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IDEASQUARE COFFEE PAPER

Coffee, theorems and…innovation

In addition to its main purpose of publishing experimental innovation research related results, CIJ also publishes lighter, inspirational food-for-thought intended "IdeaSquare Coffee Papers". These pieces are collaborative efforts prepared by researchers from various walks of life visiting or staying at the CERN IdeaSquare premises. The identity of the contributing authors is kept anonymous (although known) but helpful hints can be found in the literature references.

EXECUTIVE SUMMARY

From mathematics to the WWW, the IdeaSquare team embarks in the daunting adventure of elucidating the relationship between coffee and transformative innovation.

INTRODUCTION

"A mathematician is a device for turning coffee into theorems"

Alfréd Rényi (1921-1970)
Hungarian Mathematician

ON COFFEE AND MATHS

Despite often ascribed to the mathematician Paul Erdős[1], another one, Alfred Renyi[2], who was addicted to coffee, seems to be the source of the introduction's quote[3]. He is also famous for having said, "*If I feel unhappy, I do mathematics to become happy. If I am happy, I do mathematics to keep happy*"[4].

There apperars to be a wide consensus regarding the veracity behind the coffee quote statement among the mathematics community. Triggered by this fact, the self-appointed IdeaSquare innovation team embarked this time in formulating as well as attempting to check the truthfulness of the following conjecture:

"*Coffee is a device for turning conversations into transformative innovations*".

True? False? It is undeniable that lots of coffee cups are consumed by any team of innovators as well as that many conversations seem to take place[5]. However, how many cups are necessary to produce truly transformative innovations? Moreover, is coffee a necessary condition or a sufficient one? Or is it necessary and sufficient? In other words, closer to Philosophy's terminology, is coffee necessary or contingent?

TRANSFORMATIVE INNOVATION

The first task that the IdeaSquare innovation team undertook was defining and adopting an Innovation Taxonomy. After lengthy and vivid debate sessions, two main taxonomy axes were consensually chosen as the main ones capturing the impactful nature of innovation. The first one was the social impact that innovation delivers to society at large. The second one was the power of innovation to change the existing status quo of humankind

[1] https://en.wikipedia.org/wiki/Paul_Erd%C5%91s
[2] https://en.wikipedia.org/wiki/Alfr%C3%A9d_R%C3%A9nyi
[3] Jeff Suzuki, *A History of Mathematics*. Prentice Hall, 2002.
[4] P. Turán, "The Work of Alfréd Rényi". Matematikai Lapok 21 (1970) 199–210.
[5] If only even judging from IdeaSquare's kitchen and coffee machine statistics. The last progress report 2021-2023 quantifies 42700 hot beverages consumed with a 57% of black coffee and 10% coffee with milk. https://cds.cern.ch/record/2880272

or, in other words, the existing paradigms. As a result, the following diagram was drawn in the kitchen's white board (Figure 1).

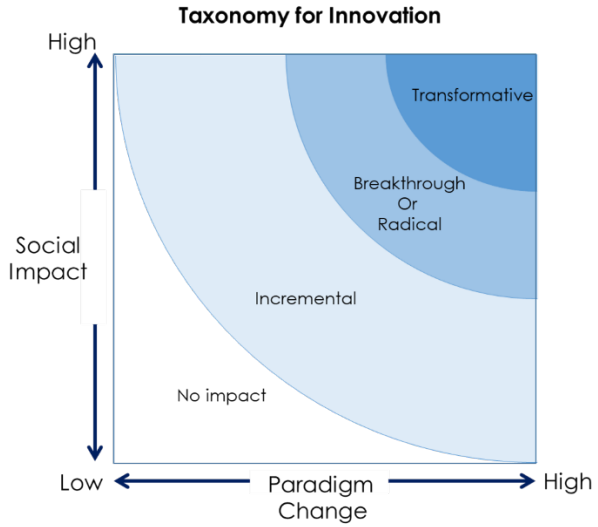

Fig. 1. Innovation taxonomy adopted by the IdeaSquare team.

As it can be directly deduced from it, transformative innovation is the one with the capacity to deliver such an high impact to society as to fully change existing paradigms. In plain words, there is a "before" and an "after" in humankind's history when transformative innovation occurs. After such a taxonomy, the second task was to enumerate a list of no more than ten transformative innovations…ten candidates that undeniably marked a "before" and an "after". Of course, the IdeaSquare team knew that, as any other top ten list, it was going to be somehow arbitrary and non-exhaustive. Anyway, after a heated deliberation irrigated with many coffees, white smoke emerged: Habemus list!

(i) The hand axe (~1.76 million years ago)
(ii) The domestication of fire (~ 1 million years ago)
(iii) The wheel (~4000 BCE).
(iv) The printing press (~1440).
(v) The piston steam engine (~1712).
(vi) The incandescent light bulb (~1879).
(vii) The integrated circuit (~1958).
(viii) The personal computer (~1971).
(ix) The internet (~1983).
(x) The World Wide Web (WWW) (~1989).

GOATS AND SERENDIPITY: AN ETHIOPIAN LEGEND

Legend has it that, in 9th-century Ethiopia, a goat herder named Kaldi from the Kingdom of Kaffa observed an intriguing phenomenon[6]. His goats, after nibbling on the vibrant red berries of a particular bush, exhibited remarkable energy. Intrigued, Kaldi decided to taste the fruit himself, experiencing an exhilarating sensation. Compelled by his discovery, he brought the berries to the nearest village place of worship, seeking guidance. Upon presenting the berries to the head monk and providing a brief explanation, the response was unexpected. The head monk, attributing the berries to the "Devil's work," promptly tossed them into a nearby fire. However, as the berries burned, a captivating and potent aroma permeated the room. Recognizing the remarkable scent, the head monk reversed his decision, instructing the retrieval of the embers from the fire and the pouring of hot water over them to preserve the fragrance. Upon consuming the resulting mixture, they experienced a tranquil, warming, and calming sensation. The effects were not only immediate but enduring, allowing them to stay alert and engage in prolonged discussions on important matters. The head monk, now enlightened by the unexpected virtues of the berries, shared his discovery with fellow monks at the monastery. Word of these energizing berries began to spread, marking the beginning of a fascinating journey.

[6] https://www.ncausa.org/about-coffee/history-of-coffee

The story above, perhaps apocryphal, was initially recounted by Antoine Faustus Nairon, a professor specialized in Oriental languages. He authored one of the earliest printed treatises dedicated to coffee titled "*De Saluberrima potione Cahue seu Cafe nuncupata Discurscus*" (Rome, 1671), bringing this captivating tale to light[7]. Regardless of its veracity, the legend has left an indelible mark on modern culture, since "Kaldi Coffee" and "Dancing Goat" have become popular monikers for coffee shops and roasting companies globally. Notably, Ethiopia boasts its largest coffee chain under the name "Kaldi's". The enduring legacy of Kaldi's mythical encounter with energizing berries resonates through these modern enterprises, adding a touch of enchantment to the world's coffee culture.

In 1615, the pits of the cherry-like coffee berry secured their place in European society when Venetian merchants introduced them after bringing them from Istanbul. Within three decades, Italy witnessed the emergence of the first coffee houses, a trend that swiftly permeated throughout the continent. The magic beverage also made its way to the Americas, mainly routing through the Caribbean islands. Remarkably, after the Boston Tea Party of 1773, large numbers of Americans switched to drinking coffee during the American Revolution because drinking tea had become unpatriotic. Today, coffee holds a significant global presence, engaging approximately 25 million farmers across more than 50 countries in various facets of its processing and production[8].

As one of the most extensively traded agricultural commodities worldwide, coffee plays a pivotal role in economies and cultures alike. On average, an individual consumes about 2 cups of coffee daily. Notably, Finland boasts the highest per capita consumption globally, with an annual average of 12 kg, equivalent to 3.5 cups per day. This statistic reflects the enduring and universal appeal of coffee as a beloved beverage across diverse societies[9].

NECESSARY OR CONTINGENT?

The IdeaSquare innovation team counted now with the basic ingredients to undertake the answer to the daunting questions: *Is coffee necessary or contingent for generating transformative innovations? How much*? Let us recapitulate about which essential ingredients were:

(xi) A daunting question in the shape of a conjecture or hypothesis: "*Coffee is a device for turning conversations into transformative innovations*".

(xii) A definition of transformative innovation: "*That one with the capacity to deliver so high impact to society as to fully change existing paradigms*".

(xiii) A list of top ten transformative innovations approximately dated.

(xiv) A historical date about the widespread of coffee in Europe (and subsequently worldwide): 1615.

(xv) The average coffee consumption per day of an individual: 2 cups of coffee daily.

AN UNAVOIDABLY OPEN (AND CONTROVERSIAL) DISCUSSION

The first observation that the IdeaSquare innovation team made was that transformative innovations 1 to 4 in the list occurred without coffee consumption. Philosophically speaking, it means that coffee consumption in relation to the generation of transformative innovation is contingent. In a more rigorous mathematical language, since 1 to 4 are counterexamples, the consumption of coffee is neither necessary nor sufficient for the generation of transformative innovation, at least from ~1.76 million years ago until ~1440. However, what happens after 1440? Are these seemingly "universal" truths still valid since coffee was available? This point was where the IdeaSquare team entered the realm of speculative reasoning regarding the rest of the list items as you may see below.

The first commercially successful engine that could transmit continuous power to a machine was the atmospheric engine, invented by Thomas Newcomen around 1712[10]. It combined the ideas of Thomas Savery and Denis Papin. The first one patented a steam-powered pump on 1698 while the second suggested in 1689 that a force pump or bellows could maintain the pressure and fresh air inside a diving bell. Thus, we might speculate that Newcomen was ideating his engine at least since 1689[11]. That means 23 years of coffee consumption assuming

[7] https://fr.wikipedia.org/wiki/Faustus_Nairon

[8] M. Pendergrast, *Uncommon Grounds: The History of Coffee and How It Transformed Our World*, Basic Books, 2019 (2nd ed.)

[9] https://worldpopulationreview.com/country-rankings/coffee-consumption-by-country

[10] https://en.wikipedia.org/wiki/History_of_the_steam_engine

[11] Thomas Newcomen was born in 1664. It means that in 1689 he was 25 years old. A good age for a young engineer to think about a piston steam engine!

Thomas was an average coffee drinker. Which at a rate of 2 cups/day gives ~16800 coffee cups for such a transformative innovation as the piston steam engine.

Well before Thomas Edison obtained patents for his incandescent light bulb in 1879, pioneering British inventors were already showcasing the feasibility of electric light in 1835. Unfortunately, these early bulbs suffered from brief lifespans, exorbitant production costs, or excessive energy consumption. Edison, along with his team at Menlo Park, entered the realm of lighting with a meticulous focus on filament enhancement. By October 1879, Edison's researchers achieved a breakthrough—a light bulb featuring a carbonized filament made from uncoated cotton thread, boasting a remarkable 14.5-hour lifespan. Persistent refinement led them to adopt a bamboo filament, extending the longevity of Edison's lamps to an impressive 1200 hours[12]. Thus, we could speculate an average coffee consumption by Edison from 1865[13] to 1879. It gives ~10200 cups of coffee.

The pioneers known for inventing microchip technology are Jack Kilby and Robert Noyce[14]. In 1959, Kilby of Texas Instruments received a US patent for miniaturized electronic circuits and Noyce of Fairchild Semiconductor Corporation received a patent for a silicon-based integrated circuit. Speculatively, the IdeaSquare innovation team, linked this invention to the transistor which was successfully demonstrated in 1947 at Bell Laboratories in Murray Hill, New Jersey, by William Shockley, John Bardeen and Walter Brattain. That meant a possible average coffee consumption by Jack Kilby and Robert Noyce spanning from 1947 to 1959. Therefore 12 years, making a total for both of ~17500 coffee cups.

What Was the First PC? The Computer Museum in Boston asked that question in 1986 and held a contest to find the answer. Judges settled on John Blankenbaker's Kenbak-1 as the first personal computer[15]. Designed in 1971, before microprocessors were invented, the Kenbak-1 had 256 bytes of memory and featured small and medium scale integrated circuits on a single circuit board. In an interview, John mentioned:

"*When I was a freshman at Oregon State College in 1949, I read about Eniac (Electronic Numerical Integrator And Computer). This inspired me to design a computing device. It was a kludge, but it inspired an interest in computers".*[16]

This revealing testimony will grant 22 years of average coffee cup consumption which amounts to a total of ~16000.

American computer scientists, Bob Kahn and Vint Cerf, are credited, inspired by predecessor's achievements, as the key internet innovators. They developed the TCP/IP, the set of protocols that governs how data moves through a network. This helped the previous ARPANET evolving into the internet we use today. Vint joined Bob on the project in the spring of 1973, and together they completed an early version of TCP. January 1, 1983 is considered the official birthday of the Internet. This gives both 10 years of coffee consumption totalling 14600 coffee cups.

Tim Berners-Lee made a proposal to CERN management in March 1989 for funding and an official okay to use some of his time to work on the incipient WWW project. The Web was not an overnight success. In fact, it took nearly two years before, on Christmas Day 1990, with help from CERN computer scientist Robert Cailliau and others , he set up the first successful communication between a Web browser and server via the Internet. The technology was released outside CERN to other research institutions starting in January 1991, and then to the whole Internet on 23 August 1991[17]. This, extremely brief, history of the webaccounts for 3 years of coffee consumption leading to 4380 cups.

After this exhaustive investigation, the IdeaSquare innovation team arrived to the following table summarizing the findings.

[12] https://en.wikipedia.org/wiki/Incandescent_light_bulb
[13] An 18-year-old coffee drinker thinking on light bulbs.
[14] https://en.wikipedia.org/wiki/Invention_of_the_integrated_circuit
[15] https://en.wikipedia.org/wiki/Kenbak-1
[16] https://www.bbc.com/news/business-34639183
[17] J. Gillies and R. Cailliau, *How The Web Was Born: The Story of the World Wide Web*, OUP 2000.

Table 1. Number of coffee cups needed for a list of transformative innovations. The assumptions are discussed in the text.

Transformative Innovation	Estimated Coffee Cups Needed	
The hand axe		Pre-Coffee Era
The domestication of fire		
The wheel		
The printing press		
The piston steam engine	16800	Post-Coffee Era
The incandescent light bulb	10200	
The integrated circuit	17500	
The personal computer	16000	
The internet	14600	
The World Wide Web (WWW)	4380	

SOME FINAL THOUGHTS

As is customary with meticulously conducted and evidence-based factual research, the IdeaSquare team found themselves confronted with a surplus of open questions and contemplative musings rather than conclusive answers. The following inquiries serve as a mere sampling, intended to stimulate future investigations within the community of coffee scholars.

- In the contemporary landscape, where coffee has become a ubiquitous elixir, the habitual Monday morning reliance on this beverage seems almost indispensable for the occurrence of anything, let alone transformative innovations. Can this anecdotal observation be empirically substantiated with a more comprehensive (big) dataset?
- As the coffee era has entrenched itself deeply into our lives, one wonders: *Is it conceivable for humankind to foster transformative innovation without the consumption of coffee? If not, could alternative beverages, such as tea, assume this pivotal role in the absence of coffee?*
- Considering the hypothetical scenario of Artificial Intelligence (AI) emerging as a "transformative innovator", would AI necessitate the infusion of coffee into its digital existence? If so, the question arises: What type of coffee would AI prefer? Would it opt for the bold intensity of a ristretto, the brisk vigour of an espresso, or the harmonious blend of a cappuccino?
- In the whimsical realm of AI androids, do they harbour dreams of electric coffee machines, or do they lean towards a preference for the artisanal touch of manual brewing?

Facing the daunting task of further researching the above questions and many others, the IdeaSquare team concluded this journey with a brief ode to coffee.

Oh, caffeinated wonder, brewed to perfection,
In the morning haze, you're my resurrection.
With a magic jolt, you kick-start my day,
Turning zombie mode into a lively ballet.

Beans roasted and ground, a heavenly smell,
In the coffee realm, you surely excel.
Espresso, latte, or a simple drip brew,
Oh, coffee, you make my troubles few.

You're the reason my keyboard doesn't nap,
A caffeinated superhero in a ceramic cap.
In meetings long, you're my secret ally,
Whispering, "Stay awake, don't let them see you sigh!"

With every sip, a burst of delight,
A java jamboree, morning, and night.
Coffee, my friend, my liquid muse,
In your warm embrace, life never snoozes.

To be continued