Okey. The One Hand Keyboard.

Thesis, written contribution
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Content

Introduction

Take a look at a computer desk. No matter where, chances are you'll see some representation of the following devices: A computer (operating device), a screen (output device), a mouse (pointer input device) and a keyboard (text input device). We encounter and use those devices to an extent where we don't think about them. But we should. Especially since one of them is not only outdated but is wrong since the days of the first computers — the keyboard.

Do you know the reason why your great grandmother knows how to type on a computer keyboard? It's because the keyboard is even older than her.

The QWERTY layout's patent dates back to the 1890s. It was designed for the typewriter and intended to separate the most common letter pairs; otherwise, the mechanical type bars got jammed. The result was lots of travel distance while typing and therefore a slow and hard typing experience. At the time of the first computers, QWERTY was already widespread. Computer engineers chose to use it as the standard layout for inputting code into computers. In the 1980s, the history of computer keyboards entered the modern era. IBM announced its IBM 5150, the first personal computer equipped with the famous model M keyboard. Other than being a layout made for typewriters, at the time QWERTY still made sense to use. Because of writing on typewriters, many people knew how to use QWERTY. When consumers switched to the new computer technology, at least they knew how to type. It was not until another big leap in computer technology that made using the computer keyboard wrong and even inhuman. Enter, the mouse. Later in the 80s, Apple released the Apple Lisa. Lisa's success was based on its graphic user interface and usage with a mouse. Lisa marks the moment when computers became the same as today. However, it also marks the moment when the human-computer interaction became inhuman.

With the keyboard and the mouse both being necessary devices to use a computer, users are forced to switch their mouse-hand back and forth from mouse to keyboard while using them. In essence, a user would need three hands to use a mouse and keyboard as intended. A problem that is especially noticeable with pro users using pro software. Even for simple tasks as pressing the Enter key or deleting, the user's hand travels from mouse to keyboard and back again.

This condition challenged me to rethink and redesign the keyboard in significant ways:

- Free the »mouse hand«. Make it human-centered, therefore small enough to use with one hand while keeping all keys and functions.

- Arrange the keys for modern language use. Layouting the keys to offer an efficient typing experience for modern english as well as the ideal work base for computer work.
- Optimize for computer work.

The result is **Okey**, the one hand keyboard that frees your hands.

While offering all necessary keys of a conventional keyboard, **Okey** uses nature-inspired space-efficient hexagonal keys, making the most of the little space it needs. It introduces the OHDIATENSR layout which lets you type 70% of all words without leaving the base position of your hand on the keyboard. Centered around the E key — the most common letter and most commonly used key — OHDIATENSR is focusing around common letter combinations for a fast typing experience. The Space key — second most used key — is placed right beneath your thumb, making it always accessible. To benefit muscle memory, **Okey's** function keys are placed on the outer positions of the keyboard, making them easy to find. **Okey** allows all of this with just one hand, enabling you to free your mouse-hand for other tasks. Moreover, using **Okey** is ergonomically excellent since your wrist is in a natural position pointing straight away from your body.

All in all, **Okey** is finally a human-centered interface that makes typing and working with your computer a smoother experience.

Abstract

This thesis shows the research and design of **Okey** - the one hand keyboard. **Okey** is targeting casual and pro computer users since it is not only designed to offer a faster and easier typing experience but is also optimized for computer work. The thesis includes research about keyboard usage, typing behavior, human-computer interaction, linguistics, and space-saving design. The design part covers the primary inventions of the design, space-savings, the hexagonal keys, ergonomics, and the new key layout called OHDIATENSR.

Research

The History of the Keyboard (And a few Milestones of the Computer)

The history of the keyboard is bound to the history of the typewriter. In fact, the typewriter is the direct predecessor of the computer keyboard.

A typewriter is a machine for writing characters. Inspired by the letterpress printing, it drove a revolution of independent writing in the 1900th century. Similar to letterpress printing, type elements applied ink to a piece of paper. Unlike letterpress, it was not a tool for mass producing prints.

The most crucial typewriter for the modern keyboard and the first one to be commercially successful was invented by Christopher Latham Sholes, Frank Haven Hall, Carlos Glidden, and Samuel W. Soule. One of the first typewriters constructed by Sholes used a piano-like keyboard with characters arranged alphabetically.

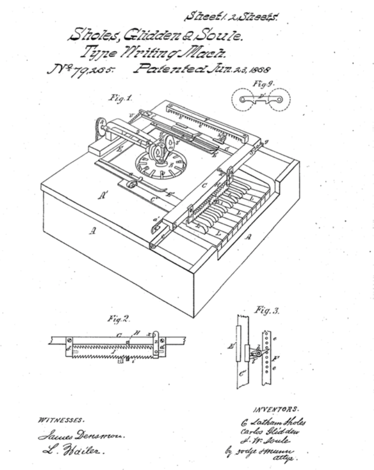

Fig 1. Type writing machine. Sholes, Latham; Glidden, Carlos; Soule, J.W. (1868). From United States Patent and Trademark Office. https://pdfpiw.uspto.gov/.piw?Docid=00079265&Input=View+first+page&PageNum=&Rtype=&SectionNum=&homeurl=http://patft.uspto.gov/netacgi/nph-Parser?Sect2%3DPTO1%2526Sect2%3DHITOFF%2526p%3D1%2526u%3D/netahtml/PTO/search-bool.html%2526r%3D1%2526f%3DG%2526l%3D50%2526d%3DPALL%2526S1%3D0079265.PN.%2526OS%3DPN/79265%2526RS%3DPN/79265&idkey=NONE

Later, the piano-like keys were replaced with buttons on four rows. The horizontal space needed for the mechanics lead to an offset of a quarter key between the keys of each row. This displacement is still found on keyboards we use today.

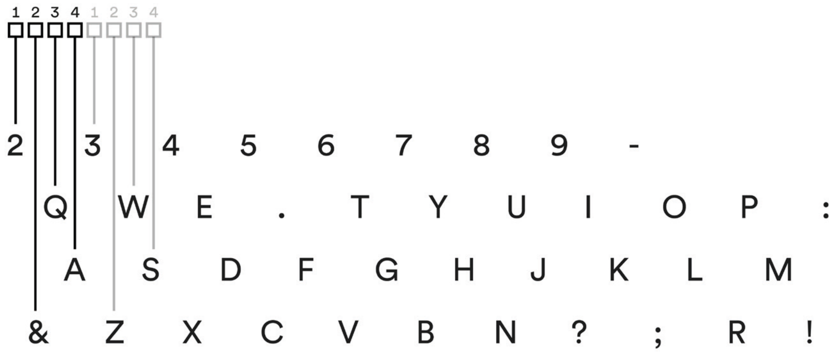

Fig 2. Horizontal space consumption of typewriter mechanics. Vincetić, Mato (2019).

The alphabetical arrangement of the keys in combination with the mechan-ics used, had flaws which led the typewriter to jam. One of the flaws occurred if neighboring characters — such as »TH« or »ST« — were pressed in sequence or at the same time. Those letter sequences led the metal arms or type bars on which those characters were mounted to clash and jam.

This mechanical flaw of the typewriter paves the way to the modern arrangement of characters still used on nearly all computer keyboards.

After years of trials and errors, Sholes arrived at a near QWERTY keyboard in 1873. The main difference to QWERTY was the placement of the letter R and the period were interchanged, making it the QWE.TY layout.

Fig 3. Keyboard arrangement in July, 1872. Scientific American, Vol.27, No.6 (August 10, 1872). The Type Writer, QWE.TY.

Only short after this, a patent was filed showing the layout changed to QWERTY.

Fig 4. Prototype of the Sholes and Glidden typewriter, the first commercially successful typewriter, and the first with a QWERTY keyboard, 1873.. Wikipedia contributors, (2019, May 17). Typewriter. In Wikipedia, The Free Encyclopedia. Retrieved 11:56, May 20, 2019. From https://en.wikipedia.org/w/index.php?title=Typewriter&oldid=897480724

This adjustment still baffles historians. While it seems that the intention of Sholes QWE.TY layout was to separate the most common letter combinations, the placement of »E« and »R« does the opposite. Since »ER« or »RE« are one of the most common letter combinations, placing them next to each other is contrary to the common theme that QWE.TY alleges. This again leads to the type bars of »E« and »R« only being separated by one other type bar, making them likely to jam.

There are two, more or less, plausible theories why the layout was changed:

- The »Watch How Fast I Can Type« theory. Since the typewriter was a new invention, it had to be marketed. The »Watch How Fast I Can Type« theory states that the »R« was placed in the upper row so that marketers presenting the typewriter to customers could type » TYPEWRITER « really fast. (All of the letters needed to type typewriter were placed in the first row.)
- In a Paper released in 2011, Koichi Yasuoka and Motoko Yasuoka argue that the »[...] Typewriter keyboard was originally derived from Hughes- Phelps Printing Telegraph, and that QWERTY was developed for Morse receivers. [...] Operators of Typewriters in the 1870's were telegraphers and shorthanders.«[1] In short, this theory states that the adjustments were made to fit parts of a layout known to telegraphers and morse code receivers.

Sadly, there are no comments whatsoever regarding this adjustment by none of the involved people.

1 Yasuoka, Koichi; Yasuoka, Motoko (2011), On the Prehistory of QWERTY. In Zinbun (2011), 42, 161-174. DOI: https://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/139379/1/42_161.pdf

Shortly after this adjustment, Sholes sold the manufacturing rights for the so-called Sholes & Glidden Type-Writer to E. Remington and Sons.

In 1878 the Remington No. 2 was released, featuring a layout that was mostly today's QWERTY including upper and lower case characters[2].

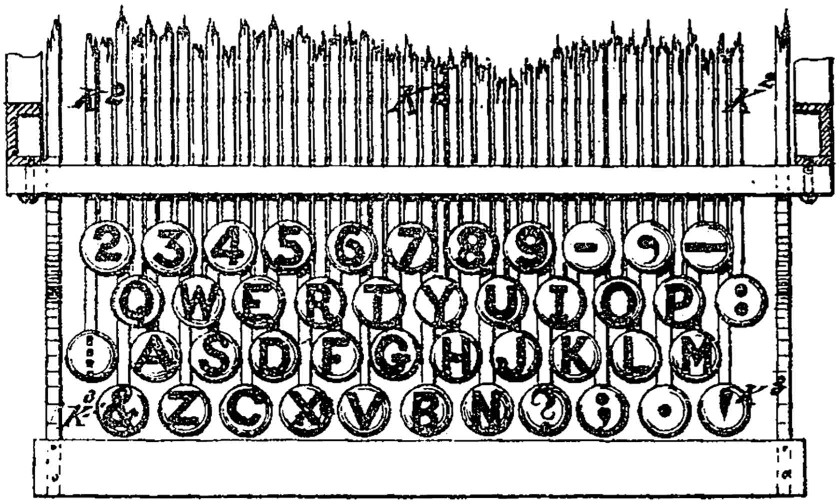

Fig 5. Keyboard of Sholes & Glidden Type-Writer. Sholes, Latham (1868). Type-writing machine. In United States Patent and Trademark Office. From https://patimg2.uspto.gov/.piw?docid=00207559&PageNum=2&IDKey=82F335A682F5&HomeUrl=/

The device was widely successful. To be so, E. Remington and Sons made a genius move to out-do the competitors with different layouts. The company not only offered the typewriters, but also »touch typing« course for private businesses, colleges, universities, and The World Young Women's Christian Association (YWCA). A few years later, the system was vastly popular, so much that so-called Remington Typing Schools were open throughout Europe. With this move, Sholes and E. Remington laid the foundation of QWERTY's lasting success. Touch typist who had learned to type with QWERTY and Remington machines were almost certain to work with the same system in the future.

Because of the Remington No. 2's success, the QWERTY layout soon started to spread and was adopted by other manufacturers, leading to the overwhelming presence it has today.

The following years the typewriter gained popularity. Every now and then it was slightly changed. The Tabulator Key was added, options for typing in different colors soon became possible and electric models were introduced. Although mechanically unnecessary, the QWERTY layout and the horizontal spacing of the

2 Sholes, C. Latham (1878), Improvement in typewriting machines. In United States Patent Office, Specification forming part of Letters Patent No. 207.559, 1-3. From https://patents.google.com/patent/US207559A/en

keys were further used due to the marketing work of Sholes and E. Remington and Sons.

The keyboard took its final step towards the modern age with a change in computer technology – the introduction of IBM 5150. The IBM 5150 featured the first computer keyboard, the famous Model M – a base-model for most of today's computer keyboards. At this point in time the QWERTY layout was bound to the computer.

Fig 6. IBM 5150. Copyright unknown. IBM 5150. Found on http://oldcomputers.net/ibm5150.html

Fig 7. IBM Model M. Wikimedia Commons. IBM Model M. From https://en.wikipedia.org/wiki/IBM_Personal_Computer#/media/File:IBM_Model_F_XT.png

It was only two years later that another leap in computer technology made the QWERTY keyboard a wrong fit for the computer. In 1983 Apple released the Apple Lisa. Lisa's success was based on its Graphic User Interface and usage with a mouse. Nonetheless, the usage of the mouse brought a problem that went unnoticed for keyboards. It took a hand away from the keyboard and put it on the mouse. However, QWERTY was made for two hands. Therefore, users had to switch hands from the keyboard to the mouse and back again. From now on, computer users used a keyboard layout invented nearly 100 years ago for machines that made it hard to type common letters, and they had to use it with a hand short because the mouse is used for more accurate work and required a hand.

Fig 8. Apple Lisa. Copyright unknown. Found on https://www.macworld.com/article/2026544/the-little-known-apple-lisa-five-quirks-and-oddities.html

After the Model M, the computer keyboard experienced the same slight modifications as the typewriter, and so did the mouse. Other than those little changes over time, the functions and more over the demands of both devices stayed the same, forcing the user to use two devices that would require three hands.

Anatomy of the Modern Keyboard

As mentioned in »History of the Keyboard«, nearly all modern latin-script based keyboards are direct successors of the IBM Model M and therefore successors of the QWERTY typewriter keyboard invented by Sholes in the 1880s. Alongside the mouse, the keyboard is used as a primary input device of computers and is, therefore, part of the human-computer interface.

All Keyboards intended for computer usage feature at least the following types of keys[3]:

3 Cf. Wikipedia contributors (2019, May 14). Keyboard layout. In Wikipedia, The Free Encyclopedia. Retrieved 16:38, May 18, 2019. From https://en.wikipedia.org/w/index.php?title=Keyboard_layout&oldid=897066096

- Alphanumeric/character /typewriter keys for typing letters, numbers and punctuation.
- Control keys for altering the functions of other keys like Control, Command, Alt.
- Navigator or arrow keys for moving a cursor.

Most of the keyboards feature the following types of keys[4]:

- System keys like Escape.
- Functions keys for specific actions on the computer like volume up or brightness up.
- Numeric keypad for calculations.

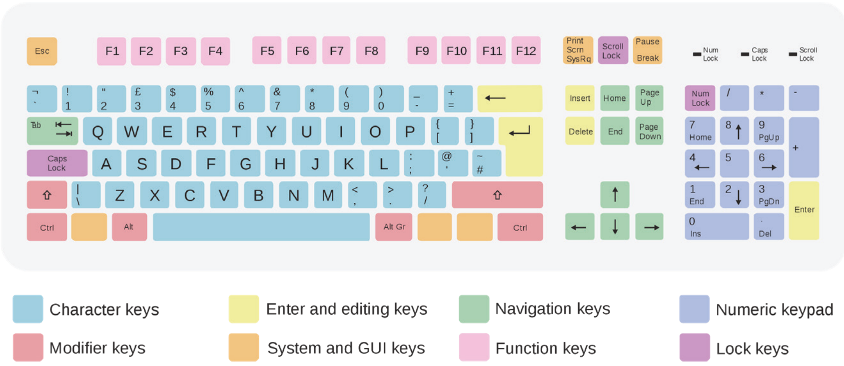

Fig 9. Keyboard Key Types. Wikimedia Commons. From https://en.wikipedia.org/wiki/Keyboard_layout#/media/File:ISO_keyboard_(105)_QWERTY_UK.svg

Depending on the number of keys and duplicate keys, keyboards are categorized in[5]:

- 100% or full-sized keyboard. Mostly found in use with desktop computers or gaming setups. This type of keyboard features all types of keys, therefore alphanumeric keys, multiple duplicates of control keys, navigator keys, system keys, function keys and the numeric keypad.
- 80% or Tenkeyless. Mostly found in use with desktop computers. This type of keyboard features all types of keys but the numeric pad.
- 75% or compact keyboard. Mostly found on small laptops and ultrabooks. This type of keyboard features only the alphanumeric keys, a few duplicates of control keys and a compact version of the navigator keys.

4 Cf. Wikipedia contributors (2019, May 14). Keyboard layout. In Wikipedia, The Free Encyclopedia. Retrieved 16:38, May 18, 2019. From https://en.wikipedia.org/w/index.php?title=Keyboard_layout&oldid=897066096

5 William Judd (2017, August 9). Full-size, TKL, 60% and more: a guide to mechanical keyboard sizes. In The Keyboard Company. From https://www.keyboardco.com/blog/index.php/2017/08/full-size-tkl-60-and-more-a-guide-to-mechanical-keyboard-sizes/

- 60%. This type of keyboard features only the alphanumeric keys and the essential control keys. Very uncommon.
- Multiple other categorizations that go into fine detail about the number and arrangement of the keys.

Fig 10. Keyboard 100%. Apple (2019). Apple Magic Keyboard with numeric keypad. From https://www.apple.com/shop/product/MQ052LL/A/magic-keyboard-with-numeric-keypad-us-english-silver

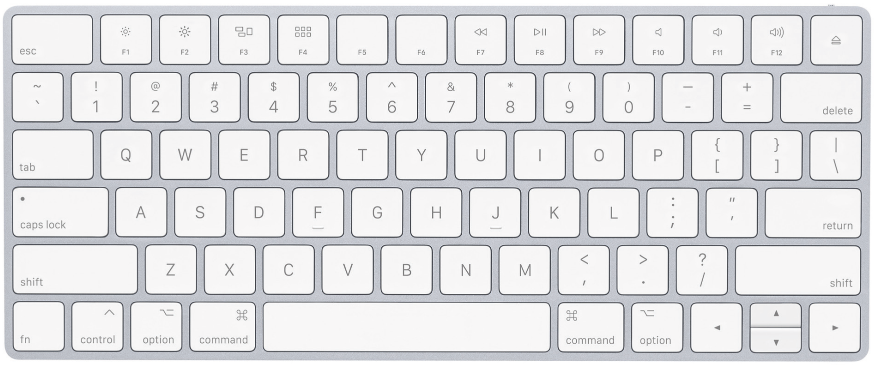

Fig 11. Keyboard 75%. Apple (2019). Apple Magic Keyboard. From https://www.apple.com/shop/product/MLA22LL/A/magic-keyboard-us-english

The different keyboard sizes can be further classified in:

- Mechanic type of the keys e.g., mechanical switch, Scissor switch, Butterfly Switch and others.
- Virtual (on-screen) or physical keyboard.
- Area of application e.g., gaming, ergonomic.
- Many other more detailed categorizations.

Most commonly, keyboard keys are 15 to 16mm wide. The distance from key center to key center is 19.05mm, making the distance between keys or key travel somewhere between 2 to 3mm.

A good mechanical keyboard has a key lifespan of about 50 million keystrokes.

Alternative Character Layouts and Efficiency

As mentioned in »The History of the Keyboard«, QWERTY was only one of multiple Typewriters at the time, all of whom had different key arrangements. With the genius marketing of QWERTY, it became the go-to design but not without being criticized for inefficiency very soon. The efficiency of layouts is measured by the placement of common letters in the home row, and the distance fingers travel while typing. The home row is the middle row of the alphabetic section of a keyboard. In QWERTY this would be the row starting with »A«. By separating common letters and letter combinations, QWERTY is counterproductive for fast, efficient, and ergonomic typing. Over time, other layouts were proposed improving on many flaws of QWERTY, the two most successful being the Dvorak Simplified Keyboard and the Colemak.

The Dvorak Simplified Keyboard or DSK was patented in 1936. It is accessible as an option in most of today's operating systems. The 1894 Apple IIc featured a switch on its keyboard making it possible to change between QWERTY and DSK. It was mentioned in one of Apple's advertisements for the Apple IIc featuring Barbara Blackburn who set the world record in typing speed with the DSK layout. »Typing, Fastest. Mrs. Barbara Blackburn of Salem, Oregon maintained a speed of 150 wpm (words per minute) for 50 min (37,500 key strokes) and attained a speed of 170 wpm using the Dvorak Simplified Keyboard (DSK) system. Her top speed was recorded at 212 wpm.«[6] In comparison, an average person using QWERTY hits about 41 wpm. DSK achieves this speed improvement by putting most of the common letters in the home row.

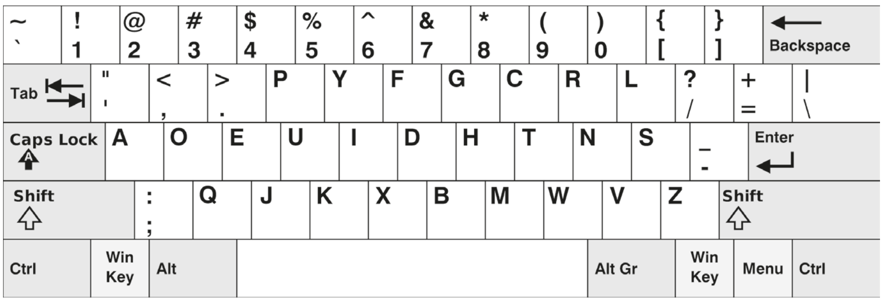

Fig 12. Dvorak Simplified Keyboard or DSK. Wikimedia Commons. Dvorak Simplified Keyboard or DSK From https://en.wikipedia.org/wiki/Dvorak_Simplified_Keyboard#/media/File:KB_United_States_Dvorak.svg

The Colemak is a layout similar to QWERTY, offering an easier change to users already familiar with QWERTY. Most of the non-alphabetic keys and important

6 McWhirter, Norris (1985). THE GUINNESS BOOK OF WORLD RECORDS, 23rd US edition.

shortcuts share the same position as on QWERTY. On the other hand, 17 keys are repositioned with the same goals as DSK, minimizing travel distance, and making more use of the home row.

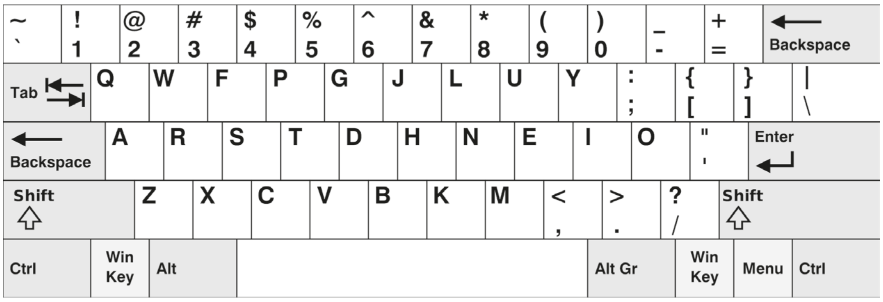

Fig 13. Colemak Keyboard. Wikimedia Commons. Colemak Keyboard. From https://en.wikipedia.org/wiki/Colemak#/media/File:KB_US-Colemak.svg

Alternative Keyboard Designs and Ergonomics

Since the design of the keyboard dates back to the 1880s, many people tried to redesign it. Other than optimizing performance, size and thickness of keyboards, two ideas took a more radical approach towards the keyboard design: the ergonomic keyboard design and the gaming keyboard design. Since gaming involves spending lots of time using keyboards, the difference between ergonomic keyboards and gaming keyboards is mostly in marketing and flashy effects on gaming keyboards.

Conventional keyboards require the user to put his hands, wrist, and forearm in an unnatural and unhealthy position.

> *When typing, holding the hands and wrists in a neutral work posture--where the hands are extended straight without significant bending at the wrist-- is thought to reduce the risk of musculoskeletal problems. Computer users sometimes use awkward or non-neutral work postures when working on the traditional keyboard. They rotate their forearms so that their palms are facing the keyboard [...], and they often bend their hands outward [...] and upward [...]. Sometimes, workers also hold their elbows slightly away from their bodies [...] while keying, particularly when the keyboard surface is too high. Alternative*

keyboards can help keep wrists straight as shown on the following pages.[7]

Therefore, as long as keyboards require both hands in front of a users body, the hands are forced into a harmful position. Some ergonomic designs tackle this by splitting the keyboard in half, resulting in a better hand posture. Although this is an improvement, it presumes the user to be a trained touch typist able to perfectly separate the left hand from the right hand while typing. Other current approaches to ergonomic keyboard designs include rotating split keyboards, tilting the keys and/or applying the keys to a concave or convex base.

How We Type

Living in a time where touch type lessons are out of fashion, the vast majority of keyboard users adopts a typing technique on their own. In contrary to common assumptions, a touch typist is not necessarily faster than an untrained typist. A study of the Aalto University[8] found out that:

1. With just 5 fingers you can be as fast as somebody using all 10.

2. Don't worry if you never took a typing course. Those who did are not neces sarily faster than you.

3. You could type without looking at your fingers, even if you never learned the touch typing system.

4. Your two hands move very differently when typing.

5. There are many strategies between "hunt-and-peck" and touch typing. In fact, we all type very differently.

In general, typists can be categorised in:

- Touch typist or somebody who learned to type with all fingers minimizing the motion necessary to perform optimally.
- Typist using the Hunt and Peck method or somebody untrained in typing using his own technique.

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7 U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health (Year unknown). Alternative Keyboards. In DHHS (NIOSH) Publication No. 97-148.

8 Cf. Feit, Anna Maria; Weir, Daryl; Oulasvirta, Antti (2016). How We Type: Movement Strategies and Performance in Everyday Typing. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI ,16), 4262-4273. DOI: https://doi.org/10.1145/2858036.2858233

- A hybrid or somebody experienced in typing who reduced travel time and improved type speed with own techniques.

Differences Between Trained and Untrained Typists

What is surprising is that there is no significant difference in input performance between touch typists and non-touch typists. »The common understanding in the literature was that touch typists could type faster and operate with higher accuracy. However, the presented findings show that touch typists and non-touch typists have comparable speed and efficiency in transcribing sentences.«[9] The main difference between those two is that trained typists travel less, use more fingers in general and use a constant pattern of fingers for key mapping[10].

Difference Between Left and Right Hand

Many studies conclude that the left hand uses more fingers and moves less than the right hand[11]. This effect is also noticeable in work environments, where most of the keyboard shortcuts are utilized by the left hand due to it being placed continuously on the keyboard, while the right hand uses the mouse.

9 Feit, Anna Maria; Weir, Daryl; Oulasvirta, Antti (2016). How We Type: Movement Strategies and Performance in Everyday Typing. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI ,16), 4262-4273. DOI: https://doi.org/10.1145/2858036.2858233

10 Cf. Feit, Anna Maria; Weir, Daryl; Oulasvirta, Antti (2016). How We Type: Movement Strategies and Performance in Everyday Typing. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI ,16), 4262-4273. DOI: https://doi.org/10.1145/2858036.2858233

11 Dhakal, Vivek; Feit, Anna Maria; Kristensson, Per Ola; Oulasvirta, Antti (2016). Observations on Typing from 136 Million Keystrokes. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI ,16), 4262-4273. DOI: http://dx.doi.org/10.1145/2858036.2858233

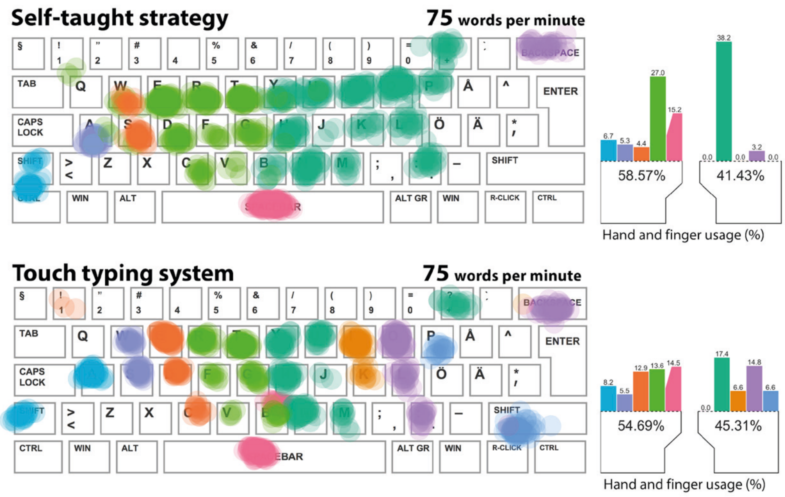

Fig 14. Self-taught vs touch typing typists, left vs right hand. Feit, Anna Maria; Weir, Daryl; Oulasvirta, Antti (2016). How We Type: Movement Strategies and Performance in Everyday Typing.In Proceedings of the 2016 CHI Conference on

Human Factors in ComputingSystems (CHI ,16), 4262-4273. DOI: https://doi.org/10.1145/2858036.2858233

Product Design

The Challenge

As described in »Introduction«, the keyboard is not only outdated but was wrong since the days of the first computers. Apple missed the opportunity to introduce a completely new interface with the introduction of the mouse and GUI. In sum, the main flaws of the conventional keyboard are:

- Made for usage with two hands. Users have to switch between the mouse and the keyboard.
- Designed for mechanical demands of typewriters, therefore it does not fit to the contemporary function.
- Bad key layout for typing due to common letters being distributed far from each other.

These conditions and problems challenged me to overthink and redesign the keyboard in significant ways:

- Human-centered Design.
  Small enough to use with one hand while keeping all keys and functions.
- Nature-inspired space efficiency.
  The Keys are distributed in a grid of hexagons, making the most of the space and introducing common travel distance between all adjacent keys. Control Keys are distinct by placement, not size.
- Linguistics and statistics.
  Based on modern short texts like google search entries and mails the most common letters and combinations build the base of the new OHDIATENSR layout explained later in *„Key Layout — OHDIATENSR“ on page 25*. Surrounding the »E«, all letters are placed in pairs next to each other.
- Blazing fast.
  By placing common letters close together, the new OHDIATENSR layout makes 70% of all words accessible from the home position.
- Optimized for work.
  Characters, punctuation, and functions meet contemporary users demands, making shortcuts accessible and keys easy to find without gazing. It is

optimized to bring all the crucial functions to where users need them – under the left hand's fingertips. It benefits on existing muscle memory by keeping the average key distance the same as on conventional keyboards.

All of these optimizations resulted in **Okey** – the one hand keyboard.

Okey – The One Hand Keyboard

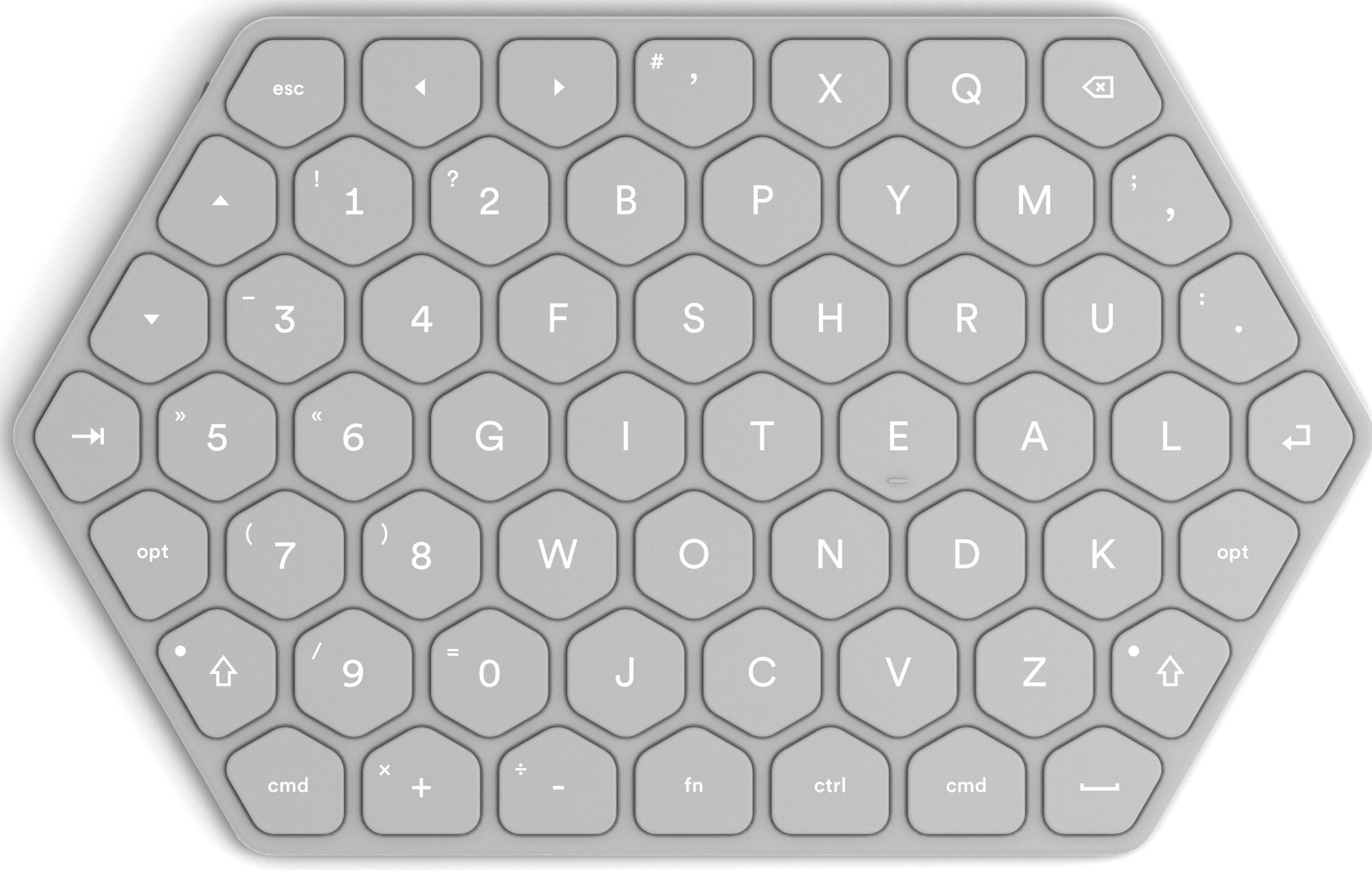

Fig 15. Okey in actual size. Fritz, Ines (2019).

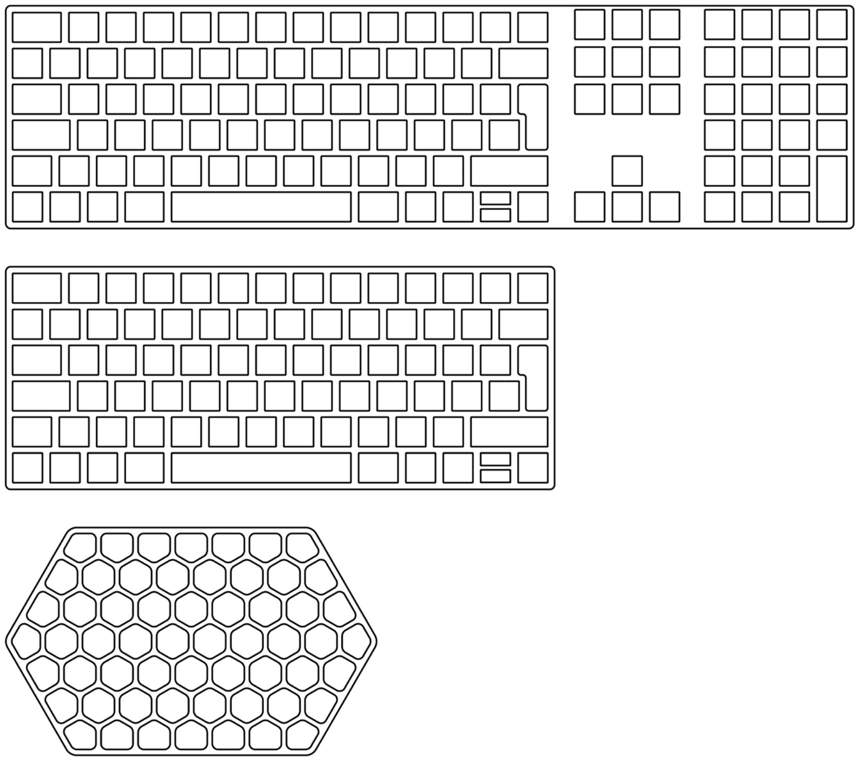

Fig 16. From top to bottom: conventional keyboard with number pad, conventional laptio keyboard, Okey. Vincetić, Mato (2019).

Specs

Height: 10 mm
Width: 117 mm
Depth: 190 mm
Number of keys: 58

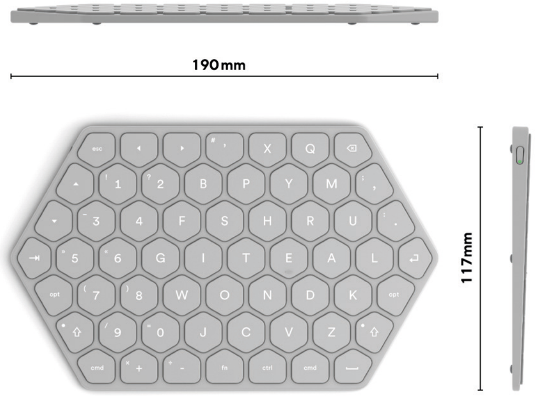

Fig 17. Okey sizing. Fritz, Ines (2019).

Form — The Hexagon

Okey obeys one of designs most cited principles; »form follows function« by Louis Henry Sullivan. Since **Okey's** fundamental function is to enable a user to use his mouse and his keyboard to the fullest at the same time, its form had to be radically redesigned. To meet the above, and all other functions needed by modern computer users (easy access to keyboard shortcuts and control keys, typing, ergonomic work posture) **Okey** introduces a unique way to be space efficient; the hexagon.

Since the base area of a fingertip pressing a key corresponds to a circle, a circle would offer a good human interface for a key. As much as the circle is efficient on its own, it starts to be inefficient when tiled. This condition is where nature came up with an incredible solution; the honeycomb conjecture proven by mathematician Thomas C. Hales in 1999.

> *Theorem 1-A (Honeycomb Conjecture). Let   be a locally finite graph in R2, con- sisting of smooth curves, and such that R2\   has infinitely many bounded connected components, all of unit area. Let C be the union of these bounded components. Then Equality is attained for the regular hexagonal tile.*[12]

12 Hales, Thomas C. (2001, January). The Honeycomb Conjecture. In Discrete and Computational Geometry, 25, 1–22. DOI: 10.1007/s004540010071

In easy words:

> *The honeycomb conjecture states that a regular hexagonal grid or honeycomb is the best way to divide a surface into regions of equal area with the least total perimeter.*[13]

Therefore, the hexagon tiling is the densest way to arrange circles (the base area of fingertips) in two dimensions. **Okey** makes use of this and introduces hexagonal keys. This leads to each key having six equally spaced adjacent keys opposed to the conventional keyboards six adjacent keys of which only the horizontal two are spaced evenly. Therefore the hexagonal tiling offers ideal conditions for a user to benefit from muscle memory for travel distance.

Fig 18. Rectangular keys vs. hexagonal keys. Vincetić, Mato (2019).

The other effect a hexagonal key offers is space savings. By using the same 19.05mm key-center distance conventional keyboards use, users have a familiar feeling of finger travel on **Okey's** keys — again benefiting of existing muscle memory from conventional keyboards. This distance leads to the keys having similar widths as conventional keys but saving area by using a hexagonal form instead of a rectangle. Saving space goes unnoticed by users since the travel distance is the same, and key widths are similar to conventional keyboards.

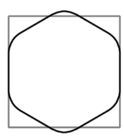

Fig 19. Rectangular keys vs. hexagonal keys. Vincetić, Mato (2019).

13 Wikipedia contributors (2019, April 8). Honeycomb conjecture. In Wikipedia, The Free Encyclopedia (Retrieved 2019, May 20, 06:56). From https://en.wikipedia.org/w/index.php?title=Honeycomb_conjecture&oldid=891577723

Therefore, the entire keyboard shrinks in size, making it easier to use with one hand.

Ergonomics

Since **Okey** is optimized to be used with one hand, the position of the keyboard in the work environment changes. **Okey** is placed not directly in front of users but by its left-hand side so that the users can leave their arms and elbows parallel to their bodies. Furthermore, since **Okey** is placed by the left-hand side, users wrists are positioned in a neutral, unbend work posture pointing straight to the keyboard, reducing the risk of musculoskeletal problems.[14]

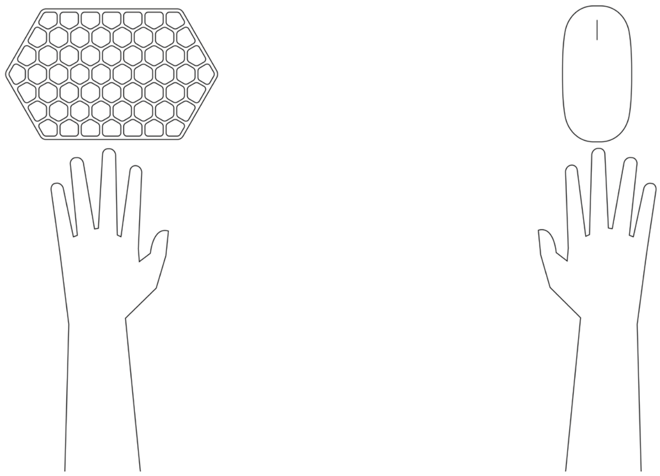

Fig 20. Position of Okey and hands in front of body. Vincetić, Mato (2019).

14 Cf. U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health (Year unknown). Alternative Keyboards. In DHHS (NIOSH) Publication No. 97-148.

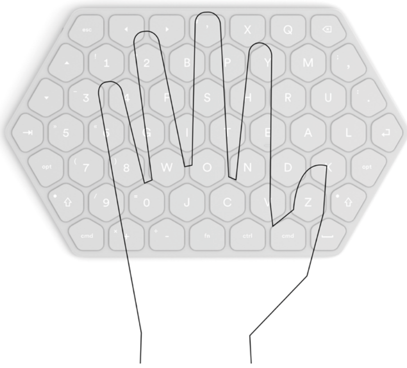

Fig 21. Position of hand with straight wrist on Okey. Vincetić, Mato (2019)

Key Layout — OHDIATENSR

As QWERTY was designed to fit the requirements of the century-old typewriter, **Okey** introduces an entirely new key layout based on the needs of modern typing and the hexagonal keys — the OHDIATENSR layout. OHDIATENSRs name is based on DHIATENSOR, a layout introduced first in 1902 for the Blickensderfer Electric typewriter.[15] »Blickensderfer determined that 70% of the most commonly used letters and 85% of words contained the letters DHIATENSOR.«[16] Those Letters are still the most common letters of the English alphabet.[17] The name OHDIATENSR is based on those letters, ordered so that the name starts with »O« and »H« followed by the rest »DIATENSR« — meaning **O**ne **H**and **DIATENSR**.

15 Cf. The Virgil Typewriter Museum (Year unknown). Blickensderfer Electric. From http://www.typewritermuseum.org/collection/index.php3?machine=blickel&cat=ks

16 Wikipedia contributors (2019, February 15). Blickensderfer typewriter. In Wikipedia, The Free Encyclopedia (Retrieved 2019, May 20, 08:38). From https://en.wikipedia.org/w/index.php?title=Blickensderfer_typewriter&oldid=883527844

17 Cf. The Oxford Math Center (Year unknown). Letter Frequencies in English. From http://www.oxfordmathcenter.com/drupal7/node/353

The arrangement of the keys is centered around the »E«, the most common letter. This position is ideal to be reached by the user's index or middle finger from the home position of the user's hand.

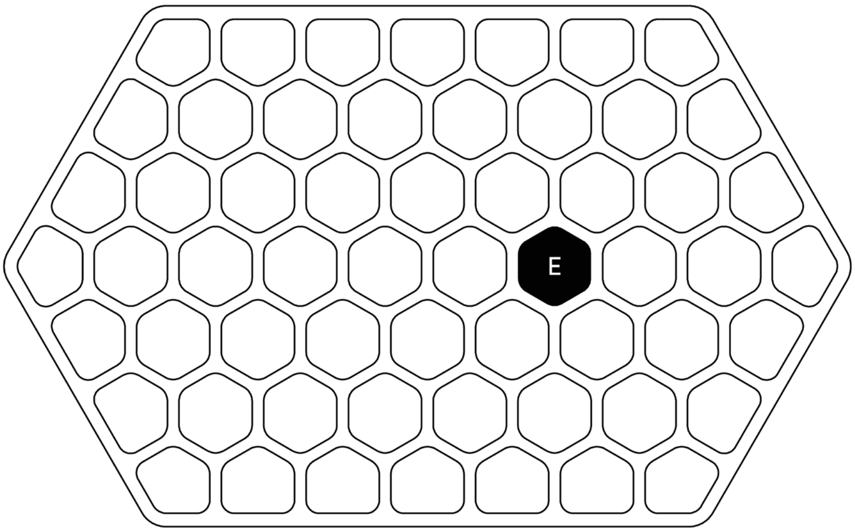

Fig 22. Okey with »E« at its center. Vincetić, Mato (2019).

Then, letters of the most common »E«-bigrams[18] are placed to surround the »E«, making typing bigrams extremely efficient. The keys being hexagons leads to the »E« having six adjacent letters of which all are common bigrams of »E«.

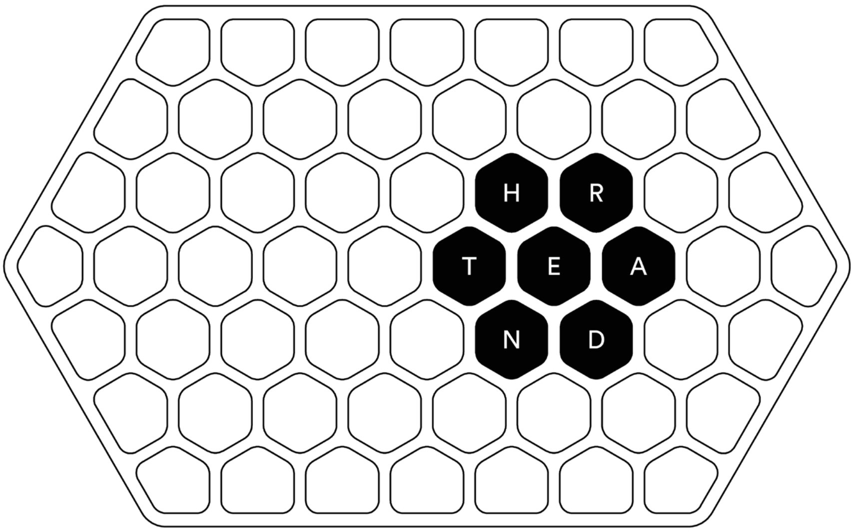

Fig 23. Okey with »E« at its center and bigrams. Vincetić, Mato (2019).

18 Wikipedia contributors. (2019, May 4). Letter frequency. In Wikipedia, The Free Encyclopedia. Retrieved 17:36, June 4, 2019, from https://en.wikipedia.org/w/index.php?title=Letter_frequency&oldid=895486144

This pattern is continued, filling the center of **Okey** and the keys accessible from the base position of the hand with the rest of OHDIATENSR.

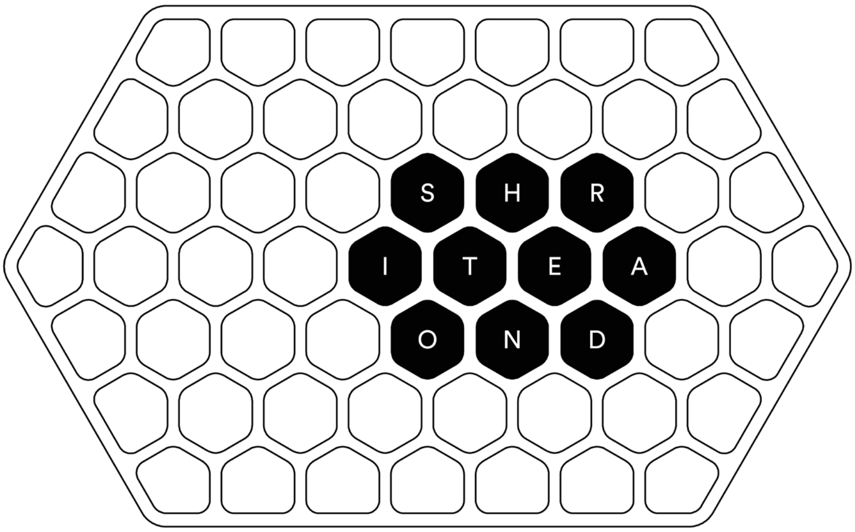

Fig 24. Okey OHDIATENSR. Vincetić, Mato (2019).

The pattern of bigrams is further continued to fill the rest of the alphabet.

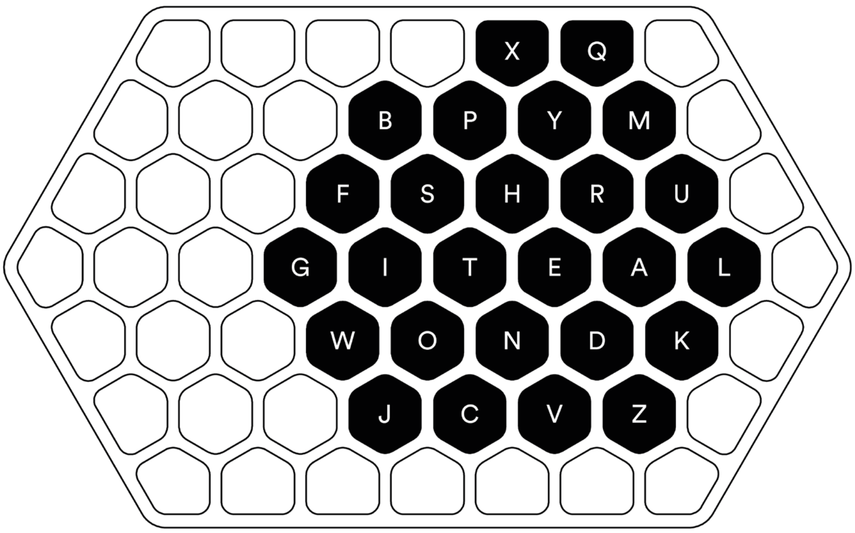

Fig 25. Okey all characters. Vincetić, Mato (2019).

But not only the bigram pattern is applied. Important letters of keyboard shortcuts such as »C«, »V«, and »Z« are placed so that users have easy access to both those keys and control keys like CMD, CTRL.

Further, the space key — second most important key[19] — is placed so that the users hand has easy access to both the »E« with his index or middle finger and the space key with his thumb.

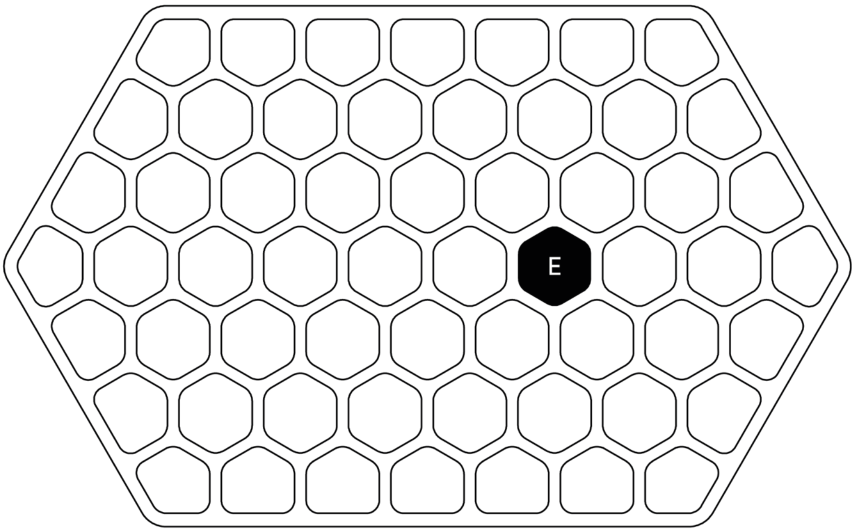

Fig 26. Okey E and space. Vincetić, Mato (2019).

The most important typewriter keys — space, enter, and backspace — are placed each in one corner to the right, making them benefit from muscle memory while still being far enough apart so that accidental hits do not happen.

A total of two shift keys are placed on **Okey** — one on the left side, the other on the right. The right shift key is placed to be reached by the user's thumb, the left by the pinkie.

The most important punctuations — period (shift: colon), comma (shift: semicolon), and apostrophe (shift: hashtag) — are placed close to the characters. Therefore, the right side of **Okey** represents the alphabetic and shortcut section.

19 Cf. Business Insider (2013, July 13). These are the Three Most Popular Keys on a Keyboard. From https://www.businessinsider.com/these-are-the-three-most-popular-keys-on-a-keyboard-2013-7?IR=T

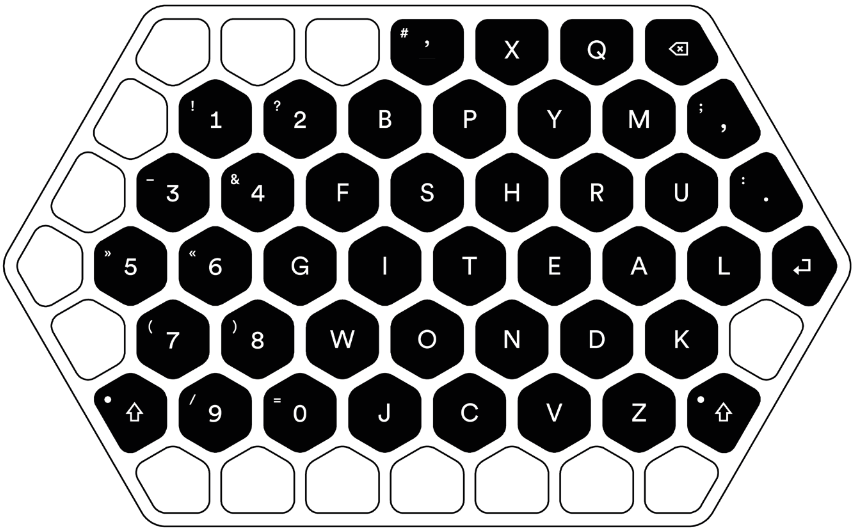

Fig 27. Okey alphabetic and numeric section. Vincetić, Mato (2019).

The left side of **Okey** features numbers, mathematical operators, control, and navigation keys. It represents the work section of **Okey**.

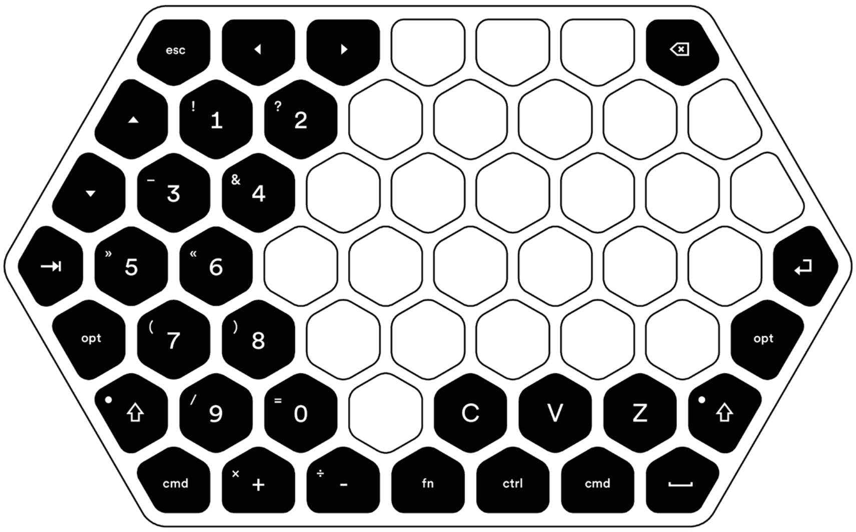

Fig 28. Okey work section. Vincetić, Mato (2019).

Again, essential control keys like »ESC« and »Tab« are placed in corners, therefore spaced far enough to not be interchanged, but still to the benefit of muscle memory.

The shift assignment follows the theme of punctuation first, mathematical operators second, making use of modern and typographically accurate punctuation.

The »+« and »-« keys have their logical multiplication counterpart as shift assignment: »*« and »/«.

Lastly, »fn« is placed so that the missing function keys functions can be easily accessed through the shortcut of »fn« and any number, thus completing the layout.

Other than the missing function keys (rarely used nevertheless accessible through key combinations), **Okey** makes no compromise in keys. Its available keys are similar to a layout found on a 70% keyboard, a typical laptop keyboard.

Up to this point this arrangement is proven by several early prototype users.

However, **Okey** has not to be mistaken for a design that is only usable by one hand. If the situation requires it — be it to write a long mail or to code — both the hexagonal keys and the OHDIATENSR layout provide ideal premises to be used with both hands.

All in all, **Okey's** form and the key assignment make it a modern keyboard, especially useful to pro users dependent on working simultaneously with their keyboard and mouse. It places all functions a keyboard needs under the fingertips of only one hand.

Branding

Since **Okey** is an entirely new device, the primary purpose of the branding is to introduce **Okey** and all of its improvements over conventional keyboards. The name »Okey« is a syllabic abbreviation of One-Hand Keyboard – **Okey**. Therefore it is a description of the device itself. Additionally, it was chosen for its resemblance to the word »Okay«. The branding builds upon the concept of freeing hands from conventional keyboards. The main message is to enable users to do everything a conventional keyboard requires two hands for with one hand. This concept culminates in the claim »Free your hands!«. An empowering invitation to a new era of human-computer interaction. When used in sequence with the name, the name (due to its resemblance to the word »Okay«) serves as an answer to this invitation – »Free your hands!« »Okey«. This wording-dynamic is further used throughout the branding.

In wording, often references are made to keyboard keys. Words like »Enter« and »Space« are used more frequently due to them having meanings as keys and words on their own. Keynames like »Esc« or »Cmd« serve further to communicate the message of **Okey** being a keyboard. This wording, in combination with the name-dynamic peaks in little stories like »Esc QWERTY!« »Okey« or »Cmd your computer with one hand!« »Okey«.

In small print applications up to DIN A3, **Okey** is shown in its actual size, inviting the viewer to simulate typing a few letters and using the device. In larger print applications and digital applications, **Okey** is mostly shown with at least one object to compare its size to, e.g., a hand or a mouse.

Fig 29. Okey in use and size comparison to a hand. Vincetić, Mato (2019).

The Logo is a logotype with the y adapted to fit **Okey’s** angle.

Fig 30. Okey Logo. Vincetić, Mato (2019).

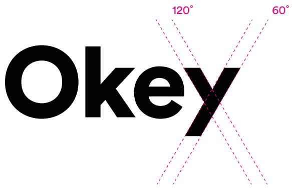

Fig 31. Okey Logo with adapted angle of y highlighted. Vincetić, Mato (2019).

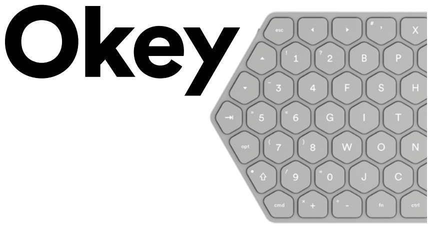

Fig 32. Okey Logo with Okey next to adapted y. Vincetić, Mato (2019).

Prospect

Okey is a bold project, it requires many steps to complete. It is my goal to make **Okey** a real product available to the market in the next two years. At this point – and as far as my thesis goes – **Okey** has completed the concept phase including research of keyboard usage, typing behavior, human-computer interaction, linguistics, space-saving design and the design of the device itself. It has entered the testing phase, which marks about 30% completion of the whole project. For prototyping and testing, **Okey** will be applied for project funding »impulse xs« of aws in the fall of 2019. With the funding, first **Okey's** linguistic research – the foundation of the key layout – will be scientifically review. After this, a functional prototype will be built and tested.

If successful, I hope to pitch **Okey** to manufactoring partner who will help bring **Okey** to life and their many customers around the world.

As a designer, I strive to create. It lies in my nature to spot problems and introduce solutions to them. **Okey** is but one of many solutions I wish to introduce. Therefore, I do not want to build my life-foundation and main business around **Okey** as it is nowadays usual with many startups. With **Okey**, I introduce a great design to a problem gone unnoticed for a long time. I wish to finish **Okey** and see it in use, improving on the human-computer interaction of many users out there. I wish to see **Okey** free a lot of hands, and while it does so, I wish to go on and find another problem to solve.

Free your hands.

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Figure Index

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