Ringing the Changes

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Abstract

Inspired by the ancient art of church tower bell-ringing, Stephanie Strickland's poems, described in this paper, are generated from code written to implement a seven-bell peal's permutations. *Ringing the Changes* is her book-length print poem published with Counterpath Press and *Liberty Ring!* is its online interactive companion poem.

Sequences of bell-ringing invented for sport—the first known company of church bell ringers was established in 1612—are today understood as group-theory symmetry operations. The earliest books on change ringing, *Tintinnalogia* (1668) and *Campanologia* (1677) [1], contain many examples of ringing sequences. The aim, specifically, was to ring all possible arrangements on seven bells, subject to the constraints of bell weight and momentum. Because the bells can weigh many tons, once set in motion there is little ability to affect their sway while still keeping the sound of each bell distinct. As a result, when a new change is rung, each bell must either stay in place or change places *only* with its nearest neighbor [2]. To ring all 7! permutations, each called a *change* or row, is a daunting task. Why seven bells? No one really knows why this particular challenge was the first chosen. Perhaps their church had seven bells. Perhaps 24 minutes to ring the changes on six bells was considered too easy, whereas a peal on eight bells—at 22 hours 24 minutes—was considered infeasible [2].

A peal of bells, also called an extent, refers to *all* permutations, but today shorter and easier "method" sequences are rung. Thousands of these have been vetted by the Central Council of Church Bell Ringers, including Scientific Triples (Figure 1), the pattern chosen for both *Ringing the Changes* [3] and for its interactive companion, *Liberty Ring!* [4]. An entire peal could be rung in about three hours. To do this the ringers had to memorize 5,040 unique seven-digit numbers. Cheat sheets were not allowed and anyone who messed up bought drinks for the others! Method ringing is a way to generate changing permutations in a continuous fashion. By memorizing rules for generating new changes, and not every single change itself, method-ringers can plot their course ahead of time. Method performances visit a number of changes, *but only once each.* In the ringing world, this constraint is called *truth*; to repeat any row would make the performance *false.* Method sequences begin and end with *rounds*, the practice of ringing all the bells in descending order of pitch. *Ringing the Changes* begins with rounds (1 2 3 4 5 6 7) and then proceeds with the Scientific Triples peal, each bell corresponding to a different chunk of text.

Rung from a church tower, changes are resonant patterns of sound, but in *Ringing the Changes* they are samples of language taken from writers who explore intertwined real / virtual worlds. In any run of the code, which is posted for sharing on GitHub [5], each bell is *randomly* assigned one of its own suite of 23 sampled texts, a text that won't reappear until all 22 others have been seen. (The random function works a little differently in the online poem.) The book ends on a pause in the peal after each text has appeared seven times, thus after 161 pages (Figure 2). In *Ringing the Changes* each of the following authors contributes a majority of the text for one bell: Sha Xin Wei, Simone Weil, Sylvia Wynter, Hito Steyerl, and Yuk Hui. John C. G. Sturdy's pedagogic hints on bell ringing provide the language for Bell 3. A medley of other authors, including Donna Haraway, Heraclitus, Leslie Lamport, and Karl Schaffer, briefly appears. Fewer texts, including passages from the Framers of the United States Constitution, appear in *Liberty Ring!*, a work with different content and aims. In both works, seven threads of thought weave new contexts for each other, in a ring, or in a line, as forms of civil conversation.

At the end of my talk, I will demonstrate the interactive online *Liberty Ring!* as it dynamically reproduces the correct peal patterns in a ring, just as the bell-ropes hang in a ring. The ancient quest to

perform mathematical patterns with human bodies will be honored by a volunteer (or Zoom) seven "bell" choir reading several sets of changes from *Ringing the Changes*.

The strict rules of ringing effectively force ringers to trace a Hamiltonian cycle in a Cayley graph associated to the permutation group S_n, the set of all 1:1 mappings from a set A to A (A being the set containing all numbers 1 to n) [6]. This tracing or path is also known today as the The Steinhaus–Johnson–Trotter algorithm or Johnson–Trotter algorithm [7].

To elaborate, one can think of the permutations as the vertices of a graph. Two vertices are connected by an edge if there is a permitted transition (according to bell ringers) that transforms one change into the other. An extent is then simply a complete tour of this graph, visiting each of the vertices exactly once, and returning to the beginning vertex. Such tours are called *Hamiltonian cycles*. In fact, every Hamiltonian cycle in such a graph corresponds to two different extents, since a cycle can be traversed in two directions. These cycles are of course traced in space—3-D stereograms of the Hamiltonian circuits associated to ringing sequences have been created [1]—whereas peals, like words, are traced in time. It is the *embodiment* of the patterns that particularly interests me, as occurs in braiding, dancing, juggling, knitting, lacemaking, and the like. A ringer's motions are often guided by so-called bluelines which trace the course of a bell's movement, moving one place per change—a slanted line—or staying in place—a vertical line.

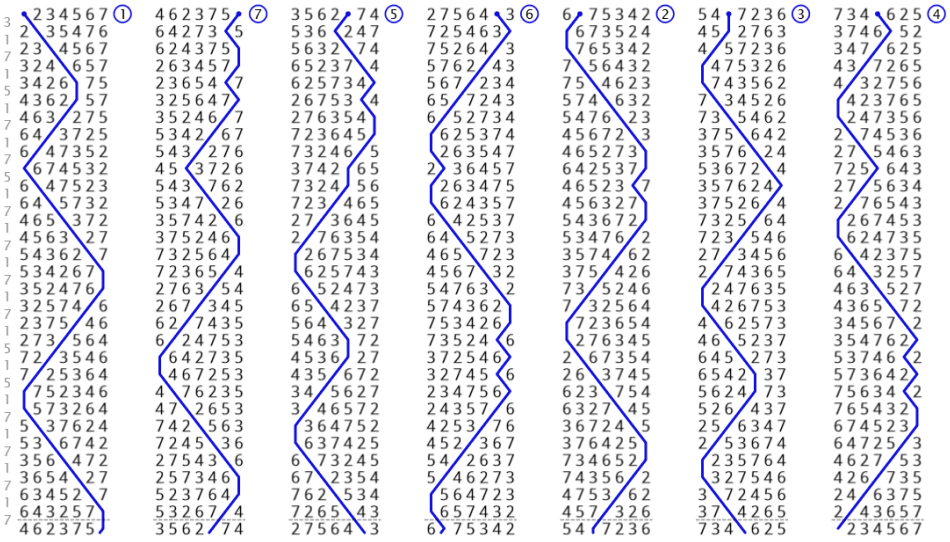
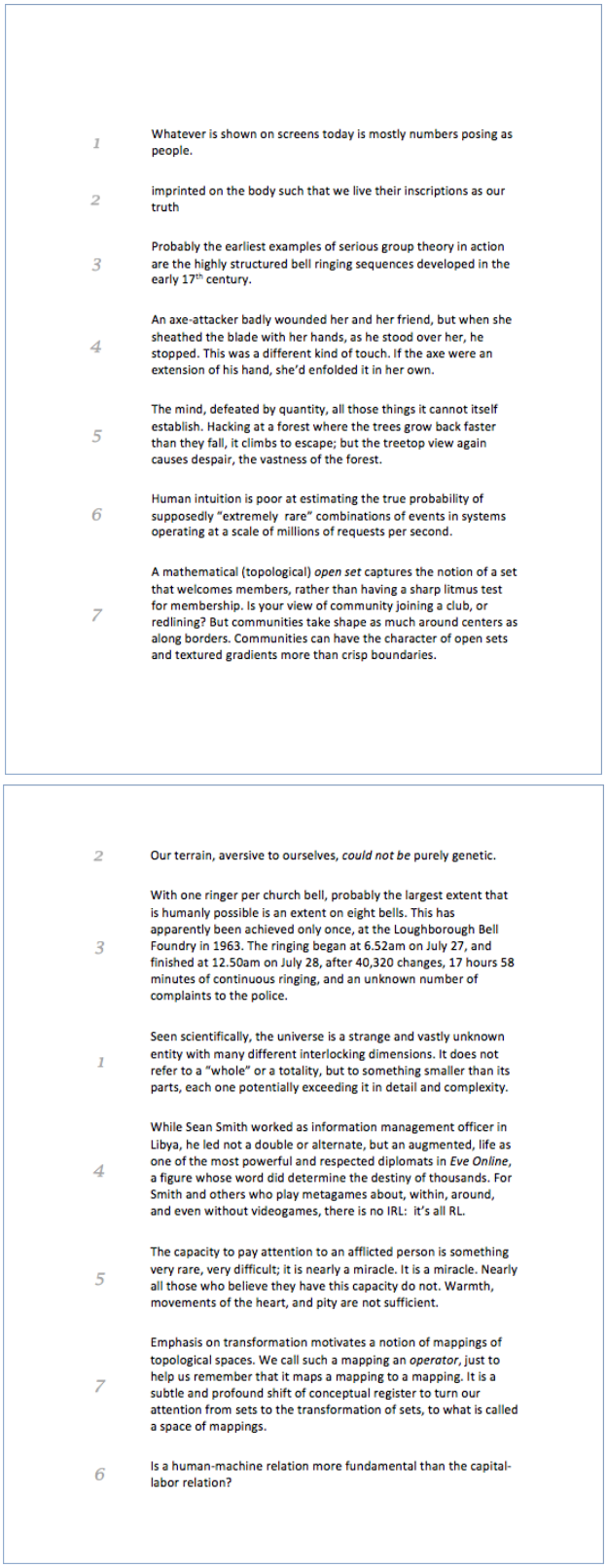


Figure 1: *Bluelines for the Scientific Triples Peal.*
https://rsw.me.uk/blueline/methods/view/Scientific_Triples

Susan Gerofsky and her co-authors [8] published a paper in *Bridges 2018 Conference Proceedings* investigating group structure in many embodied modalities, all of them focused on experiencing one 4-bell peal, with the aim of strengthening mathematical education. By contrast, my poems are intended to investigate reading as it changes under regimes of digital abstraction that are the network backbone and mold for almost all the information published today. They seek in particular to explore how poems evolve in a world where the mathematical structures behind what we read online are not consciously perceived.

In conclusion, two non-consecutive sample pages generated by the Scientific Triples peal code and a screen shot of one "ringing" of the bell in *Liberty Ring!* are shown on the next pages. Emphasis on the visual prioritizes the static and does not serve as well the intention of the interactive piece which is to imitate the dynamic way the bells sound out. One *hears* heavy metal bells sound in a temporal order, whereas in *Liberty Ring!* one *sees*, change after change, the texts materialize in the correct permutational order.



1 Whatever is shown on screens today is mostly numbers posing as people.

2 imprinted on the body such that we live their inscriptions as our truth

3 Probably the earliest examples of serious group theory in action are the highly structured bell ringing sequences developed in the early 17th century.

4 An axe-attacker badly wounded her and her friend, but when she sheathed the blade with her hands, as he stood over her, he stopped. This was a different kind of touch. If the axe were an extension of his hand, she'd enfolded it in her own.

5 The mind, defeated by quantity, all those things it cannot itself establish. Hacking at a forest where the trees grow back faster than they fall, it climbs to escape; but the treetop view again causes despair, the vastness of the forest.

6 Human intuition is poor at estimating the true probability of supposedly "extremely rare" combinations of events in systems operating at a scale of millions of requests per second.

7 A mathematical (topological) *open set* captures the notion of a set that welcomes members, rather than having a sharp litmus test for membership. Is your view of community joining a club, or redlining? But communities take shape as much around centers as along borders. Communities can have the character of open sets and textured gradients more than crisp boundaries.

2 Our terrain, aversive to ourselves, *could not be* purely genetic.

3 With one ringer per church bell, probably the largest extent that is humanly possible is an extent on eight bells. This has apparently been achieved only once, at the Loughborough Bell Foundry in 1963. The ringing began at 6.52am on July 27, and finished at 12.50am on July 28, after 40,320 changes, 17 hours 58 minutes of continuous ringing, and an unknown number of complaints to the police.

1 Seen scientifically, the universe is a strange and vastly unknown entity with many different interlocking dimensions. It does not refer to a "whole" or a totality, but to something smaller than its parts, each one potentially exceeding it in detail and complexity.

4 While Sean Smith worked as information management officer in Libya, he led not a double or alternate, but an augmented, life as one of the most powerful and respected diplomats in *Eve Online*, a figure whose word did determine the destiny of thousands. For Smith and others who play metagames about, within, around, and even without videogames, there is no IRL: it's all RL.

5 The capacity to pay attention to an afflicted person is something very rare, very difficult; it is nearly a miracle. It is a miracle. Nearly all those who believe they have this capacity do not. Warmth, movements of the heart, and pity are not sufficient.

7 Emphasis on transformation motivates a notion of mappings of topological spaces. We call such a mapping an *operator*, just to help us remember that it maps a mapping to a mapping. It is a subtle and profound shift of conceptual register to turn our attention from sets to the transformation of sets, to what is called a space of mappings.

6 Is a human-machine relation more fundamental than the capital-labor relation?

Figure 2: *Sample Non-Consecutive Pages generated by* Ringing the Changes *code*

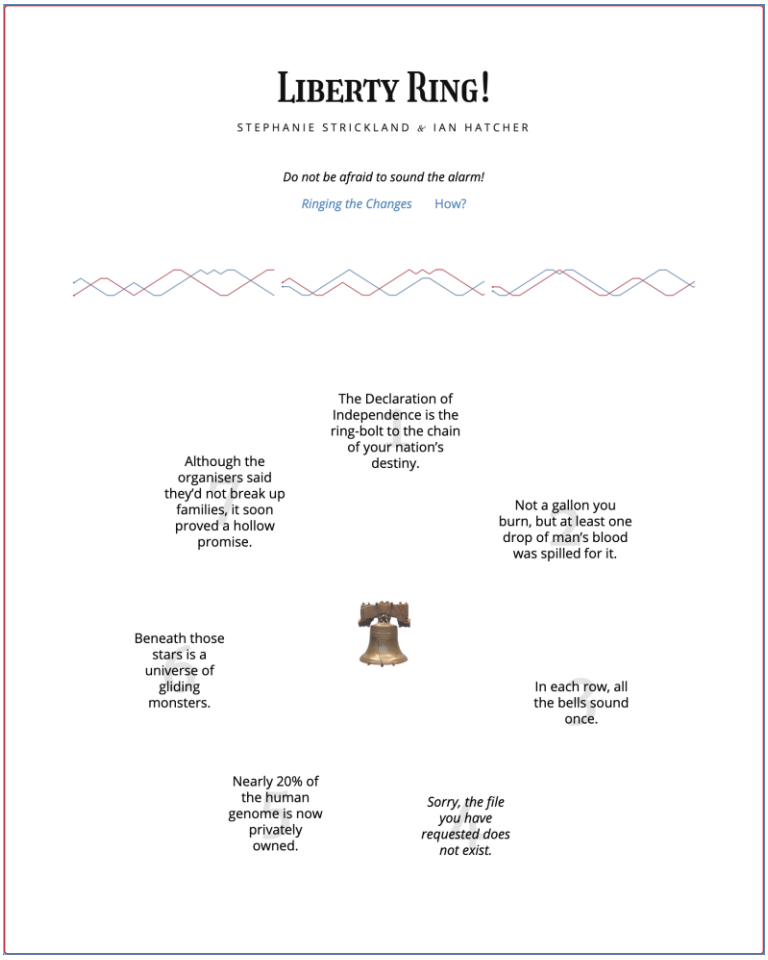


Figure 3: *Sample Scrolled Screen of* Liberty Ring!

References

[1] Burkard Polster, *The Mathematics of Juggling*, Springer-Verlag, New York, 2003

[2] Burkard Polster and Marty Ross, "Ringing the Changes," *Plus Magazine*, December 2009 https://plus.maths.org/content/ringing-change

[3] Stephanie Strickland, *Ringing the Changes*, Counterpath Press, 2020 http://counterpathpress.org/ringing-the-changes-stephanie-strickland

[4] Stephanie Strickland and Ian Hatcher, *Liberty Ring!* http://www.stephaniestrickland.com/projects/liberty-ring

[5] GitHub code repository, https://github.com/juliannechat/ringing-the-changes

[6] Bill Casselman, About the Cover, *Notices of the AMS*, January 2004

[7] Wikipedia contributors, "Steinhaus–Johnson–Trotter algorithm," *Wikipedia, The Free Encyclopedia*, https://en.wikipedia.org/w/index.php?title=Steinhaus%E2%80%93Johnson%E2%80%93Trotter_algorithm&oldid=899351653 (accessed January 13, 2020).

[8] Susan Gerofsky, et al., "Experiencing Group Structure: Observing, Creating and Performing the Plain Hunt on 4 via Music, Poetry, Visual and Culinary Arts," *Bridges Conference Proceedings*, 2018