Creative Explorations of the Glitch in Music
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ABSTRACT
Most developments in science and technology are achieved by the persistent and logical exploration of a variety of related approaches towards a known goal; a few result from sudden inspiration, which is often based on an insight into the implications of accidental occurrences. The same processes can be seen in music and other art forms. The recent interest in exploiting unintentional digital "glitches" in the musical field known as electronica is, however, not a new approach, but has a long history. As with other digital terminology, such as "sampling", the retrospective application of "glitch" to comparable earlier explorations can be fruitful. An unusual perspective on the recent change from analogue to digital technology is also offered.

My original intention to cover this subject in greater detail than I have previously done has become somewhat diverted by the addition of other related aspects that I feel are of interest in the present context. I hope you will excuse me if some of my technical descriptions are overly simplistic; this is the best that I can do, as a composer who has strayed into the history of technology. At the same time I hope that I can bring fresh light into certain areas, by studying them entirely for their musical or sonic significance.

I will start with two unusual musical instruments from the 18th century that were respectively used in and inspired by scientific research. In or before 1785 Abbate Don Giulio Cesare Gattoni constructed a giant outdoor harp or meteorological harmonica ["arpa gigantesca" or "armonica meteorologicale"] with 15 steel strings that were strung 150 "paces" from the 12th century tower owned by his family next to the old city wall in Como. This Aeolian harp responded to atmospheric changes, especially the amount of wind, but was silent when it rained. In this tower Gattoni established a "physics" laboratory ["gabinetto di fisica"] in 1764-65, and it was here that the young Alessandro Volta made his first electrical experiments; in 1768 Gattoni installed on it the first lightning conductor rod in Como (perhaps even in Italy), with "electric harp" warning bells.

The earliest musical instrument that involved electricity as an essential part of its mechanism was the slightly earlier Clavecin électrique (Electric Harpsichord or Keyboard), invented in France by another priest, Jean-Baptiste De la Borde, in or before 1761. Static electricity was used, for each note on the keyboard, to activate a striker suspended between a pair of bells tuned in unison, as used in Gattoni's lightning conductor. This is an early use of the 19th century principle of the electric door-bell, in which the movement of the striker interrupts the electrical circuit and thereby returns the beater to a resting position in which the electrical connection is re-established, producing a continuous tremolo for as long as the power supply is connected; with static electricity the same result was obtained by reversing the electrical charge in a manner that a non-specialist today can better understand in terms of alternating magnetic attraction and repulsion. Indeed in 1789 a second French priest, Abbé Pierre Bertholon, described a similar keyboard instrument called the Clavecin magnétique (Magnetic Harpsichord), which as far as I can discover has never previously been reported in this context.

Where did De la Borde's idea come from? By the late 1740s researchers were becoming aware that electrical installations contained an invisible, potentially lethal charge, for which some form of warning would be advisable; a few years later the same applied to research into atmospheric electricity using kites. Two methods existed, originally devised for specific experiments or demonstrations: "Mr. Canton's balls" (the basis of the Electroscope), consisted of two suspended pea-sized cork or pith balls whose movement visually indicated the presence and amount of an electrical charge, while an unnamed alternative method added a sonic warning to the visual one - a pair of similarly activated small bells with a striker, the inspiration for De la Borde's later instrument. This method appears to have been devised by the Scottish-born Benedictine monk Andreas (Andrew) Gordon, while he was a professor of "natural philosophy" in Erfurt, Germany; it was described by him in a book published in 1744. Benjamin Franklin was one of several researchers who adopted the "German chimes" soon afterwards, following a demonstration of electrical discoveries that he attended in Boston in 1746; Franklin's favourite portrait of himself (originally a painting, later a print that he disseminated as media stars do today with signed photographs) prominently shows pairs of electrified bells and balls, with lightning and a lightning conductor visible through a window.

This is the most common type of scientific development, extrapolating from previous discoveries. But some of the most significant technological discoveries have taken this approach much further, recognising the significance of a purely accidental occurrence, often by the application of lateral thinking. It takes a particular type of creative mind to see the potential of such an accidental discovery, especially when this potential proves in the long term to be far more important than was originally apparent.

In this presentation I will survey some of the ways in which musicians have exploited such accidental discoveries. I will call such discoveries "glitches", one of several words that have gained a specific meaning in connection with digital audio (another is "sampling") and also prove to be valuable in describing earlier unnamed analogue equivalents. Here I define the "glitch" as an accidental or deliberately-caused malfunctioning of a musical instrument or item of audio-related equipment, which often has an unpredictable and potentially fruitful result; by "malfunctioning" I encompass all methods of creating sounds that were not intended by the inventors, designers or manufacturers. In 1991 the American composer-performer Nicolas Collins described this very vividly: "Computer music in general seems sadly deficient in ‘benevolent catastrophe’. The analog circuitry of older electronic music usually sounded best when it was being ‘misused’ or was on the verge of breakdown...” A comparable trend in the visual arts in the 20th century is the incorporation of found objects and materials, in as collage and the sculptural use of scrap.

I would like to illustrate this with some accidental discoveries from outside music. The first two that came to my mind were the pollution of a test specimen that led to the discovery of penicillin (by a different British scientist called Fleming than the one we are celebrating this year), and the much more prosaic peel-off glue that is used for such things as “Post-It Notes” [DEMO], which resulted from the complete failure of an attempt to produce an extra-strong glue - who could have a use for a non-permanent adhesive!

Two further examples are much more closely related to our own interests, and without them none of us would be assembled here today: the telephone and the phonograph or gramophone. These were discovered less than two years apart. In June 1875 Alexander Graham Bell was working on a multiplex harmonic telegraph (the focus of the most advanced researches of the time); one hot day his assistant, trying to free a reed in the mechanism that had become stuck, inadvertently plucked it, and this was heard by Bell as a faint sound on his telegraph receiver in the next room - leading him to realise that it might also be possible to transmit speech in the same manner. Other priorities meant that he did not produce his first operational telephone until March 1876.

In 1877 Thomas Alva Edison was similarly inspired by the incidental sounds produced by the speeded-up “replay” of the indentations of Morse Code characters in his experiments in constructing a telegraph repeater, giving him the idea that led to the construction of the first machine capable of both recording and replaying sound (his contemporary, the French poet Charles Cros, also described such a machine, but apparently never constructed one). Here I would like to mention Edison’s first sketch of a phonograph, which his machinist apparently built overnight but actually took six days, but the histories do not mention Edison’s previous experiments with telegraph repeaters that included cylindrical machines, or that a cylinder rotated by a handle was a common basis for many machines in scientific research in the 1870s, so that the first phonograph was probably assembled from standard materials, with a stylus plus diaphragm each for recording and for playback (already explored in his experiments on a “speaking telegraph”); the only new element was the replacement of the paper by a sheet of tin foil.

These two inventions changed the world. After a slow start, they formed the basis for all modern forms of communication; many major industries in the 20th and 21st centuries would not have existed without them. But they also initiated something else, on the technical side, which may be obvious to all of you, but seems to have rarely been described in print. For the last quarter of a century we have lived in a digital age, following an analogue one. But this must be considered as the second digital age - the first one was brought to an end by these two inventions of Bell and Edison. Up to then, all communications (in the modern sense) were digital, although they were rarely binary: such as Morse Code, the electric telegraph, semaphore with flags, Native American smoke signals, whistle languages and African drum messages.

Today's second digital age may in fact turn out to be a hybrid one, in a period of consolidation after the initial explorations of digital techniques have been exhausted. Pointers towards this in musical electronics are highlighted by a nostalgia for the "warm sound" of analogue equipment and its reflection in the continuing, albeit more specialist, manufacture of vinyl LP records, the use of valve [tube] circuitry in some microphones and amplifiers, and the combinations of analogue and digital methods (as well as "virtual analogue") in certain synthesizers. Two current developments illustrate this more precisely: although the use of valves in synthesizers had been extremely rare (one very early machine and one recent one), in the output stage of its latest models a leading Japanese company, Korg, has introduced its new "Valve Force" technology that, as its American publicity states, "pumps out real tube-driven tone that goes from warm to snarling" (one reviewer has stated that, with the level turned full up, the sound is capable of "true distortion"); and one of today's growth areas in computer-based software synthesizers is the accurate emulation of significant analogue synthesizers from the 1970s.

This new perspective has substantially influenced my thinking. For example, traditional musical instruments can be classified as being either digital (nearly all keyboards, the harp and the lyre) or analogue. It is therefore not very surprising that earlier developments in mechanising or automating the most widespread digital instrument, the piano (in the form of the player piano), stopped early in the analogue era (with refinements continuing into the 1920s), and did not restart until the 1980s at the beginning of the second digital one.

Now to a brief historical survey of the use of the glitch in musical performance. Although this session is concerned with electronics and music, "glitching" in music began much earlier. I will omit the host of instruments over the centuries which were only briefly popular before ending up in museums, even though a few of them attracted the interest of major composers, such as Bach, Haydn, and Schubert; in most cases their performance techniques were identical or almost identical to those of instruments that became part of the mainstream of music. The earliest musical glitch I can think of is a technique known as "scordatura", first employed in the early 16th century, in which one or more of the strings on a bowed string instrument are tuned to a nearby pitch, so that the normally direct connection between finger positions and individual pitches is disrupted - which is initially quite disconcerting to the performer. Scordatura was thoroughly explored in compositions by the violinist-composer Heinrich von Biber, and taken to its most extreme in the eleventh of his *Rosary Sonatas* (c. 1764), where in addition the second and third strings are interchanged, so that the top and the bottom pairs of strings are each tuned one octave apart. In the late 18th century Friedrich Wilhelm Rust specified a different type of glitch, manually plucking the strings of the harpsichord for lute-like sounds.

Many unorthodox early 20th century approaches to the piano in individual works can be listed. Arnold Schoenberg instructed the pianist to silently depress certain keys, thereby raising the dampers on particular strings to add sympathetic resonance (1909), Charles Ives required "clusters" of just over two octaves of black keys to be played simultaneously by means of a 14 ¾"-wide strip of wood (1911), Erik Satie threaded sheets of paper between the strings (1913, followed in the early 1920s by Maurice Ravel and other French composers - a technique also adopted in some opera houses for a harpsichord-like sound in early operas), Henry Cowell played directly on the piano strings (early 1920s) and John Cage's exotic-sounding prepared piano, in which selected objects are inserted between adjacent strings (1940); originally found in more popular music, one can add the honky-tonk qualities of an out-of-tune piano (from the 1920s) and the tack piano, where tin tacks [drawing pins] are inserted in the hammers (various musicians from the 1930s, and a speciality of Lou Harrison since 1941). Although these were all temporary modifications, pianos were constructed with different keyboard layouts (including reversed left-handed pianos) or additional sound qualities (normally a feature of the harpsichord rather than the piano) - especially the luthéal piano (specified in two works by Ravel), in which additional dampers and metal bolts suspended on the strings provide respectively harpsichord- and lute-like timbres.

In the last 50 years glitches have been explored on most other acoustic instruments: on woodwind instruments the production of "multiphonics" - which would otherwise be considered as unintentional squeaks - is controlled by unorthodox fingerings, woodwind and brass instruments have been sounded by the player simultaneously playing and singing into the instrument, or played with the mouthpiece from a different instrument (e.g. a trombone played with an oboe reed), or even with the mouthpiece removed - although it may sound pretty avantgarde, this occurs in Ravel's opera *L'heure espagnole* (The Spanish Hour, 1907-09), in which a toy trumpet is imitated by removing the reed of a sarrusophone (a bass oboe). The wind supply of pipe organs has been switched off while the pipes are sounding, creating glissandi and other changes, and pipes have physically been removed in mid-performance. Singers have also created the equivalent of multiphonics, with split notes and overtone singing [DEMO] - although these are new to European music, overtone singing is a familiar technique in religious music in

Tibet and in traditional music in Mongolia and Tuva, where it can't be considered as glitching!

As far as musical electronics is concerned, there are far more possibilities for glitching, and many musicians today have specialised in exploring them - some of my own work can be considered in this way. I will concentrate on some of the more interesting applications and the pioneers of them. The earliest uses of electronically-generated sounds harnessed normally unwanted audio oscillations in everyday equipment: in 1899 the whistle of the electric arc lamp used in street lighting was the basis for the simple Singing Arc (preceding as it did Fleming's diode valve), which was further developed in radiotelephony and as the basis for the Poulsen Arc; two decades later the theremin (1920) and the ondes Martenot (1928) exploited the whistle produced by early radio receivers, sometimes caused by a person's hand in close proximity to the circuitry (hand capacitance, the basis of the theremin's non-contact performance technique). After World War II electronic sounds and treatments were also employed in electronic music studios, initially by adopting and often subverting standard broadcast and test equipment - such as controlling the speed of a tape recorder by means of a low-frequency oscillator. When synthesizers came on the market, some musicians developed unusual controllers for them. Indeed the complex interactions that were possible on the voltage-controlled synthesizer often meant that gradually altering the position of any of the knobs would eventually produce an unpredictable sonic result.

Among other analogue applications of the glitch can be cited the tightening of the resonance control on certain filters, especially in certain synthesizers, to a point where the circuit oscillates at the selected frequency, and the mistreatment of circuitry in the method known as "circuit bending" or "hardware hacking", whereby planned or sometimes random rewiring of simpler battery-powered circuits (not always designed to produce sound) creates unexpected results. The pioneer is this was probably Louis Barron, whose self-destructive circuits provided the sound materials for his collaborations with his wife Bebe, as in the film score for *Forbidden Planet* (1956). In the Cracklebox ("Kraakdoos") family of synthesizer-like instruments by Michel Waisvisz (from 1969), the body capacitance between individual fingers supplies links between various parts of a specially designed circuit, in even the simplest version creating a selection of modulation, filtering and triggering possibilities [DEMO; 1975 version].

A composer who has specialised in the exploration of acoustical phenomena is Alvin Lucier. In different works the acoustics of the performance space are delineated by hand-held pulsed echo-location devices, by dancers physically mapping the peaks and troughs of standing waves created by the slowly changing interactions of electronic oscillators, and by repeatedly rerecording a speech in that space, increasingly reinforcing the specific frequencies of that space so that eventually of the original sounds only the rhythm remains. A similar dependence on the space is the changing sound of a long metal wire driven by a fixed-frequency oscillator that is caused by its immediate ambience (including temperature, people walking past and small amounts of wind). Other works of Lucier have featured sounds from the ionosphere, beat-frequencies between a fixed oscillator and one or more musical instruments, and modifications of timbre by placing microphones inside what he calls "resonant vessels" of glass, ceramics or metal - occasionally playing back sound through a miniature loudspeaker attached to such a vessel (including a teapot, with which opening and closing the lid added a filtering effect).

Last night both Lucier and Nicolas Collins were among the participants in a concert devoted to aspects of feedback that was presented in London; in music we use this term not only for certain types of electrical circuits but also as an abbreviation for the "acoustic feedback" or "howl-round" that is produced by too great a proximity and degree of amplification between a microphone and a loudspeaker. Inevitably this normally undesired sound has been exploited by a number of composers as well as performers such as electric guitarists (in a variety of musical genres - notably Jimi Hendrix), modifying the feedback, for example, by gently touching individual strings at different places. With the advent of digital equipment, the creation of audio oscillations through feedback in circuitry alone became significant.

Music recordings have proved a valuable source of materials to glitch. In 1939 John Cage featured recordings of constant and variable frequencies, designed to test the stability of turntables, as sound sources that were articulated by varying the turntable speed and lifting up and replacing the cartridge tone-arm. In the 1960s Milan Knížák and, 20 years later, Christian Marclay pioneered more elaborate modifications, such as collaging together sections from different discs, mistreating the discs (warping or scratching them) or drilling a new, off-centre spindle hole. "Scratching" by DJs is a more populist form of such an approach, often using specially-designed twin-turntable disco machines. In the mid-1980s musicians in New York - including Collins - managed to glitch the new medium of the compact disc, either by interfering in the software to produce very short repeated "loops", or by taping over parts of the encoded surface to mask what is read by the laser. Inevitably digital equivalents of the DJ disco machine have also been manufactured, with fake platters for manipulation.

In the late 1980s David Myers (as "Arcane Device") interconnected digital delays, with no audio inputs, creating internal feedback. Similar glitches have been explored by Japanese musicians, causing feedback in internal circuitry by such simple methods as connecting an output of a device to one of its inputs, including the "no-input mixing board" (Toshimaru Nakamura, taken up by musicians elsewhere), the "no-input sampler" (Sachiko M) and a CD player with no CDs (Otomo Yoshihide) - Nakamura and Yoshihide also participated in the same concert last night. Also in Japan, Yoshihide and Tetuzi Akiyama have used a turntable without records, and Toshiya Tsunoda has specialised in treated environmental recordings, modifying the response of his recording microphones by placing them in resonant vessels equivalent to those used by Lucier.

This survey has only just scratched the surface, highlighting certain approaches and pioneers. The glitch has become common in visual computer art, and at least one festival has already been devoted to this theme. Within the field of popular “electronica” the term “glitch music” (or “clicks and cuts”) was introduced in the mid 1990s by Markus Popp (under the name of “Oval”) and was initially based on defective CDs; other exponents explore digital artifacts and distortions as well as tiny sampled fragments of sound and music. This focus on the glitch as a source of unexpected creative possibilities was my starting point for this expansion of its meaning.

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