy assessment* (pp. 129–146). Cambridge, MA: Cambridge University Press.

Menezes, J. (2010). *Creative processes in free improvisation* (Unpublished masters thesis).

University of Sheffield, Sheffield, England. Retrieved from http://hdl.handle.net/10174/6051

Menkman, R. (2011). Glitch studies manifesto. In *Video vortex reader II: Moving images beyond YouTube* (pp. 336–347). Amsterdam, The Netherlands: Institute of Network Cultures.

Mullis, E. (2009). The device paradigm: A consideration for a Deweyan philosophy of technology. *The Journal of Speculative Philosophy*, *23*(2), 110–117.

Murphy, M. E. (2014, August 5). Why some schools are selling all their iPads. *The Atlantic*. Retrieved from http://www.theatlantic.com/education/archive/2014/08/whats-the-best-device-for-interactive-learning/375567/

Neff, M. (n.d.). *Did I stutter: iOS panorama glitch photos*. Retrieved from https://www.flickr.com/photos/army-of-neff/sets/72157632998618461

Nelson, A. J. (2007). *Reading photobooks: Narrative montage and the construction of modern visual literacy* (Unpublished doctoral dissertation). University of Minnesota, Minneapolis. Retrieved from http://search.proquest.com/docview/304822999

Noble, D. F. (1986). *Forces of production: A social history of industrial automation*. Oxford, England: Oxford University Press.

Noble, S. U., & Roberts, S. T. (2016). Through Google-colored glass(es): Design, emotion, class, and wearables as commodity and control. *Media Studies Publications, 13*. Retrieved from http://ir.lib.uwo.ca/commpub/13

Norman, D. A. (1988). *The psychology of everyday things*. New York, NY: Basic Books.

Norshteyn, Y. (Director). (1975). *Hedgehog in the fog* [animated film]. Russia: Soyuzmultfilm.

Oral, S. B. (2013). Exploring the ideal of teaching as consummatory experience. *Education and Culture*, *29*(2), 133–158. Retrieved from http://doi.org/10.1353/eac.2013.0010

Pogue, D. (2010, December). Talk to the machine: Speech-recognition programs are no longer clumsy exercises in futility. *Scientific American, 303*, 40.

Pressing, J. (1988). Improvisation: Methods and models. In J. A. Sloboda (Ed.), *Generative processes in music* (pp. 129–178). Oxford, England: Oxford University Press.

Rost, M. (2011). *Teaching and researching listening* (2nd ed.). London, England: Routledge.

Schaaf, R., & Mohan, N. (2014). *Making school a game worth playing: Digital games in the classroom*. Thousand Oaks, CA: Corwin.

Schön, D. A. (1992). The theory of inquiry: Dewey's legacy to education. *Curriculum Inquiry*, *22*(2), 119–139. Retrieved from http://doi.org/10.2307/1180029

Schryer, C. F. (1999). Genre time/space: Chronotopic strategies in the experimental article. *JAC: A Journal of Composition Theory, 19*, 81–89.

Shaw, R., & Bransford, J. (Eds.). (1977). *Perceiving, acting, and knowing: Toward an ecological psychology*. Hillsdale, NJ: Lawrence Erlbaum.

Skopec, D. (2004). *Digital layout for the Internet and other media*. New York, NY: AVA Publishing.

Stimson Jr., T. (1961, May). Are we licking our missle fizzle? *Popular Mechanics*, *115*(1), 238.

TeachThought Staff. (2014, December 14). *52 of the best apps for your classroom in 2015*. Retrieved from http://www.teachthought.com/the-future-of-learning/technology/52-of-the-best-apps-for-classrooms/

Tiles, J. E. (1990). *Dewey*. New York, NY: Routledge.

Willis, J. (2007). The gully in the "brain glitch" theory. *Educational Leadership*, *64*(5), 68–73.

Yu, D., & Deng, L. (2015). *Automatic speech recognition: A deep learning approach*. London, England: Springer.

Endnotes

[1] The experiments discussed in this paper were conducted in, and used the technical resources of, the Digital Literacy Centre of the Department of Language and Literacy Education at the University of British Columbia.