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Convenient efficiency: A media genealogy of QR codes

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Abstract

This article explains the widespread adoption of Quick Response (QR) codes from a media genealogy perspective. Understanding QR codes as more than the materiality of their machinic embodiments and rather as a method of systematically and repeatedly addressing emergent problems, I argue that the operative logic of QR code is that of convenient efficiency. Convenient efficiency captures three dynamics that drive QR codes' ubiquity: the potentiality of spontaneous system synergies (system/distributed convenience coupled with streamlined efficiency); the autonomy of the subjects involved as part of this cybernetic system (personal convenience coupled with stacked efficiency); and the relative independence of the networks/assemblages that these practices constitute (convenient efficiency). That the convergence between convenience and efficiency as driving forces in contemporary technological culture has origins in the shop floor is consequential to the way motion, time and the body become disciplined—as well as the epistemological practices that cohere around these forces.

Keywords

Automatic identification, automatic data capture, automation, contactless, convenience, efficiency, media genealogy, QR codes, touchless

Introduction

Developed in 1994 by engineers working for Denso Wave (DW), a Japanese subsidiary company that manufactures automatic identification products, industrial robots and programmable logic controllers, Quick Response (QR) codes were a response to manufacturing needs for increased data storage capacity on barcodes (DW, 2021). The shift from mass manufacturing of one type of product to more flexible production in the 1990s gave

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rise to the demand for more detailed production control—more data collected and processed—at manufacturing sites. Faster barcode scanners were initially introduced as a potential solution; however, the solution soon revealed itself unwieldy as workers had to scan as many as 1000 barcodes per day on site—a result of the limitations inherent in barcodes as one-dimensional codes that only store approximately 20 alphabetic characters (DW, 2021). The development of the QR code—a two-dimensional code that allows for the coding of data in both horizontal and vertical directions—was therefore shaped by the dual imperatives of scanning speed and data capacity as expressions of mechanical efficiency. Storing up to 7000 kanji, kana and alphanumeric characters per code, QR is legible to scanners even when printed on a small area and can be scanned up to 10 times faster than its barcode competitors (DW, 2021).

QR codes belong to a family of automatic identification and data capture (AIDC) technologies that mechanically reproduce different bodily and extra-bodily senses. AIDC technologies include optical character and image recognition (barcodes, QR codes), biometrics (voice identification, fingerprint procedures, retina identification) and radio frequency identification (RFID, such as smart cards and contactless mobile payment). These technologies automate otherwise manual human labour—understood as disruptive, unwieldy, and slow—in order to script desired results, such as scanning QR codes to speed up manual form-filling or using electromagnetic 'contactless' mobile payment to bypass manual galvanic contact. AIDC technologies—and QR codes in particular—can be understood as logistical media that coordinate and control the movement of labour, people, and things situated along and within global supply chains (Rossiter, 2015). Logistical technologies derive their power to govern thanks to the dual forces of standardisation across industry sectors and algorithmic architectures designed to orchestrate protocols that facilitate connection between software applications and workplace routines—the epistemic structure of which I will articulate as convenient efficiency in this article.

QR codes problematise bodily practices as inefficient ('suboptimal') and inconvenient (both on the system level as well as on a personal level) so that bodies and senses can be disciplined and mobilised according to the dictates of convenient efficiency as an epistemic structure arising out of the shop floor assembly line. As a solution to its own problematisation of bodily practices, QR codes interpellate their users as programmable, distributed decision makers whose autonomy is arranged to be of equal footing to the system as a whole before enrolling them into extractive and generative structures of data collection and control. QR codes render the people who interact with them legible to data controllers as data subjects, so that these data subjects can be accounted for, extracted from, profiled against, spoken on behalf of. As a particular technical expression of convenient efficiency, QR codes as a piece of 'contactless' technology is always in contention with other technologies that share the same operative logic, such as near field communication (NFC)—which promises to facilitate truly 'touchless' interfaces and therefore more faithfully carry out the project of convenient efficiency.

This article examines the operative logic of QR codes and the way they emerge as an apparatus for enacting efficiency in the evolving post-pandemic condition through the framework of media genealogy. I follow Ramati and Pinchevski's (2018) articulation of operative logics as the methods a technology employs, the conventions it assumes, and

the practices it generates. Convenient efficiency as a model for the operative logic of QR codes captures its global efficacy from the viewpoint of (techno)social synergies, following Lazzarato (1996). Convenient efficiency captures three dynamics that have driven QR codes' widespread adoption and growing list of applications: (1) the potentiality of spontaneous system synergies (system/distributed convenience coupled with streamlined efficiency), (2) the autonomy of the subjects involved as part of this cybernetic system (personal convenience coupled with stacked efficiency) and (3) the relative independence of the networks/assemblages that these practices constitute (convenient efficiency). In the next section, I will discuss the media genealogy approach before moving on to locate a decisive moment for the formulation of convenient efficiency as epistemic practice in the early 20th century shop floor, where the development of a range of technologies would produce a series of discursive effects that inform the inscription, physical disciplining, and surveillance of data subjects against their data controllers.

Media genealogy as methodology

This article subscribes to the media genealogy approach, which takes an interest in how technologies *become* established—through the mechanisms and processes that have led to the development of power and truth structures within technology cultures. Within these structures, sociotechnical apparatuses are also arenas for individual and social practices, ways of life, cultural patterns, knowledge, power and control (Apprich and Bachmann, 2017). Media genealogy is often discussed in connection with media archaeology, with both approaches relying on Michel Foucault's methodological concepts: his investigations into the archaeology of knowledge (Foucault, 1970) and his history of power in the genealogical sense (Foucault, 1977). Media archaeology is concerned with the material basis of mediality, which tends to freeze the object of its study and view technological shaping of society as ruptures of discrete time layers rather than processes (Ramati and Pinchevski, 2018). Media genealogy, on the other hand, engages ideally with its object–and from the perspective of 'situated knowledge' (Haraway, 1988) that puts an emphasis on continuity and interconnections between historical periods, focusing on mutual influences of society and technologies. The underlying assumption of both methods is that along with technologies, a sort of 'media unconscious' has taken form—the implied knowledge of which can become *visible* with the help of media archaeology, but only *legible* with the reflexive approach of media genealogy (Apprich and Bachmann, 2017).

Media genealogy traces the different descents of technologies with an eye for the present, while always being conscious of many other possible genealogical lines so that it could unsee technology as prior and determinative. The notion of 'problematisation' is central to this endeavour; a problematisation is

> . . . a base out of which we elaborate the institutions, functions, and objects constitutive of our practices. To understand our practices and the strategies and techniques composing them, we must understand the problematisations to which they are a response [. . .] Genealogy thus functions as a history of the present on the basis of the emergence of the problematisations that have enabled the development of present practices in response to these problematisations. (Koopman, 2013: 98)

Problematisation, in Koopman (2013)'s interpretation of Foucault, is both *clarifying* as a descriptive account of how certain past problematisations have enabled the development of present practices and *intensifying* as a normative tool that heightens our concern with the problematisations that continue to inform our present ways of constituting ourselves. To Koopman, the historicity implicit in genealogy should be understood in terms of its concern with processes of emergence, rather than with the origins of the present. While we cannot explain the *technological functioning* of particular media–such as their component arrays, wiring, hardware, and programming–by their original frames of reference, what we can explain about media technologies by tracing their various overlapping genealogies is *their emergence* (Monea and Packer, 2016).

In what follows, I trace the processes through which QR codes act as a translator for a project similar to AIDC–that of managing increasingly mobile and diverse populations. The recent emergence of a mobile ordering sector that trades exclusively in user data through push adoption of QR codes latches onto existing extractive and generative data infrastructures to engineer solutions to the problematisation of post-pandemic behaviour as a field of practice that has become rendered uncertain and unfamiliar. This development, I will argue, demonstrates the changeability of efficiency as justification for increasingly widespread adoption of QR codes–from a balanced efficiency of vertical oversight and management to a transformational efficiency of horizontal growth. This changeability is facilitated by the convergence between convenience and efficiency as the driving forces of contemporary technological culture. The media genealogy developed below provides a basis from which to examine this recent development in the operative logic of QR codes.

Efficiency in motion: from stopwatch to motion picture camera

Before data capacity and scanning speed became a central concern to manufacturing efficiency, standardising labour into uniform and measurable tasks was at the heart of the efficiency movement across industrial countries in the first decade of the 20th century (Alexander, 2008). Frederick Winslow Taylor, whose name became synonymous with the movement itself, is known for his development of scientific management principles that aimed at increasing efficiency through specialised tools, high wages, and the precise delegation of foremanship duties to consolidate management authority and stimulate productivity. A mechanical engineer by training and by trade, Taylor's management theories are influenced by his earlier experiments on metal cutting to determine the angles and speeds of cutting blades that made them wear the longest and cut with the greatest precision (Alexander, 2008). Taylorism is underpinned by efficiency as motion streamlined–through tools that facilitate ease of movement, and planning that allows for smooth and continual flow of work. This efficiency is mechanical in inspiration, and disciplinary in practice: through machine-like structures of order, workers perform their work with controlled and uniform motion towards managerial goals of reliability, stability, and predictability.

Citing the Gilbreths' motion study in bricklaying in his *Principles of Scientific Management* (Taylor, 1919), which reduced the number of motions per brick from 18 to 5 and substituted fast for slow motions, Taylor concluded that 'almost every act of

the workman should be preceded by one or more preparatory acts of the management which enable him to do his work better and quicker than he otherwise could' (p.26). Recommending 'accurate, minute, motion and time study' to discover 'one best method' across the shop floor (p.25), Taylor married his stopwatch–the symbol of the Taylor system–with scientific analysis of work motions to optimise how things should move and in what relation to each other. The subsequent rift between Taylor and the Gilbreths posed a brief decoupling between time and motion in efficiency, when Taylor dismissed Gilbreths' micromotion study, which employed a motion picture camera to record the performance of a worker on the job to ultimately simplify and improve their kinetic motions, as unimportant and irrelevant to stopwatch time study (Nadworny, 1955). In response to this, the Gilbreths launched 'an indictment of stop-watch time study' (Gilbreth and Gilbreth, 1921), characterising time study as unethical, wasteful, and inaccurate. In the same article, they pointed out commercial interests in the sale of stopwatches, time study devices, and method books among the disciples of Taylor, denouncing developers and practitioners of time study for failing to cooperate with motion study, and made the case that motion study was, in fact, neither the same as, nor even part of, time study.

Motion, as it were, became divorced from time as regularised and temporal movement; it became individualised as discrete bodily units of quantification oriented around space. Disciplining time in the interest of efficiency became deemphasised as photography–operationalised in a series of techniques such as cyclegraph, chronocyclegraph, and stereochronocylegraph by the Gilbreths–formed the basis to the idea of streamlining workflows through reducing fluctuations in a single efficiency line. The cyclegraph method involved mounting a miniature electric light on a ring slipped onto a worker's finger to plot their movement; the movement of the light created a bright line on a single time-exposed photograph, with a line full of twists and turns suggesting inefficient movement (Price, 1989). Chronocyclegraph–an improvement upon cyclegraph to record time and direction of worker motion along with the bright line that sketches trajectories of movement –allowed for the subsequent development of the stereochronocyclegraph, which created a three-dimensional image of motion by using time-exposed photographs from two slightly off-set cameras, the positives from which could be viewed through a stereopticon or stereoscope (Price, 1989). Time became deemphasised as the body was frozen in photographs; bodily movements became representational with the disciplining logic of the flattened line of efficiency, as depth becomes curtailed to make way for regularities as space rationed. Inasmuch as individuals are embodied in space, efficiency means taking up less space, so that time can be mastered through repetition of discrete motion.

Another compelling aspect of the Taylor-Gilbreths controversy is the emergence of motion as an operationalisation of well-being in a context where American labour unions launched a federal inquiry of the Taylor system, in which Taylor was asked to be a witness before a congressional committee (Krenn, 2011). While the hearing found no evidence of abuses of labour attributable to the Taylor system, a resolution was passed to prevent the implementation of time study in military agencies of the government (Wren, 2005). The Gilbreths were occupied with issues such as worker fatigue and social happiness as psychological variables of work efficiency; Lillian Gilbreth distinguished

between two classes of fatigue: one that resulted from work that must be done and is necessary, and one that arose from unnecessary motions and is unnecessary (Krenn, 2011). The optimisation of motion around worker well-being is underpinned by the logic of a kind of personal convenience–in the sense of ease and absence of individual trouble or disadvantage–even when not explicitly articulated as such.

The Gilbreths' legacy in laying the groundwork for contemporary managerial concepts and practices such as ergonomics, work/life balance, job enrichment, and job placement imbues efficiency with moral and social dimensions. While notions of moral improvement are already explicit in Taylor's discussions of a 'mental revolution' among workers through optimising time on task, the morality of efficiency as inclusive of labour satisfaction through optimising motion turns the body into a site of self-control and self-determination. The factory floor, then, became a cybernetic system (Galloway, 2021) in which workers are agents of autonomy arranged to be of equal footing to the system as a whole, each endowed with the power of local decisions according to local variables and functions. The disciplinary power resulting from this techno-social arrangement seeks to be imperceptible and unremarkable: individual workers are remade in response to the technologies that have been introduced not as an expression of power, but rather as mechanisms that constitute social relations within the factory (Foucault, 2008). The factory, following Peter Miller and O'Leary (1994: 470), is also a laboratory–'an intrinsically theoretical and experimental space, one where phenomena are created'. It is through the fragile and shifting relations across a diverse and heterogeneous group of actors–consultants, experts, managers, and commentators of various kinds who pronounce deficiencies of existing ways of doing things–that fundamental transformation of working practices and principles comes into being. Problematisation creates problems so that optimisation can create solutions; this discursive process creates news regimes of practice through reciprocal and mutually constitutive relations across the different locales beyond the shop floor, rather than within one locale or another–as the next section will show.

Stacking things in place: from solid-state electronic to camera phone

Optimising time and motion is not an endeavour exclusive to scientific management and mechanical engineering, however. In a neighbouring discipline, electrical engineers were occupied with creating industrial applications for semiconductor materials–wherein electronic actions occur in a solid state through permanent contact–to replace the vacuum tube as a means of controlling electronic current flows in a gaseous state (Becker et al., 1946). Thermionic vacuum tubes worked by controlling current conducted by a gas of particles moving in a vacuum within a sealed tube; while offering the first easy way to amplify electric signals since their invention in early 20th century, the vacuum tube was rendered bulky, fragile, and energy hungry by its successor–the transistor–which is made of semiconductor materials such as pure silicon and germanium. The transistor made it possible for the development of solid-state equipment–a term first used to distinguish electronic equipment using semiconductor devices such as the transistor from those using vacuum tubes. The term solid state subsequently evolved to distinguish solid-state electronics from electromechanical devices, with solid-state electronics

having no moving parts that could cause mechanical delays–such that access time and latency can be kept minimal (Tiziani et al., 2011). The trajectory of motion optimisation in electrical engineering throughout the 20th century was centred around arresting movement towards fixing things in place–a kind of static efficiency that champions stability and predictability.

Solid-state electronics, in both senses of the absence of vacuum tubes and of moving parts, gave way to the development of portable consumer electronics such as transistor radio, cassette player, walkie-talkie, personal computer, and mobile phone. The microprocessor as a solid-state, single integrated circuit that can be produced cheaply at a large scale not only increases the reliability of computing processing because there are much fewer electrical connections that could fail but also the data processing capacity of portable computing devices. Another integrated circuit commonly found in the smartphone as the most ubiquitous modern computing device is the complementary metal oxide semiconductor (CMOS) sensor, which first found its way into webcams attached to personal computers in the early 2000s (NASA Technology, 2007). The CMOS sensor subsequently became a low-power solution to high-definition video capturing in digital cameras and camera phones, which would prevent batteries from overheating and draining. The stacking of fixed and static efficiency, as it turns out, gave rise to a transformational efficiency of people having the capacity to do more and more on their portable devices beyond the balanced input–output model of yield: an efficiency of growth.

While QR code reading was one of the first applications for camera phones with the production of the J-SH09 phone by SHARP in 2002, it was not until the early 2010s that smartphones started offering built-in QR code readers, with the iPhone adopting this as late as 2017 with the development of iOS 11 (Etherington, 2017; Mall, 2016). Smartphones–phones that can wirelessly connect to the Internet and run apps–make it feasible for the enactment of QR code as visual interface for linking and accessing Internet resources from portable devices. The idea of wirelessly marrying Internet with AIDC technologies such as barcodes and QR codes, however, was already present in management studies literature in the early 2000s. For example, the Internet was positioned as a more cost-effective mechanism for information sharing than electronic data interchange systems, and AIDC technologies were positioned as a reliable way to ensure quality of data that would eventually be shared over the Internet (Smith and Offodile, 2002). AIDC data are identification data in that they are directly associated with an object–or an asset–of interest to information and asset management in the context of manufacturing, material flow systems, and distribution logistics. AIDC data can be images, sounds, or videos; a transducer–or sensor–is used to convert the image or sound into digital format for computer analysis (Bhatt, 2011).

Gaining its first International Organisation for Standardisation accreditation in 2000 for AIDC techniques, QR code uptake in consumer settings began in 2002 with the launch of the first mobile phones containing built-in QR code readers: the J-SH09 phone, produced by SHARP for Japan's J-Phone (now Softbank) mobile operator (Eurotechnology, 2009). Since then, QR codes have been applied in various domains of practice: display of multimedia content as part of exhibitions and in retail settings, mobile payment, website login, joining a Wi-Fi network, story and gameplay elements in video games, loyalty programmes in marketing and advertising, digital authentication,

counterfeit protection on products, immigration and border control, augmented/mixed reality, and even in funerary contexts where QR codes are put on gravestones to connect to personalised online memorial pages. The COVID-19 pandemic has seen further applications of QR codes, as they are variously deployed as COVID-19 health status/vaccination certificate and travel pass, contact tracing through check-in systems, managing people in health quarantine, and most recently, contactless ordering at restaurants using mobile phones partly as an infection mitigating measure (Shachar and Mahmood, 2021). QR codes became understood as a 'contactless technology' useful to pandemic management, where contact tracing and contactless interactions (e.g. contactless house delivery, contactless instore click-and-collect) became the mainstays of infection mitigation strategies across sovereign contexts. The fast-expanding applications of QR codes in everyday data practice owe themselves to the dual imperatives of speed and data capacity being established both as solutions and as problematisation–as a set of ideas, practices, and networks that together form a strategic power field for the emergence of QR codes as proxy for malleable instantiations of efficiency.

Insofar as QR codes signal to users that a particular mode of engagement is required (i.e. scanning the code with a smartphone) to set off a chain of events, it is a multisensory piece of technology that braids together visual and tactile sensoria as transmitted through media. The supposedly simple task of scanning a QR code would require what Parisi and Archer (2017) articulated as media braiding: image (separate lines of code tell the computer how to encode information in textual format into black squares arranged in a square grid on a white background, which can be displayed either digitally on a screen or printed out on paper; pattern recognition applications on phone cameras that locate the eyes/finder patterns, separators, quiet zones, alignment markers of a QR code, along with the built-in Reed-Solomon error correction algorithm that decodes information even when parts of a QR code are obscured); and touch (aiming the camera so that a QR pattern can be recognised from background 'noise', tapping on the link decoded, following the instructions shown on phone). This synchronisation of image and touch weaves together the optic and haptic dimensions of QR codes as material-semiotic text, allowing what exists as homogeneous data to achieve a material and sensory differentiation through the interface. Braiding touch into media, as Parisi and Archer (2017: 1529) note, also necessarily involves braiding 'the genealogy of tactility into the genealogy of media more generally'. The absence–or absolution–of touch from media, however, is vital to the construction of cybernetic systems that enact convenience in service of streamlined efficiency, as we will see in the next section.

Convenience in motion: cybernetic systems from 'contactless' to 'touchless'

'Contactless' has since been used extensively in the mobile payment sector as a metonym for anything ranging from RFID credit cards to smartphones and smart watches with NFC integrated circuits that can facilitate secure payment with a point-of-sale terminal. RFID is a relatively young AIDC technology; first developed in the 1980s, RFID gave rise to an interdisciplinary field of research into contactless identification–which is often characterised as more flexible than contact-based automatic identification procedures

(e.g. chip-based smart cards), which can be impractical in certain use cases, and optical codes (e.g. barcodes), which cannot be reprogrammed and have a low storage capacity (Finkenzeller, 2010). RFID systems use magnetic or electromagnetic fields to facilitate data exchange between the data-carrying device and the data reader; their being 'contactless' is based on the absence of 'galvanic contact', which forms the basis of data exchange for procedures that involve material objects such as smart cards (Finkenzeller, 2010). RFID systems allow for a maximum distance between data carrier and data reader of up to 5 metres, compared to a maximum of 50 cm in the case of barcode and voice recognition (Finkenzeller, 2010). Early applications of RFID include keys and key fobs, contactless smart cards, and smart labels.

In practice, this framing of 'contactless' proves to be somewhat of a misnomer: contactless payment at point-of-sale is often marketed as 'tap-to-pay' or 'tap-and-go'–wherein consumers are instructed to make direct contact between their payment method and the payment terminal. This marketing catchphrase is both a security measure to avoid accidental charges being made to the wrong card or phone, and a behavioural conditioning tactic to transition consumers out of the sliding motion that accompanies chip-based or magnetic stripe credit and debit cards. 'Hover-and-pay' might not convey the same sense of ease as 'tap-and-go'; tapping exists in the same conceptual space as 'contactless' insofar as they both gesture at a categorical change in payment tactility that demands less attentiveness–a mechanism oriented towards convenience as a normative consumer value. The efficiency of convenience is that of growth; while technological developments centred around the domination of nature (Scheler, 2012) and the taming of chance (Hacking, 1990) are oriented towards stability and fixity, technological innovations centred around convenience are oriented towards 'setting bodies in motion', a utility embedded in broader frameworks of liberal individualism in modern technology culture (Tierney, 1993). Bodies set in motion overcome spatial distances as inconveniences–and thus constraints–on individual liberty. The tracking and mechanisation of bodies in motion tends towards stability and predictability (accounting for individuals in a population) as well as growth (when tracking data is transformed to speak on the tracked individual's behalf).

Space as obstacle and speed as a mechanism to overcome space comes with an implicit conception of the body as a limit to overcome rather than a demand to satisfy; spatial distances, as such, are limits upon the body rather than an environmental feature of embodiment (Tierney, 1993). Even though time can be saved from the demands of the body (which impinge upon time), time can also be saved from the body's limits with the help of technology (which accomplishes things the body cannot). It is in this sense that different attitudes towards the body shape the design, application, and popularisation of technology: technologies of convenience, such as contactless payments, problematise the demands of the body and streamline the body's motion as solution to help it overcome its limits. Streamlined bodily motion here, as in the factory floor captured by micromotion cameras by the Gilbreths, positioned consumers as agents of efficiency that interoperate with the contactless convenience system as equal peers–even though they are not equal to the system in either power or type.

Contactless payment has also come to include QR code payment, where smartphone cameras can scan QR codes to facilitate app-to-app payment or access the price and

payment details of individual products or business services before finalising payment. The smartphone can also act as a QR code display, where the consumer's payment details are represented in the form of a secure QR code that can be scanned by the service provider to facilitate transaction. While perhaps not as elegant as applications of RFID or NFC in terms of enacting convenience (i.e. aiming, adjusting angle, scanning, waiting, thumbing fingers on phone vs tapping a card/phone to pay), QR code payment nevertheless fits into the category of 'contactless' insofar as there is no direct, or galvanic, contact between the consumer/payment method and the service provider/payment terminal. Indeed, QR code payment finds its most compelling use cases in contexts where bypassing acquisition of payment hardware (a payment terminal, or indeed a debit/credit card) is seen as desirable (Sorensen, 2021). Here, convenience becomes decentred away from practices of streamlined, individualised motion and instead redistributed across the cybernetic system of efficiency; convenience becomes embedded in a reformed division of labour that capitalises on the stacked efficiency built into increasingly ubiquitous mobile electronic devices. Distributed convenience harbours an efficiency of growth in setting bodies in motion while deputising these bodies with infrastructural duties; in this sense, convenience takes on its pre-modern meaning, aligning with its Latin origin *convenientia* which means 'meeting together, agreement, accord, harmony, conformity, suitableness, fitness' (Tierney, 1993: 39). As such, the value of convenience and efficiency as converging in this particular emergent application of QR codes is as much a value of the technology consumer as it is of the technology producer and innovator. As convenience moves away from the self–a personal convenience of ease and absence of trouble or disadvantage–and instead into distributed infrastructures of convenience of which the body is a part, people's relationship with technological convenience changes. While personal convenience implies a certain freedom born out of the body overcoming its own limitations, distributed convenience is contingent upon individuals acting according to the technologies of efficiency to which they suddenly find themselves beholden.

It should be noted here, however, that this emergent distributed convenience exists alongside ongoing efforts to further streamline bodily motions towards enhancing personal convenience. Touchless technologies–an emergent category that has come to include RFID applications, gesture-based technology (motion sensing applications, ultrasonic haptic applications), voice control, and eye-tracking–is gaining traction in sectors such as retail check-out systems and office automation as marketers strategise for ways to communicate newness and innovation (Dopson, 2022; Greetly, 2020). Touchless as a technological concept first emerged in the biomedical context with the development of lithotripsy–a non-invasive procedure that involves the physical destruction of hardened masses like kidney stones–by focusing ultrasonic shockwaves (Finkler and Hausler, 1976). Since then, touchlessness continues to be an area of research and application in biomedical practices, with the development of touchless polygraphy for monitoring of breathing function using dynamic thermal data captured through infrared imaging systems (Murthy et al., 2004) and touchless interaction with medical images to help surgeons maintain sterility during surgical procedures through motion sensing technologies (O'Hara et al., 2014). While having much in common with contactless technologies in the sense that physical contact is absolved, touchless systems are nevertheless extracorporeal. If contactless starts from within the body by problematising its demands, then

touchless starts from without by seeing the body as a site to be traversed, beneath which to go further. Bodily motions need not be regulated, for they are autonomous to a sovereign body; by not focusing on discretising bodily motions, touchless as a category relates to the body as a visible and readable totality. Inasmuch as touchless technology speeds up the chain of convenience by not relying on optimised performance of bodily motions, its orientation towards bodily limits is temporal rather than spatial: convenience becomes about how fast the body *moves along*, in the sense of speedy conveyance. In this sense, touchless corresponds to a vision of automation where the morality of bodily limits is altogether absolved; touchless carries with it a plurisensorial structure, whose technical infrastructure cannot be outsourced to localised, individual technical capabilities. As we will see in the next section, it is in the absence of such a plurisensorial technical infrastructure that QR codes become the key mechanism with which convenience and efficiency converge at the centre of the emergency situation of a global pandemic as it continually problematises bodily practices.

QR codes and the reordering of the post-pandemic restaurant

The paper has, thus, far discussed the malleability of efficiency as a value in managing human activities with and through technology–that efficiency can be oriented towards stability and predictability as well as growth and transformation. As efficiency interacts with convenience–a value located in both the personal and the distributed, and oftentimes oscillating between the two–convenient efficiency as an emergent model of technological efficiency becomes encoded in wider systems of social automation and data extraction. This is most evident in the emergence of the QR code table ordering sector, which trades exclusively in user transaction data through existing digital infrastructures and platforms. Examples of the start-ups in this space include me&u, Loke, Order Up!, MrYum, OrderBuddy, OrderMate, and Ritual; while their service offerings slightly differ for the sake of differentiation, they all share the same ethos of delivering solutions oriented around trimming inefficiencies and streamlining workflows–a language well-rehearsed since the 1930s efficiency movement. QR code table ordering entails four main components: (1) a QR code prominently placed atop the dining table that once scanned, would link to (2) a digital (usually web-based) menu on the customer's smartphone which allows customers to (3) browse a menu, place an order, and make the payment while (4) the order is sent to an integrated point-of-sale (POS) system and respective printer (e.g. kitchen or bar) for production. For examples of table ordering QR codes, please refer to Figures 1 and 2.

Insofar as QR code table ordering is a solution, it must be a response to problematisations of present practices. Lightspeed, a Canadian cloud solution company, articulates the following on their website entry on what to consider when adopting QR code table ordering:

> For as far as we can recall, when a customer is ready to place an order, they'll crane their neck, lock eyes with waitstaff, and then smile affirmatively to indicate that they're ready to order. This may not always be the most efficient system, but it's a system that customers know and are

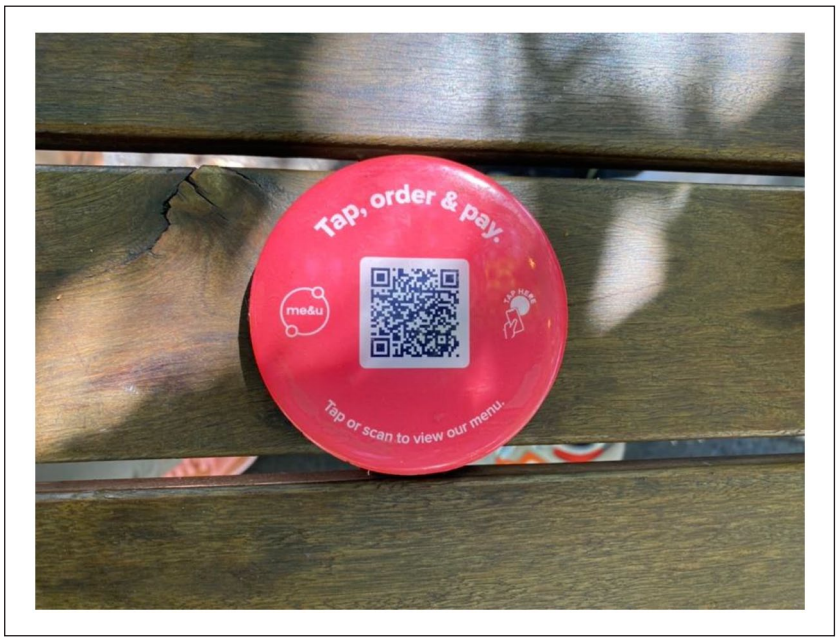

Figure 1. QR code table ordering by me&u.

> used to. To replace this learnt behaviour with a new way of ordering will cause a shift (however welcomed or unwelcomed) in their familiar dining experience. While Table Ordering is designed to address inefficiencies and streamline workflows, it nonetheless presents a change for everyone–requiring training for staff and reinforcement for customers. (Lightspeed, 2021)

The problematisation of existing restaurant etiquette as inefficient homes in on a personal convenience that is contingent on acceptance and adoption of distributed convenience–that while QR code table ordering might be counterintuitive to both the customer and restaurant staff in the immediate present, it will improve overall system efficiency in the long run. In this new system of efficiency, personal convenience (customer/staff satisfaction) is already pre-factored as an inevitable outcome of optimising every autonomous yet interlinked component in the chain of efficiency–where staff and customers are autonomous, self-determining agents positioned to be of equal footing to the system as a whole. In a sense, customers and restaurant staff should feel more satisfied as a result of a more successful enactment of streamlined efficiency, as notions of individual moral improvement are already baked into the overarching morality of efficiency. Here, as in the 1930s factory floor, optimising time on task becomes optimising individual motion as discrete instances of quantification, readily recorded so that they can be plotted, analysed, made to provide insights afterwards. That personal convenience is made contingent on distributed convenience here has the effect of rendering individuals beholden to a range of technologies of efficiency–the QR codes, the mobile device, POS system, the printer. Personal convenience, as such, is no longer simply about producing a certain

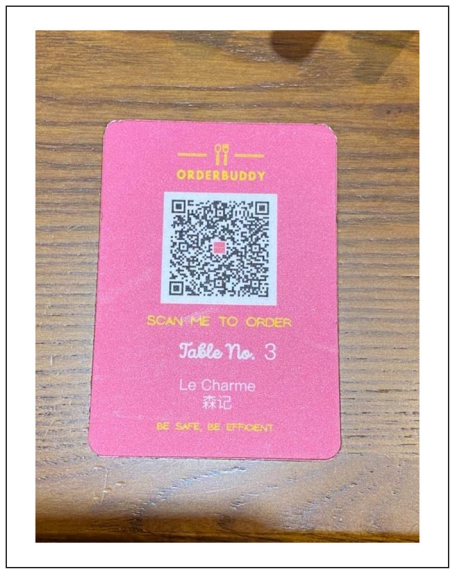

Figure 2. QR code table ordering by OrderBuddy.

freedom in the body overcoming its own limitations but becomes more broadly about how well the body plays a part in an entangled techno-social assemblage of efficiency that can only be set in motion through bodily compliance. The body is then an obstacle to overcome by the demands it seeks to satisfy: the problematisation comes full circle, the solution to which can only be extra-bodily, most conveniently in the existing technological capabilities that rest within the increasingly pervasive mobile devices that accompany the post-pandemic consumer. Kim Teo, co-founder of Mr. Yum, an Australian QR code table ordering start-up, articulates the following in an interview after raising $89 million for the company's Series A funding round:

> We made a big bet on QR codes early on. . . We saw that QR code readers had been embedded into the iPhone camera about three months before we launched, so we took that as a signal they would become more widely used. Obviously QR codes are now commonplace and the past couple of years has saved us years of consumer education and any hesitation around them. (Shu, 2021)

Emphasising in the same interview that the pandemic had normalised QR codes in a way that would have otherwise taken as long as 5 years, Teo explained that the company's 13 million global users across 1500 venues are expected to grow with time, citing onward trends in adoption even post-lockdown. Targeting the United Kingdom and the United States as Mr. Yum's next expansion markets, Teo remarked that there are some areas where U.K. and U.S. customers are lagging behind their Australian counterparts:

> The UK is probably 12-18 months behind on cashless payments adoption, and the US would be even further behind than that. You walk into some restaurants in the US, and they're still signing

> the bill and writing tips on paper. . . Australia is almost like this perfect little ecosystem where you can build something new pretty quickly because consumers just flock to it. So it actually makes for a really good breeding ground. (Shu, 2021)

As it turns out, the problematisation of restaurant etiquette alone is not enough for QR code table ordering to smooth out inefficiencies; it has to extend also to payment habits and everyday monetary transactions. Personal convenience, in this sense, not only piggybacks on the distributed convenience of linking up existing infrastructures–it is *contingent on* a distributed convenience made possible by localised enactments of personal convenience (e.g. successful adoption of cashless or contactless payment as measures of personal convenience). This feedback loop is a key feature of the convenient efficiency model–it is anticipatory of all the possible forms of convenience and efficiency it can produce, rather than oriented around actual individual enactments of convenience and efficiency it can produce at present. It is in this sense that convenient efficiency is an efficiency of growth and transformation: it envisages a range of possible optimisations much broader than existing changes that can be readily made and asks why particular cases within its system should conform to its existing restrictions through dynamic, ongoing problematisation.

Adaptation to and around convenient efficiency is often taken for granted: given sufficient time (but not space), the assumption is that growth and transformation would eventually occur. Whether or not systems of convenient efficiency account for context (i.e. space rather than time) is often irrelevant; what matters is the extent to which data about movements within these systems are recorded, so that they can be relied on as determining and controlling factors for the next iteration of system optimisation. The QR code as an AIDC technique lies at the heart of the post-pandemic system of convenient efficiency, holding together malleable enactments of convenience (distributed, personal) and efficiency (of stability, of growth). QR codes serve all three main functions that John Durham Peters (2013: 42) identified as the mechanisms with which media act as designers of 'both ultimate things and the texture of everyday life' through its organisation of space and time: recording, transmission, and logistics. Logistical media arrange people and property into time and space: they are fundamentally data processors because they establish the central points around which culture rotates. Like calendars, clocks, and towers, QR codes have come to appear neutral and given as the zero point of orientation around which convenience and efficiency converge–the basis of which is the source of their ubiquity.

Bodies as assets: accounting for lives in a pandemic

The QR code as a solution to more efficient asset management in manufacturing was important to the workflow of the factory. Given the inherent spatial limit of the factory floor, speed becomes the marker of efficiency–operationalised through how fast physical assets move along the assembly line. QR codes are a mechanism with which data relating to assets can be quickly captured and recorded; asset management, however, also entails the integration and management of asset data towards decision-making about those assets. It should be noted here that assets in themselves are not static,

isolated objects–they are relational arrangements with legal and economic dimensions (i.e. whose asset it is, what value an asset assumes and to whom). Much like citizens of a nation, assets are accounted for, managed, decided on behalf of; the decisions made about assets are contingent on a variety of factors, including business profitability, life-cycle strategies, and organisational policies. Different levels of management also devise different decision categories across strategic, tactical, and operational contexts; it is for this reason that an asset is dynamically and anticipatorily tied to decision-making about itself through its data.

Distinctions have been made between tangible and non-tangible assets, with the former including physical and engineering assets and the latter including financial, intellectual property, and human capital (Allee, 2008; Yallwe and Buscemi, 2014). Human capital as an intangible asset class is usually defined in terms of disembodied capabilities such as knowledge, skills, abilities, experience, intelligence, training, and competences; human capital, as such, comes into existence only through contractual obligations between people and organisations as legal entities–as opposed to the material existence of tangible assets (e.g. inventories, equipment, buildings) independent of any contract, even as legal rights pertaining to them can be created through contracts. From this perspective, citizens are assets to their governments in both tangible and intangible senses: while a citizen's allegiance and potential contribution to statehood might be intangible, other dimensions of citizenship such as welfare and mobility are tangible insofar as they require material investment and management by the state (e.g. roads, trains, hospitals). Tracking citizens as assets to be managed becomes paramount in emergency and disaster scenarios, where a citizen's entitlement to state protection is materialised through them being accounted for and reported on in a timely manner. While record-making and recordkeeping are already essential activities to non-emergency enactments of statehood (e.g. tax and tithe rolls, property rolls, conscription lists, censuses), automated collection of citizen location and mobility data as an added instrument of statecraft presents itself as useful against the background of existing pervasive practices of data extraction by private-sector technology companies. The logic of these extractive practices has been variously characterised as platform capitalism (Srnicek, 2017), surveillance capitalism (Zuboff, 2019), and data colonialism (Couldry and Mejias, 2019). While these characterisations differ in the nuances they articulate, they all gesture towards general trends in the quantification and datafication of social lives not as a form of static efficiency of maintenance and administration, but as a growth efficiency oriented around data surplus–where vast amounts of data are collected not because they can be readily applied towards immediate optimisations of the present, but because their collection is automated so that this automation always generates excess. This excess is fed into advanced manufacturing processes such as machine learning and deep learning which fabricate predictions about the future; predictive futures as a revenue stream in turn condition human actions through feedback loops that require and produce more and more data. That privately owned digital infrastructures and platforms are developed towards real-time extraction of data about large populations raise a range of critical concerns about privacy, liberty, democracy, and self-determination.

Against this background, the rollout of QR codes by governments around the world to track citizen mobility towards managing the COVID-19 pandemic has further created

conditions for practices of distributed convenience. China, for example, assigned each of its 900 million residents a QR code within a span of 2 weeks; residents are required to provide these QR codes through either mobile device or printable in order to move in public spaces (Wu et al., 2020). The designation of QR codes is reportedly based on algorithms that combine people's self-assessed health status, the government's comprehensive data on its people, and China's real time collection of data on aviation, ground transportation systems, and social media (Shachar and Mahmood, 2021). Checkpoints were set up at community entrances, major traffic exit and entry points, airports, train stations and city/district lines where QR codes must be scanned. In Australia, state governments rolled out QR code check-in systems for public venues where citizens were required to scan these QR codes with their phones; if this is not possible, then the venue must record patrons' contact details by an alternative method, usually in the form of paper-based records. In the case of China, QR codes are an automated technology already embedded in an automated decision-making system; in the case of Australia, QR codes help automate otherwise manual form-filling that was understood as disruptive, unwieldy, and slow to the workflow of pandemic management. In both cases, however, the efficiency of pandemic management is understood alongside the value of convenience as distributed–as the harmonious coming together of various automated data-collecting mechanisms and capabilities.

By means of convenience, data that are not otherwise categorised as health data are put to use as data that help predict health outcomes and inform healthcare planning; data harmonisation as a paradigm of data processing is in this sense an exercise in making convenience efficient. The European data strategy, for example, instructs the development of 'common and interoperable data spaces' through data harmonisation so that 'data can flow within the EU and across sectors, for the benefit of all' in a 'single data market' (European Commission, 2019). Harmonised data spaces are to be traversed as frictionless flows, free of original context and purpose; hopscotching from data source to data source would be inefficient and inconvenient. Here, the disciplining logic of efficiency as flattening depth towards rhythms of continuity echoes that of the 1930s factory floor chronocyclegraph–the smoother the movement trajectory, the more efficient the workflow. However, while in the factory the worker was (and still is) photographed, with QR codes it is the code that is photographed in order to reveal data on the individual. Because scanning a QR code is not as a place-dependent process as photographing the worker was, it is not secluded to the lab or factory, but might be on a museum wall, at the entrance to a place, on a restaurant menu, or carried as a document within the mobile phone. In this way, we come to it to scan it, or it is brought to us: these phenomenological differences mark the multisensory nature of QR codes as an ocular-tactile technology, wherein the manifold sense of touch (Paterson, 2007) became central to how post-pandemic realities are regulated.

That QR codes have been understood as a 'contactless technology' also contributed to its widespread application in pandemic management, where contact tracing and contactless interactions (e.g. contactless house delivery, contactless instore click-and-collect) became the mainstays of infection mitigation strategies across sovereign contexts. QR code check-ins and scanning at checkpoints are convenient in that they allow citizens to become intelligible as automated data subjects to authorities through existing distributed,

piecemeal digital capabilities that map onto public spaces as spaces of flow–a distributed convenience–oriented around distributed efficiency. Distributed efficiency in this sense is concerned with motion as decoupled from time; it is instead contingent on motion as discrete bodily units of quantification oriented around space. Parisi (2016), writing about the rationalisation of touch, commented that contrary to narratives that ascribe vision the role of the 'master sense' in modernity, touch also became understood as rational, predictable, and manageable through its subjection to a psychobiological and psychophysical model of scientific tactility. That the mode of tactile measurement became inextricably linked to the measured object–scientific tactility–is crucial to understanding the relationship between tactility and technology, especially between media technology and the haptic. The modern touch is to function informatically–to reliably mediate the external world as an efficient epistemological instrument–not only to measure the external world accurately and predictably but also to report on the embodied self faithfully and predictably from a safe distance. The continued popularisation of haptic human-computer interfaces, of which QR codes can be understood as part, allows touch to take on a new role in the economy of information circulation in the configuration of media apparatuses.

In practice, the speed with which QR codes can be scanned varies across uneven hardware and software capabilities (e.g. phone model, integrated scanning application, printing quality on paper). The disruptive nature of having to stop in one's track to scan a QR code runs counter to undisturbed flows of movement as emblematic of stable efficiency, as well as the ease and absence of trouble inherent to personal convenience. Like the haptic button, whose simplicity, mundaneness, and sometimes even magicality tend to often be romanticised (Plotnick, 2018), there exists a wide chasm between the simplistic convenience that QR codes are often touted to facilitate and the terms of its actual use. Even though inventors of buttons and QR codes alike intended these technologies to streamline control and communication, buttons and QR codes often malfunction, cause confusion, generate concerns, and irritate their users. QR codes as a photographic AIDC technique inherits the disciplining legacy of the chronocyclegraph in decoupling time from motion; the difference here, however, is in efficiency as enacted around keeping space as keeping distance, rather than as rationing space through curtailing depth of action. The effects of disciplining motion through the logic of photography, nevertheless, is the same: the space kept between the data subject and the data capture apparatus, as well as between the data subjects themselves (i.e. the 'safe distance' of 1.5 m) are inviolable–an inactivated, disembodied in-between space not to be trespassed. The bodies whose data are recorded as discrete quantities are made to overcome not the limits of their embodied being in relation to space, but rather the consequences of that embodiment: breathing lung excretion in and out, shedding viral particles, becoming disease vectors.

This is not to say that the photographic gaze is strictly discrete in its logic; facial recognition technology, for example, allows for the moving body to be recorded and captured without making it stop: a touchless technology that sees the body as a visible and readable totality from without. This otherwise pervasive technology was flummoxed by another, albeit more controversial, pandemic mitigation mainstay: the face mask. At the same time, relying solely on facial recognition for the purpose of contact tracing and mobility tracking would require a level of comprehensive and potentially irreversible

surveillance infrastructure most countries are either not currently capable of or/and comfortable with. Distributed convenience as superseding personal convenience in this sense is not only a matter of making do but also of mitigating contested values beyond efficiency. What distributed convenience lacks in efficiency, it makes up for in a sense of participation and resourcefulness. Yet as long as efficiency is a malleable project, especially when it interacts with the value of convenience, emerging QR code practices can always be reconfigured towards personal convenience and growth efficiency. The drive to 'QR codify' every aspect of life is reminiscent of the drive to previously 'buttonise' the social world (Plotnick, 2018), which emerged out of an automation and efficiency craze that sought to reconfigure how humans relate and delegate to machines. Just as power buttons hid wires and other messy aspects of electricity that could undermine harmonious, pre-electrical environments, QR codes obscure the highly complex and opaque processes in which data are collected, stored, analysed, and put to use–the details of which could seriously disrupt enactments of convenient efficiency as concerted efforts to mobilise spontaneous system synergies.

Conclusion

Insofar as the QR code shares certain genealogical lines with the miniature electric light ring slipped onto the 1930s worker's finger to plot their movement through discrete bursts of light that are made to flash on quickly and die away slowly, the QR code also records data about the activities of data subjects through discrete instances of quantification that occur quickly and made to form trajectories *ex post facto*. The body as emanating data through its movements is a body imbued with moral obligations: that in order for it to be legible and understood, it has to comply with, make way for, and be more skilful at the technologies of efficiency to which it suddenly finds itself beholden. At the intersection of convenience and efficiency as the predominant values driving contemporary technological culture lies contested visions about, and practices of, automation–not only as offloading bodily capabilities to machines or overcoming bodily limits through technological enhancement but also as making bodies productive as sites of data extraction. With the spill-over of the disciplining logic of tracking and managing assets on the factory floor into pandemic management and beyond, a new configuration of social automation emerges–one that is based on people taking on infrastructural responsibilities to enable systems of convenient efficiency. Through this configuration, personal convenience becomes contingent on distributed convenience of systems, and efficiency of stability becomes a precursor to eventual efficiency of growth and transformation. It is with this operative logic that contemporary QR code applications latch on existing extractive and generative data infrastructures to engineer solutions to the problematisation of post-pandemic behaviour as a field of practice that has become rendered uncertain and unfamiliar.

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