# Transient Computational Designed Boundaries enhancing Creativity in Workplaces

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## Abstract

Until artificial intelligence surpasses human creativity, the creativity of a single human brain will be at the core of architectural innovation. That said, in a modern context where one needs to be connected to others (and other disciplines) to be up-to-date to work on complex multidisciplinary projects, the creative individual cannot remain isolated. Therefore, the individual needs a creative workplace to achieve the coexistence and/or succession of time and space required of group work, and the time and space for individual work. Both work environments need to be expanded through the possibilities of computers.

This article questions the architectural tools developed by computational design that enable the transformation from collective workplace to individual workplace in the same space. Two reasons underpin the fact that both alternate or coexist in the same space: price of working space; but mainly the fact that transformable architectural features directly affect the perception of the persons working, by evocating transformation, affecting the senses, and thus enhancing creativity.

Computational design technologies enable the shaping of complex transformative boundaries. There is a difference between pure transformation enabled by technique and a ‘creative’ architectural boundary which is, according to French philosopher Mehdi Belhaj Kacem, linked with the creation of affect and concept. Following his theory of affect, a transformable architectural boundary needs to keep gradients or intensities of space in order to create affect (in opposition to homogeneous space of continuous transformation). Also, evocating creativity through an architectural boundary would mean focusing on a system that follows theories of ‘emergence’, developed in similarity to creative emergences in natural environments. The way parameters and algorithms could be set to function in this model is theoretically feasible in the future according to theories of ‘emergence’.

Analysis of Google workplaces will show the gap between their present realisations and the possibilities of computer technologies.

**Keywords**

Computational, design, private place, collective place, creativity.

The article focuses on boundaries between individual and group office workplaces in order to enable collective creativity. When related to people, ‘creativity’ is understood in its usual definition: by the ability to produce original, imaginative and novel ideas. It means not following a predetermined solution, but opening oneself to doubt and any surprising juxtaposition of ideas, etc. In the context of this article, ‘creativity’ will be tinted by the sense of resistance towards the purely functional and playful in working places. The hypothesis is that the interior architecture of the workplace can influence the creativity of the persons working there through its flexibility in order to host individual or group work, and through its artistic quality.

The artistic quality of the interior architecture enhances the creativity as being in a place that is the outcome of a creative process prompts creativity.[1]

The contemporary technological tool that enables flexibility of the workplace, and especially in this article of boundaries between working areas, is computational design. ‘Computational design’ refers to the use of computers and a mathematical approach in the generation of geometries, objects and architecture. Computational design is comparable to ‘parametric design’ in that both focus on designed networks and processes instead of designed objects, however, there is a distinction that can be made between the two design approaches. ‘Computational design’ is more artistic. In ‘parametric design’, which is about using parameters to design things (if the parameters change, the results change), the process is more linear and thus can lack artistic potential. As the outcome is a tangible architectural feature, the question of artistic quality is legitimate (even if the outcome is transformable). Computational design technologies enable the shaping of complex transformative surfaces that enhance the fluid organisation of these reconfigurations. They also tend to blur the limits

between places. The term ‘place’ is used in this article to describe the area that is used by one person or a group of persons at a certain time, defined by boundaries that are walls, partitions or big-scale objects. The term ‘place’ does not refer in this article to the centralised aspect of ‘place’ as a location or close surroundings of one person. The term ‘space’ refers to the abstract notion of infinite space, or to the whole level of an open-plan office. The term ‘workplace’ is a generic term whose sense focuses especially on its function.

This article questions the architectural tools developed by computational design that keep the coexistence of the collective and individual workplace: who controls the data input that enables good governance?

**Introduction: Creativity through Interactions**

During the two-day conference *Next Generation Workplace* that took place in Sydney on the 12th and 13th of July 2017, the panel of participants from major international firms (Rabobank, Google, QBE, Coca-Cola Amatil, etc.) drew a contemporary portrait of their leading aspirations in terms of workplace environments. Going further away from the logic of hierarchical setting and enclosed private offices, the main tendency is towards open plans that enable people to be in contact to share information and knowledge, in a collegial or community-like way. On the timeframe of the development of office environments, open plans are an old idea. Since their developments in the nineteenth century, open plans are more space efficient, and thus costs efficient. Matthew Harvey, Head of Facilities at Vodafone described how his firm has increased space utilisation whilst decreasing floor space and cost. In this context, the tendency is to organise the adequate flexibility on the open plan. Henry Lee, Property and Facilities Manager at AGL Energy reported that they worked on ‘effective technology and systems that enhance workplace productivity and efficiency’ for their ‘George Street’ building in Sydney. Frank Restuccia, Co-Founder of Finder.com and Chris Beale, Workplace Design Lead at Telstra also analysed the benefits of ‘an open plan flexible work structure with higher management hot desk (no assigned seats) to foster mobile and collaborative working’. Already in 2003, the Norwegian telecommunications company Telenor witnessed accelerated decision

making when it incorporated ‘hot desking’ and places that could easily be reconfigured for different tasks and evolving teams.[2] Google has since been a leader in the development of hot desking in open plan offices, that are intended to heighten the likelihood of collisions and cross-pollination, and thus enhance creativity. Zappos in Las Vegas uses a new metric – ‘collisionable hours’ – to measure a space’s effectiveness.[3] (Figure 1.)

In his 1977 book, *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D Organization*, Thomas J. Allen was first to measure the strong negative correlation between physical distance and frequency of communication. According to Ben Waber from the MIT Media Lab, even with the expansion of online communication and distance-shrinking technologies, the Allen curve holds.[4] In fact, as distance-shrinking technology accelerates, proximity is apparently becoming more important. Waber shows that both face-to-face and digital communications follow the Allen curve: proximity enhances physical and virtual communication. This confirmation of the social efficiency of hot desking in open plan offices matches the economic efficiency already mentioned, and sustains the existing practices of the major firms that expressed their strategies during the 2017 *Next Generation Workplace* conference. These social and economic characteristics underpin the development of the business model of co-working spaces: ‘Co-working spaces benefit an increasingly mobile workforce, create diverse communities of workers and integrate exciting designs and technologies that allow for an exciting new work experience. […] The corporate workspace is changing and the potential for larger companies to put their people in co-working spaces to allow them to leverage off agile and innovative thinkers.’[5] (Figure 2.)

With the world making a move to mobility and freelancing, Google has established that their workplace ethos better aligns with presence and wants to keep up an environment where everyone attends work, fostering interaction. The firm is advanced in the development of group-working strategy: ‘office culture promotes “casual collision” between employees. This is paramount in demonstrating how collaboration promotes creativity and drives production.’[6] A visit to the Google offices in Sydney[7] shows that next to open plans, individual or two-people working corners have been

built to enable more private discussions as well as quiet relaxing and thinking places. The boundaries of these areas are fixed, and thus are determined in their function, which creates a radical dissociation from the open plan. There is an emphasis on the design of these small individual relaxing or working places: Woods Bagot designed them in a diverse array of shapes, colours and textures. The shift from group work in the open plan, to individual work in enclosed corners is not fluid in their current design. There are some exceptions that will be mentioned in the next paragraph, as well as Google's applied research on the subject for the future.

**Limits of 'Hot Desking'**

The existence of private corners in the Google offices shows that having only open plans is not the solution. More generally, a literature review on the subject of workplace organisation shows a growing resistance to the suppression of individual office places, that goes against the ideological mainstream promotion of hot desking in open plans. Open plans can be fundamentally criticised as creating a spatial continuity and homogeneity of the workplace: this global tendency can just be mentioned in this article. More concretely, open plans including hot desk, can be inadequate for the functioning of the workplace. In a 2014 article entitled 'Google got it wrong. The open-office trend is destroying the workplace'[8], Lindsey Kaufman draws our attention to the necessity of keeping a minimum of individual functioning and privacy, at chosen timeframes, in the workplace. Some voices could be heard in this sense during the 2017 *Next Generation Workplace* conference. 'Are open plan offices the solution or are they swaying us away from deep work?'[9] Clinton Parr, Head of People and Culture at Clemenger BBDO, discussed whether the pendulum is swinging too far and whether mobility is compromising the ability to complete work outcomes, and made conclusions about the importance of the concept of 'Deep Work' and of the benefits of staying focussed in a distracting environment. Open plan offices can be too distracting and there is a need to create places where people can really focus. Clinton Parr, Dr Darragh O'Brien, Knowledge and Design Leader at Peckvonhartel, and Alice Drew, Head of Workplace at LendLease discussed how 'one size does not fit all': adaptable, smart environments should display a hybrid space, where collective and individual

work coexist to accommodate varying personality types and work styles. There are effects of open plan workspaces on privacy and confidentiality, and there is an impact of not having a set desk: personalising or nesting one's desk enhances wellbeing, creates opportunities for privacy, and does not mean that there are no collaboration and social interaction at other times. Computationally designed boundaries could enable this flexibility, from individual to collective work and interaction, and thus enable the different components that ultimately ensure collective creativity.

**'Politics of the Workplace' in Preserving Differences between Collective and Individual Places**

Creativity of the individual is enhanced by the relation the individual has with other employees or co-workers. However, until artificial intelligence surpasses human creativity, human creativity will rely on individual brains. In a modern context, one needs to be connected to others (and other disciplines) to be up-to-date to work on complex multidisciplinary projects, and the creative individual cannot remain isolated. Therefore, the individual needs a creative workplace to achieve the coexistence and/or succession of time and place for group work, and the time and place for individual work. Both work environments need to be developed, and in the best case be expanded through the possibilities of computers. Computational design is expanding the array of architectural tools that enable the transformation from a collective workplace to an individual workplace in the same space. One driver motivates firms to subscribe to this idea that both workplaces alternate or coexist in the same space: price of working space.

Which are the latest technologies used by firms like Google to organise the fluid shift from group work to individual work amongst its employees? The examples of meeting rooms that are publicly documented by Google do not yet rely on high-level technologies. Google Sydney offices, designed by Woods Bagot, display a series of open plans next to meeting rooms of different sizes. One meeting room is nicknamed 'the cube' has one plain wall with a plasma screen and three glass walls that can be obscured through rolling screens in relation to the level of privacy the gathering group needs. One entrance area is defined by thread curtains in the shape of a spiral. The classical

flexibility of the curtain linked to the semi-transparency of the thread curtain creates a place where boundaries are blurred and transformable.

In Google's London offices designed by AHMM (Allford Hall Monaghan Morris) in 2016, central to the flexibility concept is a modular meeting and videoconferencing room, which can be reconfigured in multiple ways. Employees gave it the name Jack, and AHMM even prepared a helpful manual encouraging everyone to 'Hack a Jack'. It is built with plywood panels that can be simply bolted together. Both the interiors and the exteriors are purposely neutral for personalisation with different cladding and shelving.[10] The design of Google's LA office at Playa Vista is kept confidential at this date. Jeremy Neuner, Real Estate and Workplace Services at Google, contributes to the development of collaborative environments where employees can 'thrive'[11]. The innovative ideas and concepts of the actors of these projects will be presented in the next paragraphs.

Issue 119 of Frame magazine[12] tackles 'the responsive workplace' and explores offices that 'adapt to their digitally empowered personnel'. 'Today's advanced digital technologies go even further: what we think of a 'fixed interior' can become places that change in response to human movement.'[13] Nicola Russi and Angelica Sylos Labini's project for the new Milan offices of QuintilesIMS (2017) presents a series of flexible furniture along the full length of the workspace, that adapt to different uses. One can easily imagine how computational design could facilitate the flexibility of the structure, but the use of data input to activate workplace features seems to so far have been rarely applied. One example is Georgia Tech's Crosland Library, designed in partnership with Herman Miller (Jennifer Magnolfi who used to work for the firm at that time) in 2010 displays interactive walls and lighting features.[14] Omar Khan's project *Design Innovation Garage*, Buffalo, NY[15] (Figure 3) is a design innovation centre modelled on open source concepts, using multiple communications options between black boxes including secure information networks, projections, visual reflections, opacities and transparencies, occupant conversations, overhearing and glancing. In terms of partitioning, the concept stays rudimentary in its realisation, even if its representation evokes the idea of flexibility of boundaries between individual and collective places.

There should be more use-related application coming. The number of artists' projects tackling interactive technologies is a sign of their future application in interiors and especially in the workplace. Topological transformations of the 'structure' in space and time are not yet deployed in our everyday environments and are only laboratory prototypes for the moment[16].

**How Can Computational Design Contribute to the Flexibility of Individual and Collective Work?**

Antoine Picon describes in his book *Digital Culture in Architecture: An Introduction for the Design Professions*[17] from 2010 how with computational design architecture shifted from 'architectural design' to 'technology-based architectures'. A first distinction can be made between 'parametric design', which is about using parameters to design things (if the parameters change, the results change), and 'computational design' that refers to the use of computers and a mathematical approach to the generation of geometries, objects and architecture. In both cases, the focus is on designed networks and processes instead of designed objects. The system is usually controlled from the outside, but the dynamics mimic self-organised bodies as we find them in nature. Systems and processes could accommodate ever-quickening continuously-changing contexts.

The first stages of parametric design are based on rational systems that are inherited from the history of techniques, but in an extremely complex and dematerialised way today. Complex surfaces replace traditional plain walls. 'The digital turn in architecture and design has freed surface from the 'body' of a built object to a new landscape of possibilities.'[18] Forms are replaced by 'patterns', and the way surfaces become complex, creates a shift towards the notion of 'hypersurface', as multiple parameters or algorithms implied mimic the possibilities of a n-dimensional space, projected or interpreted or represented in our 3-dimensional space. Complex joining and panelling systems can be developed. There is a shift from the fabrication of modern walls that can be considered as standardised for ideological or technological purposes, to non-standard surfaces that open up a wide range of possibilities and versions based on a set of parameters or algorithms. With computational design, the system can be less linear in its functioning than with parametric design. The shift from

parametric to computational facilitates the creative aspect of the design. Instead of relying on a fixed structure, we shift to complex continuously dynamic systems, and instead of a law, we shift to variations of the norm. For Frédéric Migayrou, our current situation, when the object positions itself in a continuum through variation, sees the fluctuation of the norm replace the permanence of the law.[19] 'This norm, always in the process of being defined and always deferred, is transcribed into objects fluctuating on the variable curves of the new industrial series…. There are no longer pre-established functions requiring a form, we have only the occasional functions of fluctuating forms.'[20] This relates to 'dynamic tectonics' according to the *Handbook of Interior Design*'s definition of versioning, and would have an impact on the structuring of the workplace environment.

The use of data input and computationally designed partitioning can be an efficient tool to organise the passage from individual to collective work and vice versa. New digital technologies enable designs of unprecedented complexity, and through parametric methods and their technological realisation, an interaction with data coming from a person, a group of persons, or a broader context. The virtue of these technologies is adaptation to changing needs, especially in the types of action and interaction we have with others in space. On the base of the respect of 'common laws' of humans in terms of interactions (or its approximation, that enables respect of each other; it is utopian to code the common laws or rules of interactions between individuals), and of 'common rules' of the workplace, each person could influence the characteristics of the interior: size of the area, level of closeness and privacy of the partitions, level of natural light, acoustic qualities, etc. Like politics in general, workplace relations are a constant negotiation. Boundaries between places would frequently have been negotiated, accelerating to the timeframe of hours or minutes what is negotiated today at the timeframe of years with fixed partitioning. The knowledge and experiences around permanence and adaptability of partitioning is the historical background of these innovations. The status of places and ways to maintain privacy (for example of an office place in an open plan project) have been researched extensively. A smart design of long term adequate partitioning has been the main aim of architecture so far. Even if there was a primary and a secondary structure that could evolve in a lapse

of a few months or years, and even if there was a wall or furniture piece that could expand and retract according to the needs, the plasticity enabled by new technologies is now unprecedented.

Who would control the change of boundaries in the workplace? The possibility of collective creativity needs to be questioned by taking into account this new redistribution of power. If we follow Google's philosophy on the expression of each of its employees, each person should be able to discuss these boundaries and be able to play with them and act on them. By welcoming the innovation processes around the plasticity of shapes of walls, and maybe also floors and ceilings, through parameters and algorithms, it is necessary to think and control the design of these near future possibilities because they challenge the political organisation of the workplace. The transformations of partitioning in laboratory prototypes enabled now in a short period of time (seconds) are new characteristics that affect work relations. Richard Sennett[21], who analyses the two extreme tendencies of homogenisation and extreme clustering of individuals in our society, proposes concepts that can be guidelines for new organisations, such as 'concentration without centralisation': on the basis of the concept of a working unit without a centralised decision-maker, designers could propose new flexible boundaries of workplaces. Having multiple leading persons, in an open changing process in time, could be organised through multiple 'cores' on the open plan, like those represented in Omar Khan's project. The input of each employee could be managed by these multiple decision makers in order to achieve each time a temporary consensus that matches the working requirements.

**Computationally Designed Boundaries as a Creative Environment**

Could there be 'an adequate aesthetic' of computationally designed boundaries that enhances collective creativity in the workplace? Perceiving around oneself walls that are not easily understandable rational structures, but have an aesthetic quality, could tend to inspire oneself to be creative in the same way. In the context of computationally-designed boundaries, the perception of the boundaries could be slightly different each time, which enhances their contemporariness. They could enhance creativity because transformable architectural features affect directly the perception of the persons working by evocating transformation, affecting the senses, and thus enhancing creativity.

Between purely functional purpose (without aesthetics) and purely artistic use (without function), new technologies need to be used adequately for design issues, and especially for the partitioning of workplaces. If we follow the hypothesis from the introduction, i.e. that an artistic partition feature stimulates the creativity of people working in this environment, one still needs to study the need to have an artistic computationally-designed partition. Technological innovation is not automatically aesthetic innovation. Designers are challenged to top-up the complex technical requirements to develop aesthetic qualities that inspire the people who work in the environment. How can we safeguard creative singularities in the system that keeps the aesthetics of these boundaries? There is a difference between pure transformation enabled by technique and an aesthetic architectural boundary, which is, according to French philosopher Mehdi Belhaj Kacem, linked with the creation of affect and concept.[22] Technological innovation can create new kinds of shapes and thus bodily sensations, but there might be a difference between producing new bodily sensations and creating innovative architecture that creates an affect, linked with a concept (as will be defined in relation to Mehdi Belhaj Kacem's theory of affect). In which cases does the artistic potential associated with kinesthesic sensations create an affect? An example of a highly technological project is Mark Goulthorpe's (dECOi) *Hyposurface* from 2003. He used triangular shapes that are animated through a mechanical system creating moving 'waves' at the surface, in an interaction process with the persons who approaches it. According to Goulthorpe, '*HypoSurface* is the World's first display system where the screen surface physically moves. Information and form are linked to give a radical new media technology: an info-form device.' This surface moves, and we can witness on his website's video how the surface surprises people, and has a real impact on them. The system enables infinite possibilities. Each iteration of the experience provides another slightly different pattern on the surface. The openness of the system questions the possibility of an aesthetic value of an iteration, or of the system as a whole. Mehdi Belhaj Kacem's theory of affect could be summarised as follows: he defines an affect based on the 'virtual' as the gap between presentation and representation, or what fails in the forcing of representation into presentation. Affect is 'the identity of this infinity'. Kacem considers the event as the real of a disintegrated representation. There is a negative aspect of any relation, and this aspect is inherited from Hegel's notion of the 'Negative' as well as the negative of any

relationship in Lacan (the real of pleasure proves it). Void is always integral to things, and the site of the event (or 'eventual site') is always 'at the border-of-the-void'. Against the disappearance of aesthetics value in art and architecture, and against the disappearance of boundaries between public and private space, architecture is considered as the site of the event (or 'eventual site'), 'at the border-of-the-void'. *Hyposurface* has a too linear parametric functioning (and a generic aspect of the triangular shapes) in order to create real affect. At the opposite end of the spectrum, the chaos of its movements does not create a real affect either. With a parametric system functioning on a strict law, or its opposite of endless possibilities through the absence of any law, boundaries tend to disappear between human and nature. Homogeneity through repetition and the systematic tends to prevail. At the scale of the array of boundaries, the consequence is that boundaries between places of different statuses, as defined by cultural and political functioning, and aesthetic value, are also disappearing. At the scale of the boundary itself, a clear shift from parametric design to computational design of the *Hyposurface* surface (and a distance taken with the generic triangular shape of the elements) could enable a clear aesthetic value of the dynamic surface, through the creative intention of an individual or collective author.

The MIT Self-Assembly Lab is at this point today in terms of research on transformable walls. It is a cross-disciplinary design research centre to develop innovations that serve societal needs. They develop research on transformable structures, comprising transformable screens and transformable meeting places, using different geometric and material properties. The aim of the 'transformable meeting places' team is to reimagine interior office or building environments. Open office plans have been shown to decrease productivity due to noise and privacy challenges, yet they provide flexibility and collaborative opportunities. Fixed offices offer privacy and quiet environments but restrict the type of working places available and occupy more square footage. This research proposes an alternative whereby structures can easily transform between private phone booths, lounge places or other quiet meeting places into open flexible areas. After Skylar Tibbits (MIT Self-Assembly Lab) met architect Michelle Kaufmann at a TED conference in 2016, they started a research collaboration with Google to explore the future of workplace environments. Over the

subsequent months, they turned initial sketches into concepts that became these prototypes of Transformable Meeting Places. They published one project of transformable office pods[23]. Other projects include a transformable woven structure, and an interactive rolling partition (Figure 4).

Architect Michelle Kaufmann had already joined forces with top-secret research lab Google X team (Astro Teller and Sebastian Thrun) as a consultant in 2010. In 2012, she co-founded Flux[24] to apply artificial intelligence and computer science 'to help make thoughtfully designed, healthy, durable buildings accessible to everyone.' Kaufmann says her start-up, the first official company spun out from Google X (now part of parent company Alphabet), will enable architects and urban planners to tap in to the massive efficiencies of a software platform in a profession where 'essentially each building is still designed and built from scratch.' Flux builds software that Kaufmann says will adjust for everything – from zoning regulations to the angle of the sun or the size of a screw – in seconds. Kaufmann runs the R&D lab for Alphabet and Google's new campus in Mountain View, near San Francisco, which is set to break ground in 2018 (and also for Google Sunnyvale, California and in Google London). She is collaborating with the project's two architects, Bjarke Ingels and Thomas Heatherwick, using rapid prototyping and other product-design principles to develop new kinds of building materials and adaptive structures, like 'a handkerchief [roof] in the middle [of a building] that can open and close and create energy.'[25] Details of the projects are not known at the date of publication of this article.

**Possibility of Collective Creativity**

Following what has been described about computational design, its complexity, and its links with natural processes, means that if there is creativity in nature, it would be theoretically possible to witness a collective creative process on the base of computational design tools. It would just be a question of complexity and calculation capability. In relation to the subject of collective data input into a system of architectural boundaries, it means that the collective could be 'creative' in this manipulation itself, and thus enhance their creativity for other tasks.

As the technological environment tends to mimic natural processes, collective creativity could emerge on the model of 'emergence' in the animal realm. 'In the simplest commonly used definition, emergence is said to be the properties of a system that cannot be deduced from its components, something more than the sum of its parts.' The theory of emergence posits that sometimes nature 'jumps' from one state to another in sudden and unpredictable ways[26], creating 'singularisation' and 'individuation'[27]. The way parameters and algorithms could be set to function in this model is theoretically feasible in the future according to theories of 'emergence'. On the bas of the possibilities of computational technologies to take into account a considerable amount of input data and parameters that relate to the key sociological aspects of negotiations of boundaries between individual and collective workplaces, a creative outcome could happen in the system. It could be a threat or an unprecedented positive tool to use for collective practice. What computational tools enable, and that creates a shift from traditional practice, is the input by multiple participants (with negative and positive effects that it can engender). As mentioned previously, the use of collective data questions the transfers or sharing of power and decision-making. Through the multiplicity of parameters and algorithms, power can be shared at different levels: between the boss and a group, or between a group and an individual person[28]. The use by a group of persons, with the tensions inherent to the functioning of this group, could have a consequence on the emergence of a creative configuration of the system. It is a utopian idea to imagine the emergence of singular events in architecture, but if René Thom is not contradicted, it is theoretically feasible with the level of complexity achieved by computational tools. If this evolution is possible in nature, the hypothesis is that with the level of data and complexity enabled by computers, it is also possible for artificial objects.

Through the lens of history, the notion of collective creativity is not especially new and is deeply rooted in the period before the emergence of the figure of the individual artist as a genius in the Renaissance. This emergence of the notion of the subject in the Renaissance era coincides broadly with the emergence of rational and controlled planning of cities and architecture. The similarities of the layout of cities with nature-related shapes in Mesopotamia and Egypt, ancient India and China, ancient Greece and the periods to the Middle Ages (with the exception of the Roman *cardo* and

*decumanus maximus*), are replaced by rational geometric planning in the Western world. During the Renaissance, a shift to a rational and artificial way to layout cities is clearly visible. Computational design is a powerful contemporary tool that enables us to embrace ideas and concepts from pre-Renaissance history. Also, because of the capabilities of computers today, emphasis is on what makes humankind irreplaceable: the creativity of the individual. By being able to combine both collective and individual forms of thinking and creating, through fluctuating relations between persons enabled by interior architecture configurations, the computational design relates in two ways to historical aspects. Neither the isolated subject from the *studioli* that appear in Renaissance paintings, nor the purely functional and playful open plan models of the workplace developed in the nineteenth and twentieth century, can have the fruitful outcomes made possible by the new connection between these two figures from the past (that is, the collective creativity and the emphasis on the creativity of one person). This conceptual model could be more similar to the *botteghe* from the Renaissance, described by Piero Formica as 'the innovative coworking places of 15th-century Italy'.[29]

**Conclusion: The Possibility of a Creative Workplace through the Development of Computationally Designed Boundaries**

In the actual context of a critical approach towards classical open plan offices, computational design enables the creation of boundaries that organise shifts between individual and group work in the same space. Cost efficient in terms of allocated space, they also stimulate collective creativity through the alternating of private thinking moments and collective discussions. The possibilities of computer calculation enable collective input and control at the scale of the group, and thus question the sharing of power in the workplace. Employees can possibly have more control on their workplace environment. This is possible if the 'boss' or multiple horizontal decision makers allow this sharing of power. Considering these capabilities could effectively create better places of creative co-working practice. The computationally designed boundaries themselves, can stimulate the body and the senses, and enhance creativity.

In a more theoretical and utopian way, the collective input of data in a computational system could generate creativity in the design of workplace features, on the basis of ‘emergence’ as with nature. It is a question of scale (complexity and data). The collective body would be able to evolve in an environment that enhances events, affects and singular evolutions in time. This concept is not new in the history of planning our environment, as collective creativity existed in the Middle Ages (cathedrals are an iconic example), and the focus on the creativity of one person has been a deep shift from the Renaissance era. However, both aspects are more highly valued today because of the power of technology. Collective creativity and individual creativity, combined in the creative work organisation can be greatly expanded through technology. As we know from the subjects of the ongoing research by laboratories like the Google X team, computational designed workplaces have immense potential for our future.

## Figures

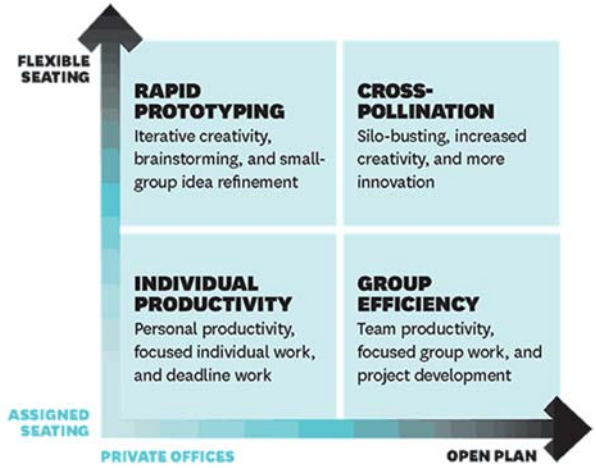


Figure 1. *Source*: Ben Waber, Jennifer Magnolfi and Greg Lindsay, "Wokspaces That Move People," *Harvard Business Review* (October 2014), https://hbr.org/2014/10/workspaces-that-move-people.

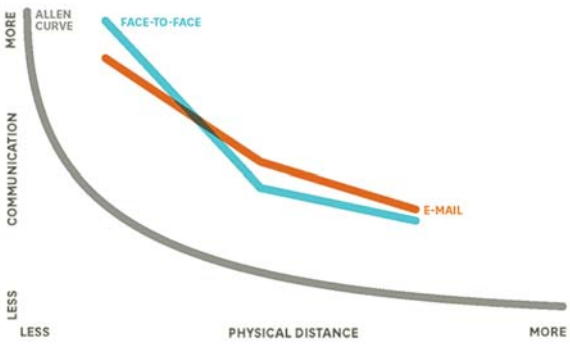


Figure 2. *Source*: Ben Waber, Jennifer Magnolfi and Greg Lindsay, "Wokspaces That Move People," *Harvard Business Review* (October 2014), https://hbr.org/2014/10/workspaces-that-move-people.

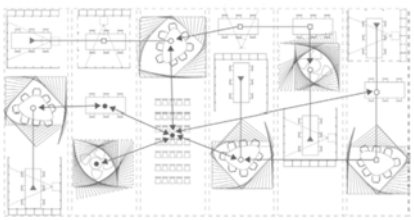

Figure 3. Omar Khan, *Design Innovation Garage*, Buffalo, NY, 2013 © Omar Khan.

Figure 4. MIT Self-Assembly Lab, *Transformable office pods*, 2016.

**Notes**

[1] An artistic quality does not necessarily mean overly expressive. There are other points of view on this aspect. The complementary point of view, which is equally compelling, is that one needs a neutral environment to be able to open up to new ideas and aesthetics, and not be stuck by the aesthetics of the time when the environment has been created. In SpaceEncounter's project for Sony Music offices (2017) in Amsterdam, the application of interactive design is levelled at a minimum: displaying a programmable ceiling lighting that creates a sensory environment into a minimal greyish geometric environment. Instead of adding the sum of individual requirements, the interactive environment is levelled at its minimum.

[2] Ben Waber, Jennifer Magnolfi and Greg Lindsay, "Wokspaces That Move People," *Harvard Business Review* (October 2014), https://hbr.org/2014/10/workspaces-that-move-people.

[3] "Wokspaces That Move People."

[4] "Wokspaces That Move People."

[5] "2017 Next Generation Workplace conference program," 12–13 July 2017, Sydney.

[6] Workspace Design and Build Ltd, "What can we learn from Google's offices about workplace design?" http://www.workspacedesign.co.uk/what-can-we-learn-from-googles-offices-about-workplace-design.

[7] On 7 February 2017.

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