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An (An)Archive of Communication: Interactive Toys as Interlocutors

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Introduction

When Paul Breedlove, a "computer specialist" working for Texas Instruments, wrote the words "SPELLING BEE" on the first page of his *Laboratory and Engineering Notebook* on November 1, 1976, he probably was not aware of the onrush of archival work that would soon ensue. Earlier this year, Breedlove was assigned the task of developing one of the company's "specialty calculators", a learning aid for spelling. Two years later, this device, now called *Speak & Spell*, was introduced to the public, becoming one of Texas Instruments' most recognizable projects in consumer electronics. Its primary function consisted of dictation and the subsequent automatic review of the user's spelling. Words were given as acoustic phenomena, and the users needed to type them in correctly using the keyboard of the device. Then, algorithms checked the input against the correct spelling and gave spoken feedback whether the user's attempt was successful. The toy's success made it inevitable that its development would be meticulously documented in the company's internal archive, bringing together lab notebooks, memos, technical drawings, audio recordings and other materials. Then, a second wave of archival work started in 2005 when the company donated large parts of its collections to the Southern Methodist University in Dallas, Texas, making it accessible to archivists and researchers.[1]

Thus, *Speak & Spell* has left a considerable archival trace on the shelves. But, in this article I also want to argue that it is an archive in itself. An archive of possible communications. Or even an anarchive, if one were to follow the theoretical distinction proposed by media archaeology.

In my analytic work with electronic toys I often find the conceptualizations of these devices as mere tools for playing unsatisfactory. They seem to share more characteristics with archives than with instruments. Like archives, interactive toys hold in themselves a predefined choice of informations and interactions, thus enabling certain modes of inquiry and discouraging others. Especially the electronic toys that draw on algorithms and data to present the user with an imitation of

[1] A copy of the *Laboratory and Engineering Notebook*, issued to Paul Breedlove on March 1, 1976, is now part of the *Texas Instruments Records* collection held by the Southern Methodist University in Dallas (accession no. A2005.0025.91-34). A differing copy is also included in Gene Frantz, *The Speak N Spell* (OpenStax CNX, 2014). Audio recordings from the development phase of *Speak & Spell* (accession no. A2005.0025. 88-81) are available at https://sites.smu.edu/cdm/cul/tir/ (accessed on March 15, 2018). The internal organizational and financial history of the project is presented in Breedlove's *Memorandum. October 2, 1980.* (accession no. A2005.0025.91-34). The device's success has been discussed from the point of view of the company in Caleb Pirtle III, *Engineering the World. Stories from the First 75 Years of Texas Instruments* (Dallas: Southern Methodist University Press, 2005), 131–133.

human communication are able to offer branching paths of interlocution within their domain or topic.

In this article, I analyze the *Speak & Spell* electronic toy (Texas Instruments, 1978) from the perspective of the communication that it enables. First, I offer an explanation of the toy's technical structures that store speech and spelling data and enforce certain patterns of input and output between the device and its user. Then, I propose the use of the notion of the archive, or, alternatively, anarchive to describe the space of possibilities that defines this process of communication. In the last part I argue that the study of such algorithmic archives of possible communication needs to be based on interactive experimentation and can not be grounded in static recordings or descriptions alone. Overall, I show how interactivity with algorithmic machines involves archiving, and how the archival capabilities of the *Speak & Spell* bear the imprint of earlier "communicating" and "speaking" devices.[2]

The issue of communication between humans and machines, or of its imitation, is certainly an urgent problem not only of technology (how to make it more efficient), but also, and primarily, of philosophy (how to think subjectivity and otherness in this new situation, where to put the boundaries).[3] Compared to today's spoken dialogue systems such as those currently produced by Apple, Amazon or Google, *Speak & Spell* seems simple in its lack of voice recognition technology (the input is carried out by the user with the help of an integrated keyboard).[4] Yet, communication does not need to be speech-based to facilitate interaction that is meaningful for human participants. In the realm of technology, different communication channels are available, and sometimes even a fairly constrained algorithmic system can provide the basis for formulaic, but still meaningful interaction. Thus, what is crucial about the *Speak & Spell*'s communication system is not the input channel (a keyboard instead of a microphone and a speech recognition system), but the hidden algorithmic logic of questions, answers and replies, stored inside the toy's memory chips. At the same time, while the choice of keyboard for input is in line with the device's purpose of training the spelling, so is the developer's decision to use speech synthesis for output.

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[2] I would like to thank the editors of this volume, Zachary McDowell and Nathanael Bassett, and the anonymous reviewers for their notes and suggestions.

[3] See the "Introduction to 'Machine Communication' " by Zachary McDowell and David Gunkel, *Communication + 1*, Vol. 5 (2016).

[4] For a discussion of spoken dialogue systems with regard to questions of communication see David Gunkel, "Computational Interpersonal Communication: Communication Studies and Spoken Dialogue Systems," *Communication + 1*, Vol. 5 (2016).

Speak & Spell

The *Speak & Spell* is a noteworthy example of successful consumer-oriented design of an electronic appliance. It is a portable, yet sturdy, and algorithmically complex, but intuitively accessible device. The various parts of the interface are clearly distinct from each other, but they are unified by the overall color scheme of the red case with the yellow inlay for the keyboard and the black band holding the display and the loudspeaker. On the surface, it is a monolithic structure, the proverbial black box, albeit painted in cheerful colors. Yet, when the back panel of the device is removed, the modular structure of its technological interior becomes immediately visible (figure 1). The loudspeaker on the upper right is a self-contained piece of technology, connected to the main board merely by two wires, as is the battery compartment in the lower part of the case. With the lid removed, the unity of the appliance falls apart into a multiplicity of discrete parts. Some of these parts are visible (like the cone of the loudspeaker) while others are hidden from view (like the algorithmic logic stored inside the microscopically small electronic components of the integrated circuits which are soldered on the reverse side of the board). Memory to store speech data, processor units for speech synthesis and program logic, as well as input and output electronics, are all part of the whole. Together, they form a complex machine that creates a labyrinthine map of possible sequences of communication. From the start, it includes all possible words, all spellings, and all reactions to the user's correct or incorrect input.

The interactive character of the toy's dictation-input sequence requires a medium that makes possible fast, alternating access to various snippets of speech such as the dictation materials, the names of letters (for acoustical feedback during user input) or the phrases that inform the user whether their spelling was right. A typical *Speak & Spell* session includes interaction and dialogue similar to the following transcript:

- The user turns on the device.
- The start melody is played.
- "SPELL A" is shown on the display, indicating that the spelling training mode is active, using the set of words labeled "A".
- The user presses the button "GO" to start the exercise.
- The device's speech synthesis unit outputs the phrase "Spell 'baby'".
- The user presses the buttons "B", "A", "B" and "Y". Each part of this input is acknowledged by the device by printing the letter on the display and outputting its name acoustically.

- The user presses the button “Enter”, prompting the algorithm to evaluate the input against the spelling stored in memory.
- The correct input is acknowledged by the acoustical output “This is correct”, followed by another word from the list (“Now spell 'dinner'”).

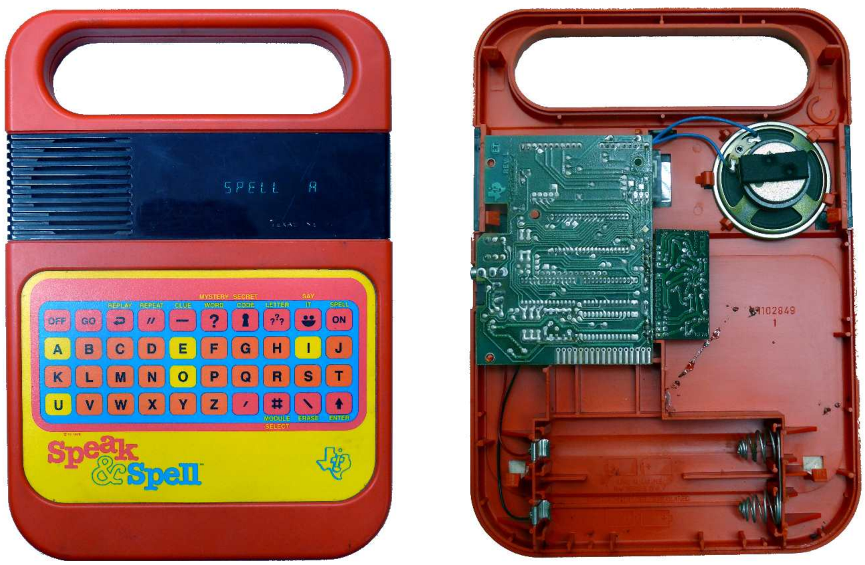

Figure 1 – *Speak & Spell*, ca. 1980-85, in operation and with the back panel removed.

Because the user's input is unpredictable to the creators of the device, the programmed logic needs to include all possible situations, or states, of the machine, defining not only what has to be done at a certain point, but also all the possible paths that can lead from one state to another. For example, after outputting “Spell 'baby'” the device needs to continuously check whether the user has pressed a button with a letter, prompting it to store it and to return to the same waiting state, or whether the button “enter” has been pressed, which leads to the evaluation of the entire input sequence (see figure 2).

This diagrammatic layout of possible interactions with the machine is designed and built by the engineers who create it. Already this limited example, showing a severely simplified scheme, allows for some interaction with the machine. For example, the user is free to test whether the machine would act as it should if they press “enter” without storing any letters, or if this would lead to a situation that has not been foreseen, prompting the device to halt. However, the real device is infinitely more complex than the diagram in figure 2, including not only many more states and connections, but also memory storage, input and output electronics, and specifying the inner structure of each block of the diagram in meticulous detail. This complex assemblage enables innumerous paths through its space of possibilities. Given that each session will include not only some variation in the order of tasks presented by the algorithm, but also inevitably deviations in the user's performance, it is safe to say that no single sequence of use will be exactly like the others. Still, the overall structure of the interaction with the machine will be recognizable each time, stabilized by the boundaries set during the device's development. In the next part of this article I will return to this diagrammatic structure, discussing it as an (an)archive of possible communications. At this point, however, some explanations about the technology behind the *Speak & Spell*'s speech synthesis unit are in place, to explain why a digital solution was necessary and to situate it amid its historical predecessors.

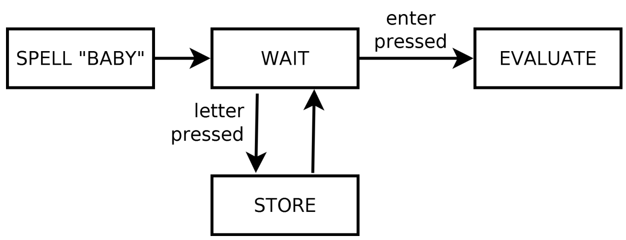

Figure 2 – An overview of the states associated with input and the evaluation of the spelling.

The developers at Texas Instruments were conscious of the extreme interactivity of the medium on which they were working, i.e. of the ways in which it was different from other, non-algorithmic technologies. A device capable of collecting input from the user, transforming it according to the rules of its algorithm and data, and giving back signals, was needed for the kind of interaction that the creators of *Speak & Spell* envisioned for their product. Breedlove writes about this in his *Notebook*: “Logical decision making and control is required”. At the same time, the 'speaking' toy had to accommodate temporal patterns of oral communication, meaning that it could not be based on tape-recorded responses that would take too long to rewind. Instead, some kind of digital storage of speech information had to be employed in order to emulate the flow of the student-teacher dialogue. This is reflected in a further remark by Breedlove: “The tape medium could be used for this purpose [to store a variable word list], but the speed of response would be slow". The adoption of any other common storage medium of that time such as a cassette or a disk would have been unpractical for the same reasons.[5]

To accommodate fast interactive response and algorithmic logic, the developers had to rely on digital circuits. Yet, the economic constraints of that time meant that a full digital recording of the speech parts was out of reach because of the high cost of memory components. Therefore, *Speak & Spell* does not rely on the direct playback of a digitized recording of human speech. Instead, sounds are produced by a speech synthesizer that is driven by a stream of data coming from a memory chip. Although these data were derived from a recording of a human speaker, they only contain synthesis parameters, not the actual sound itself. Thus, rather than using the precious memory to directly save sound, only the control data for the system that generates it need to be retained. This kind of speech storage is technologically more complex than a digital recording. Yet, in the late 1970s it was meaningful from the point of view of the economy of production because such control data take up less space than audio recordings of comparable quality.[6]

By including a speech synthesis unit into their device, the engineers at Texas Instruments tapped into a tradition that went back many centuries, revitalizing and popularizing a long line of attempts at creating a speaking machine. Today, professional-grade speech synthesis software is able to create acoustic imitations of human speech that are not just understandable, but even almost indistinguishable. Yet, this current state of affairs is preceded by a long history of phonetic research

[5] Paul Breedlove, "Laboratory and Engineering Notebook," 1976, Accession no. A2005.0025.91-34, Texas Instruments records. DeGolyer Library, Southern Methodist University. Dallas, Texas, pages 11 and 12 (partially capitalized in the original text).

[6] *Speak & Spell* speech data were stored on two 128 kBit modules, each containing over 100 seconds of voice material. (See the Texas Instruments press release from June 11, 1978: http://datamath.org/Speech_IC.htm, accessed on March 20, 2018). Thus, the data rate, which varied depending on the amount of silence in source audio and other factors, was ca. 1 kBit per second. For comparison, an mp3 file with the lowest possible quality settings still needs 8 kBit/s, and an audio CD has a data rate of ca. 1411 kBit/s. Engineers Richard Wiggins and Gene Frantz, who worked directly on the development of the toy, proudly describe its data rate as "less than 1200 bits per second" (Gene A. Frantz and Richard H. Wiggins, "Design Case History: Speak & Spell Learns to Talk.," *IEEE Spectrum*, no. February 1982 (1982): 47. Further details of the technical structure of *Speak & Spell*'s speech unit can be found in Peter Vernon, "A Closer Look at the TI Speak & Spell," *BYTE Magazine*, April 1981: 150–54. This publication, which reads like a result of a professional reverse engineering effort, was probably the motivation behind the creation of the article written by the Texas Instruments engineers. Further explanations of the LPC speech storage technology used for the *Speak & Spell* are included in the US patent by Paul S. Breedlove et al., Learning aid or game having miniature electronic speech synthesis chip, 4970659, filed July 1, 1988, and issued November 13, 1990.

and the development of algorithmic technologies.[7] One of the earliest groundbreaking developments in the realm of phonetic analysis and imitation was the so-called 'speaking machine' created by the inventor Wolfgang von Kempelen and described by him in his 1791 book *Mechanismus der menschlichen Sprache*.[8] The aim of von Kempelen's speaking mechanism was to recreate the sounds of human speech by technical means. At that time, this was a considerable task, given that many basic principles of modern phonetics were not yet understood, and had to be developed through experimentation. The central idea that connects von Kempelen's machine to the *Speak & Spell* and, in fact, to almost all later developments, is that an attempt is made to imitate all the different sounds using only one mechanism inspired by human physiology, as opposed to imitating each sound with a dedicated appliance. Only such a unified mechanism was able to recreate not just the individual sounds, but also the transitions between them.[9] In von Kempelen's design, we also find the idea of using several distinct segments of the mechanism to imitate the respective parts of the human vocal tract - a pathbreaking decision that is also mirrored in the structure of the *Speak & Spell*'s voice synthesizer.

After von Kempelen, a wave of mechanical imitations of human speech emerged in the 19th century that gradually expanded and perfected his approach. Joseph Faber's *Euphonia* and Charles Wheatstone's modification of von Kempelen's

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[7] Following the proliferation of digital tools, speech synthesis has become an active field of research during the last decades. The literature associated with this field is, however, primarily focused on questions of technical implementability. See the *Speech Synthesis Bibliography* compiled by Joaquim Llisterri: http://liceu.uab.es/~joaquim/speech_technology/tecnol_parla/synthesis/refs_sintesi.html (accessed on March 18, 2018). The prehistory of modern speech synthesis technology is discussed in Robert Linggard, *Electronic Synthesis of Speech* (New York, NY, USA: Cambridge University Press, 1985), 4–12; James L. Flanagan, *Speech Analysis, Synthesis and Perception* (Berlin: Springer, 1965), 166–73 and Manfred R. Schroeder, *Computer Speech. Recognition, Compression, Synthesis*, Second Edition (Berlin: Springer, 2004), 23–30. Introductory materials gathered from the literature can be found on the website of Haskins Laboratories, a research institution dedicated to the study of speech. See the page entitled *Talking Heads: Simulacra. The Early History of Talking Machines*, http://www.haskins.yale.edu/featured/heads/simulacra.html (accessed on March 19, 2018). The state of speech synthesis technology during the development and the period of popularity of *Speak & Spell* is presented in Dennis H. Klatt, "Review of Text-to-Speech Conversion for English," *Journal of the Acoustical Society of America* 82 (3), September 1987 (1987): 737–93.

[8] Wolfgang von Kempelen, *Mechanismus Der Menschlichen Sprache Nebst Der Beschreibung Seiner Sprechenden Maschine* (Wien: J. B. Degen, 1791), http://digitalcommons.ohsu.edu/hca-books/1/.

[9] See Linggard, *Electronic Synthesis of Speech*, 4 ff. Von Kempelen's speech mechanism and its mechanical recreation were discussed by Fabian Brackhane and Jürgen Trouvain in several publications since 2008. See Jürgen Trouvain and Fabian Brackhane, "Zur Heutigen Bedeutung Der Sprechmaschine von Wolfgang von Kempelen," in *20. Konferenz Elektronische Sprachsignalverarbeitung (ESSV '09), Band 2*, 2010, 97–107.

machine are some of the most important steps in this development. Among the experiments with electronic speech synthesis that superseded their mechanical precursors in the 20th century, the *Voder* machine stands out as the most iconic example. It was exhibited in 1939 at the New York World's Fair[10] and it can be said to be the direct predecessor of *Speak & Spell*. With *Voder*, the arrangement consisting of a sound source capable of creating tones or noise, and a set of ten filters, has stabilized into a form that has went on to survive decades of technological development, also forming the basis of *Speak & Spell*.[11]

Being a portable device, the *Speak & Spell* of course testifies for the miniaturization of electronics that compressed the bulky machine of the 1930s into a lightweight plastic box. Yet, this technological change, while the most visible, was not the most important. Instead, the crucial difference between *Voder* and the toy lies in the way the control data is created and used. While in the case of *Voder* - just like with *Euphonia* - the control parameters are fed to the machine in real time by its specially trained human operators, *Speak & Spell*'s data needs to be created just once. After it is semi-automatically derived from a recording of human speech, it is being retrieved from the device's electronic memory in exactly the same form each time an utterance has to be produced.[12]

This history of speech imitation formed the basis for the development of *Speak & Spell*, a device that finally seemed to fulfill the promise of artificial interlocution. Yet, phonetic synthesis alone was not sufficient in this case. In order to create an interactive device, speech had to be combined with the new possibilities offered by algorithmic control and electronic data storage. Taken together, synthesis, storage and control created a new medium that was able to substitute for a human teacher in giving the pupil spelling tasks and checking their answers. Or, at least it was a novelty product that was interesting enough to prompt parents to buy the toy for their child. Later, *Speak & Spell* went on to become the focus of various creative activities by artists interested in distorting its sounds, deranging its clear algorithmic logic and short-circuiting the paths through its electronic memory. Widely known as *circuit bending*, these practices have been analyzed as

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[10] A technical description of *Voder* is given in the US patent by Homer W. Dudley, System for the artificial production of vocal or other sounds, 2121142, filed April 7, 1937, and issued June 21, 1938. See also Flanagan, *Speech Analysis, Synthesis and Perception*, 172–73.

[11] Curiously, the number of filters used in the *Voder* is derived from human physiology, but is not based on the characteristics of the vocal tract. Instead, it comes from the number of fingers used to control the *Voder* through its custom keyboard in settings where the pitch parameter was adjusted with a pedal. See fig. 5 in Dudley, System for the artificial production of vocal or other sounds.

[12] The editing work that was needed for the creation of *Speak & Spell* speech data is described in Frantz, *The Speak N Spell*, 30.

manifestations of do-it-yourself activism or as ways of challenging the "linear and deterministic views of technological development".[13] By bringing disorder into what was perceived as an excessive amount of technologically created orderliness, the *benders* took delight in disrupting the clean archival logic of *Speak & Spell*.

An Anarchive of Communication

The notion of the archive suggests itself in discussions of the structure of an electronic device like the *Speak & Spell*. After all, the storage function of an archive is mirrored in the device's electronic memory chips that keep available the information on which the interaction with the device is based. Yet, the relation between an archive as an institution and an electronic device is not a straightforward one. The German media archaeologist (and former historian who knows about archival work from first-hand experience) Wolfgang Ernst writes about the "anarchive of sound in technological storage as opposed to the archival order of musical notation".[14] By positing this dichotomy, Ernst draws attention to the difference between merely symbolic notation and indexicality. Whereas indexicality means the preserving of physical traces of an event, for example in the form of a phonograph groove that follows the vibrations of the air that caused it, symbolic notation is abstract and arbitrary. Yet, this "symbolic order" (a term initially inspired by the writings of Jacques Lacan, but later adapted by Friedrich Kittler and others to the specific theoretical needs of German media theory) is, according to Ernst, exactly what enables the durability of records in the archive-as-institution. After all, the limited number of letters in an alphabet makes copying and error correction much easier

[13] One of the earliest texts describing the process of circuit bending is Reed Ghazala, "Incantors," *Experimental Musical Instruments*, no. Vol. 8, Nr. 4, June 1993. Later, Reed Ghazala, *Circuit-Bending. Build Your Own Alien Instruments* (Wiley, 2005) codified the common knowledge of bending in an accessible form. Analytic approaches include Garnet Hertz and Jussi Parikka, "Zombie Media: Circuit Bending Media Archaeology into an Art Method," *Leonardo* 45, no. 5 (July 5, 2012): 424–30; Lauren Elizabeth Flood, *Building and Becoming: DIY Music Technology in New York and Berlin*, 2016 and Trevor Pinch, " 'Bring on Sector Two!' The Sounds of Bent and Broken Circuits," *Sound Studies*, no. Vol. 2, Issue 1 (2016): 36–51 (the quote in the text is on page 36). While an analysis of the motivation behind circuit bending is beyond the scope of this article, it should be noted that other explanations of its popularity are also possible, including the understanding of bending as a compulsive or obsessive activity linked to feelings of uncanniness produced by a 'speaking' machine.

[14] Wolfgang Ernst, *Digital Memory and the Archive* (Minneapolis: University of Minnesota Press, 2013), 174. Ernst's notion of the archive is partially inspired by, but distinct from the Foucauldian *archive*. See Rudi Laermans and Pascal Gielen, "The Archive of the Digital An-Archive," *Image & Narrative. Online Magazine of the Visual Narrative*, no. 17. The Digital Archive (2007), http://www.imageandnarrative.be/inarchive/digital_archive/laermans_gielen.htm.

than in the case of an indexical recording.[15] Thus, since the technological means of sound reproduction such as the phonograph do not employ arbitrary symbols to store information, the use of the term "archive" for them is problematized by Ernst. Instead, he resorts to the "anarchive" as a term that clearly indicates archival connotations, but also differs from the institution itself. Building upon this line of thought, I propose the use of the term "anarchive", or alternatively "archive", for interactive devices. From the moment they are created or modified they hold in themselves all the future use scenarios and all communications that will or will not eventually emerge when they get to be used by the consumer. The reason for the retaining of both terms in my definition is that some devices, like the *Speak & Spell*, do in fact employ indexical as well as symbolic storage. The *Speak & Spell* operates on the level of the alphabet for the display and the input of spellings, and it works with the indexical trace of a voice recording for output. And because the voice output is created by a synthesizer driven by numerical values, the symbolic and the indexical are here inextricably linked with each other.

Throughout his media archaeological writing, Ernst has returned to the notions of the archive and the anarchive, first drawing attention to the shortcomings of the traditional archival discourse that privileges storage over transfer, and later cautioning against an inflationary use of the word "archive" for all kinds of "idiosyncratic collections" that lack the institution's structural rigidity.[16] With his

[15] Eric A. Havelock notes that the acquisition of writing and reading abilities connected to counting and mathematics preceded the development of speech-related literacy. See Eric A. Havelock, *The Literate Revolution in Greece and Its Cultural Consequences* (Princeton, N.J: Princeton University Press, 1982). The long-term retention of information about quantities, such as in notes of debt, would not be possible without a writing system. This can be seen as an early example of the stability of communication enabled by a limited set of symbols, as opposed to indexicality.

[16] Wolfgang Ernst, "Archive Im Übergang," in *Interarchive: Archivarische Praktiken Und Handlungsräume Im Zeitgenössischen Kunstfeld.*, ed. Beatrice von Bismarck, Hans-Peter Feldmann, and Ulf Wuggenig (Köln: König, 2002), 137; Wolfgang Ernst, "Good-Bye, 'Archive'. Towards a Media Theory of Dynamic Storage," 2017, https://www.musikundmedien.hu-berlin.de/de/medienwissenschaft/medientheorien/ernst-in-english/pdfs/archive-good-bye.pdf. Further writings by Wolfgang Ernst on the (an)archive include "Between the Archive and the Anarchivable," *Mnemoscape*, no. 1. The Anarchival Impulse (2014); *Stirrings in the Archives: Order from Disorder*, (Lanham: Rowman & Littlefield Publishers, 2015) and other texts. A general overview of media archaeological methods is given in Angela A. Piccini, "Media-Archaeologies: An Invitation," *Journal of Contemporary Archaeology*, no. Vol 2, No 1 (2015). It should also be noted that Ernst's use of the terms is distinct from how they are used by other media theorists. See Siegfried Zielinski, "AnArcheology for AnArchives: Why Do We Need - Especially for the Arts - A Complementary Concept to the Archive?," *Journal of Contemporary Archaeology*, no. Vol 2, No 1 (2015): 116–25 and Claudia Giannetti and Hans Belting, eds., *AnArchive(s): Eine Minimale Enzyklopädie Zur Archäologie Und Variantologie Der Künste Und Medien* (Köln: König, 2014). Michael Goddard, "Opening up the

theories, Ernst has contributed to a more precise epistemology of the machine as an (an)archive. With my proposition, however, I would like to shift the attention from how information is created and stored to how it structures the user's possibilities of interacting with the device.

All information that is needed to fully describe the algorithms and the data that comprise the *Speak & Spell*'s program is stored in the device's memory chips. On the one hand, it is used to drive the speaker and to activate the display, and on the other, it structures the flow of voltages in the device's processor that effect the logic prescribed by the programmers. Taken together, these data and algorithms create the diagram of possible uses of *Speak & Spell*. Like a map, this diagram can be traversed in multiple ways, yet it also structures the journey by enforcing certain boundaries. For example, in the simplified diagram given in figure 2 there is no way to directly return from the state labeled "wait" to the state "spell 'baby'" because the arrow that connects them goes in only one direction. Whereas in reality the *Speak & Spell* does offer such a possibility (achievable by pressing the "repeat" button), this only makes the diagram more complex, but does not free the user from the dictate of its algorithmic structure.[17]

During the last decade, and especially after the innumerous scandals related to massive surveillance and data storage by state and commercial actors, the notion of the digital archive itself seems to have acquired some additional sinister connotations that need to be addressed in analyses of electronic interactivity. These connotations come from the manipulative and restrictive practices that are based on archives of data about citizens. While the *Speak & Spell* itself, a device incapable of retaining user data beyond the single session or of transmitting this data to the manufacturer, seems unproblematic in this sense, its interactivity can be seen as a crucial precursor to more modern data-gathering practices. In the current knowledge-oriented economy, compiled user data is a precious commodity that can enable more precisely targeted manipulation by advertisement and even fuel political campaigns.[18] Arguably, the interactive, but disconnected learning aids like

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Black Boxes: Media Archaeology, 'Anarchaeology' and Media Materiality," *New Media & Society* 17, no. 11 (2014): 1761–76 offers a discussion of different strands of media archaeology. A stronger focus on the analysis of power relations has been suggested for media archaeology in Alexander Monea and Jeremy Parker, "Media Genealogy and the Politics of Archaeology," *International Journal of Communication* 10 (2016): 3141–3159.

[17] Setting some clear boundaries around the user's path through the diagram is in fact a sign of a well-conceived design as the opposite would inevitably cause confusion and frustration with the product, especially in the case of a children's learning aid.

[18] See the latest, as of this writing, scandal around the use of data gathered with the help of a popular app: In 2018, a data analytics company linked to the presidential campaign of Donald Trump and

the *Speak & Spell* have paved the way for more modern learning platforms that are now able to collect all kinds of data about the user and deposit it in the company's archive. By allowing machine-enabled interaction into the previously protected space of the children's room, they also prepared the ground for the currently upcoming wave of interactive, data-gathering devices and robots for the home.[19] This aspect of data *gathering* alone may seem innocuous at first, as no concrete use of this data is prescribed from the start. Yet, as Laermans and Gielen put it in their discussion of the digital archive, "data storage anticipates active operations", meaning that there might be future uses of data that are still unknown when it is collected, but whose possible existence already forms the motivation behind the data gathering effort. This connects the massive data storage practices of today to the modest algorithmic structure of *Speak & Spell*. Like the toy, they form an (an)archive of possible use scenarios. Unlike the toy, however, they are vastly larger in size, expandable in their data base and modifiable in their algorithmic logic, meaning that the contexts of their utilization are virtually unlimited.

Activating the Anarchive

A historical recording like the Edison phonograph cylinder, impressed by sound waves from the 19th century, carries in itself indexical traces of the past. But so does an electronic toy from the 1970s like *Speak & Spell*. Its circuitry and its loudspeaker recreate, albeit very roughly, the vibrations of the air caused by the speaker who recorded the words to be used with the toy. What is more, however, the interactive toy keeps available a whole diagrammatic net of possible interlocution, enabling analytic experiments that can reveal its structure. This kind of interactive *experimental interlocution* is indispensable for the study of devices that process user input according to the algorithmic logic expressed through their electronic layout.

to the Brexit vote became the focus of an investigative journalism effort. Carole Cadwalladr and Emma Graham-Harrison: *Revealed: 50 million Facebook profiles harvested for Cambridge Analytica in major data breach*. https://www.theguardian.com/news/2018/mar/17/cambridge-analytica-facebook-influence-us-election (accessed on March 24, 2018).

[19] See the description of the upcoming *Asus Zenbo* home robot. https://zenbo.asus.com/product/overview/ (accessed on March 25, 2018). Among the functions listed for the device, "Speak convenient audible reminders ..." and "Hear and respond to your spoken requests ..." underscore the aspect of interactivity, while "Move around ...", "Take photos, capture videos ..." and "Learn and adapt ..." point to data-gathering and machine learning practices enabled by the collected data. Examples of interactive, but non-moving home appliances with online connectivity and data-gathering potential include Google Home and Amazon Echo, among others.

The sounds and other kinds of output generated by them can only be understood in their specific context when they are interwoven with other elements of interactivity.

This connects such experimental interlocution to experimental archaeology, a well-established subdiscipline of archaeology that seeks to gain insights into the past by physically recreating practices that can only be hypothesized in our time.[20] Experimental archaeology is oriented towards practices that are unknown because of their temporal distance and lack of sources. Often, a prehistoric tool or an artefact form the initial point from which attempts are made to understand if the hypothesized mode of work would have led to the expected result. Despite the historic proximity of its object, experimental interlocution with electronic media is similar in this regard: The most probable, or sensible, paths through the diagrammatic net of possible interactions need to be discovered and proven through experimentation. Like a traditional archaeologist working with ruins of previously intact places and buildings, a media archaeologist investigating an interactive electronic device often needs to deal with "ruins" of the development work that has led to the creation of the apparatus. Ordered and accessible accumulations of development materials like the collection of *Speak & Spell* archivalia at the Southern Methodist University in Dallas are the exception in the realm of electronic toys and other short-lived consumer products. Still, even the existence of this archive of materials does not free the media archaeologist from the need to activate the (an)archive of possible communications through trial and error.

This reliance on active interaction with the machine raises the difficult question of sources. In the traditional, paper-based archive philological methods (e.g., asking whether the style of the text mirrors the language of the time period to which it is allocated), as well as physical examination of the paper, the writing materials etc. can help determine the veracity of the used source. Likewise, in the realm of electronic interactive media it is of crucial importance to ensure the originality and authenticity of the device: Is this really an apparatus from the specified time period, or is it a replica? Were parts removed or replaced in an effort to repair or modify the device? Does the aging of electronic parts affect the performance? Whereas some of these factors might be negligible in areas connected to symbol-based representation (for example, when the display is dim, but still readable), sounds are especially

[20] Andreas Fickers discusses media archaeological methods inspired by experimental archaeology as grounded in the figure of the "recreated user" ("nachgespielte Nutzer"), describing them as "Ways of appropriation or use, created through artificial staging as part of an experiment, and making the 'tacit knowledge' tangible through reconstruction" (translated from German by the author of this article). Andreas Fickers, "Hands-on! Plädoyer Für Eine Experimentelle Medienarchäologie," *Technikgeschichte* 82, no. 1 (2015).

susceptible to deterioration due to failing parts, and need to be judged accordingly, especially in work carried out with historical electronic media.

Finally, the question of emulation arises in dealing with historical electronic devices. Is it permissible to carry out experiments not with the original apparatus, but with an electronic, or even software-based copy? Again, the distinction between symbol-based and indexical modes of storage and representation is helpful in determining legitimate uses of recreated sources. A piece of software which is known to be used in the device, and which has survived in an archive or in a publication, can be a valuable asset. By reading the code and, crucially, by executing and modifying it, interactive modes of study can be grounded in an even deeper understanding of the device's algorithmic logic. However, the device as a whole can not be replaced by a copy or a virtual representation. There will always be aspects of the original device that have been deemed unimportant by the creator of the copy, but that can not be ignored in an examination of its interactivity.[21] Furthermore, even today's standards of audio definition can be prohibitively crude in imitations of decades-old electronic sound because of the incompatibility of their timing characteristics.[22] As a result, the study of such algorithmic archives of possible communication as the *Speak & Spell* generally needs to be grounded in interactive experimentation with the original medium and can not be based on a static recording or a description alone, just as little as there can be an archival study based on the finding aid and nothing else.

[21] Doron Swade makes a corresponding argument with regard to physical artefacts in "Preserving Software in an Object-Centred Culture," in *History and Electronic Artefacts*, ed. Edward Higgs (Oxford: Clarendon Press, 1998), 204: "Physical replicas can incorporate only features and characteristics perceived to be significant at the time of replication, and part of the justification for preserving original objects in preference to a copy is that the original can be interrogated in an open-ended way in the light of unforeseen enquiry." Emulations of computer hardware have been variously proposed as a way of keeping software runnable for a longer period of time. However, the central issue of "artefactual identity", mentioned by Swade (197), also prohibits the exclusive use of replicas of computers in the same way that it does with other domains of material culture.

[22] For example, so-called 1-bit-sounds, a technical trick used in early generations of cheap home computers that lacked more sophisticated audio hardware, often rely on ultra-short bursts of voltage. These impulses are driven directly by the processor of the device that normally has a much higher clock rate than even the highest-resolution professional audio standards of today (for instance, the *ZX Spectrum* computer has a CPU clock rate of 3.5 MHz whereas even studio-grade audio normally does not use sample rates higher than 192 KHz).

Summary

To archive interactivity, the structure that enables it needs to be kept operational. This means that even the most perfect paper-based archive of development materials related to *Speak & Spell* can not replace the (an)archive of possible communication that is the device itself. The complexity of the toy's electronic structure precludes any kind of merely speculative analysis of its function. A precise drawing of a telescope can be used to calculate its characteristics and simulate the view that it gives, even if only roughly. Yet, it is impossible to imagine and keep in memory all the branching paths of interactivity that the algorithms create, much less the details of sounds formed by electronic circuitry. Also, to understand all processes inside the device exclusively through its user-oriented output would be to impose meaning on the workings of an inherently abstract mechanism. What manifests itself for the user as interlocution is in reality only the visible surface of the constant routing and switching of voltages, governed by the diagrammatic logic of the device's circuitry. Only in the act of perception and cognition is meaning constructed here by the user - but this process takes place already outside of the apparatus. Thus, because communication can not be confined to the device itself, it also can not be archived by preserving the machine. What can be archived, however, is possible communication, the totality of all future uses of *Speak & Spell*.

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