The Psychology of Collaboration Space

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Executive summary

The purpose of this paper is to provide a literature review of the research into the psychology of collaboration spaces highlighting the impact of psychological factors on collaboration and the implications for workspace layout, design and furniture. Particular attention had been made to the effect of personality factors and the profiles of collaborative team members.

Research into the psychology of collaboration uses the same language as the workplace design and strategy community: "group effectiveness is a function of environmental factors, design factors, group processes and psychosocial traits". However the "environmental factors" actually refer to the external economic market and the "design factors" refer to the features of the group that can be manipulated by managers to create the conditions for effective team performance. It appears that the impact of psychological factors on the design of collaboration space has not been previously explored in any detail. The lack of studies into the psychology of collaboration space justifies the need for this introductory paper and further research, but it also means that, for now, inferences must be drawn from obliquely related research studies.

Collaboration is not simply interaction between colleagues, it involves two or more individuals working towards a common goal and creating a new product (e.g. an idea, solution, or insight) beyond what that they could have achieved individually. Effective teams are characterised by trust and collaboration such that building trust through creating a community, interaction and socialising is important for nurturing collaboration. Therefore whilst collaboration is more complicated than interaction *per se*, interaction helps build trust and is therefore a prerequisite for true collaboration.

Personality is derived from persona which is Latin for "mask" but nevertheless there is no consensus amongst psychologists on a single all-encompassing definition of personality. However, there are several reoccurring elements of personality such that personality can be defined as "an individual's unique set of traits and relatively consistent pattern of thinking and behaviour that persists over time and across situations". Personality is a bias towards particular traits (characteristics) that in turn affect behaviour. This embedded proclivity for behaving in a particular way means that it is also likely that people have a preference for and seek out environments that support their natural mode of behaviour and underlying personality.

Upon starting this study, one hypothesis mooted was that by determining the personality of team members we could in turn understand the best environment required to support their collaboration. The flaw in this hypothesis is that it assumes that all team members will have a similar personality allowing a single optimum collaboration space to be created. However, much research has been conducted comparing the performance of teams in which the members have either similar personality profiles or quite different ones. The research clearly showed that people with different personalities are better at different tasks and a mix of personalities in the team makes for a more effective and successful collaboration.

Personality theories date back to ancient Egypt and Mesopotamia but the ancient Greeks are most recognised as developing the first structured theory of personality. At the turn of the century the psychoanalysts, Freud and Jung, developed the psychodynamic theory of personality. Cattell followed by Eysenck applied new statistical techniques to psychodynamic theory resulting in trait theory. This then became the root of the most popular modern-day theories of the Myers Briggs Type Inventory and Five Factor Model.

The Big Five factors are Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism, often referred to as OCEAN. The effect of the Big Five personalities on team work and the implications for collaboration spaces are as follows:

- *Openness* – openness is important for creative and imaginative tasks but less important, or possibly detrimental, when the task is of a more routine nature:
  - open people prefer face-to-face (F2F) meetings, brainstorming, plus stimulating and new spaces; not open types prefer formal, familiar, conforming and traditional spaces.

- *Conscientiousness* – should be positively related to team performance across a wide variety of tasks and settings:
  - conscientious people prefer planned, formal, well-organised, minuted meetings; undirected people prefer impromptu informal meetings and quick interactions.

- *Neuroticism (emotional stability)* – the level of emotional stability should be positively related to performance for a wide range of team tasks:
  - neurotic people prefer well-planned formal meetings with advance notice; stable people are comfortable with large, impromptu or informal meetings.

- *Agreeableness* – good for the performance of long-term teams with tasks that involve persuasion but can inhibit performance when tasks do not require social interaction:
  - agreeable prefer large meetings with structure to help gain group consensus; antagonistic prefer unstructured F2F meetings were they can challenge/derail.

- *Extraversion* – enhances team performance for imaginative or creative tasks but inhibit performance when tasks call for precise, sequential and logical behaviour:
  - extraverts prefer large group F2F, informal meetings and stimulating spaces; introverts prefer written communications, small groups, teleconferences, and subdued spaces.

The increasing globalisation of organisations, and business initiatives such as off-shoring, may lead to team members being more dispersed resulting in a decrease in face-to-face collaboration or conversely increase in virtual collaboration. Studies comparing the performance of teams found that virtual teams tend to exchange less social information than co-located ones; this may slow the development of relationships and in turn reduce creativity and motivation. Face-to-face team meetings are usually more effective and satisfying than virtual ones, but nevertheless virtual teams can be as effective if given sufficient time to develop strong group relationships. Social interaction in the workplace, and between team members (virtual and co-located) is particularly important when the team is initially forming. Repeated encounters, even without conversation, help to promote the awareness of co-workers and to foster office relationships. So, again, although interaction alone is not a sufficient condition for successful collaboration it does indirectly support collaboration.

Co-location of teams allows the use of non-verbal communication including: different paralinguistic and non-verbal signs, precise timing of cues, coordination of turn-taking or the repair of any misunderstandings. Extroverts gesticulate for longer and more often in meetings than introverts. As 55% of communication is non-verbal, 38% done by tone of voice, and only 7% related to the words and content, clearly non-verbal communication is a key component of interaction. Virtual collaboration systems therefore need to replicate this basic communication need, especially in the early stages of team forming or when the team consists of a high proportion of extroverts.

A comprehensive review of the social science literature revealed several general conditions for creating successful interaction and collaboration spaces: proximity, accessibility, privacy, legitimacy and functionality. Aesthetics could also be added to the list, for example different colours affect the performance of different types of task. Other research has shown that stimulating environments with vibrant colours, music or noise, and a buzz of activity may enhance the performance of extroverts but more calming environments will better suit introverts. Furthermore, complex tasks may be better done in calm environments whereas

mundane repetitive tasks may benefit from a stimulating environment. The design trick is to provide the correct balance of stimulating (noisy or colourful) interaction spaces versus calm (quiet and subdued) ones to support different personalities and tasks.

Although a range of spaces for collaboration should be close to the team, these spaces do not all need to be dedicated collaboration spaces but can be other legitimate and accessible spaces for interaction (and intermingling) such as service and amenity spaces. However, these interaction nodes alone are not sufficient for collaboration and dedicated collaboration spaces, with good functionality and privacy, are required such as bookable teamwork, project and war rooms. Uniformly distributed clusters of shared spaces, i.e. local hubs, are more effective than banks of centrally adjacent spaces. A balance is required of distributed nodes for spontaneous interaction, local hubs for team collaboration plus central resources for planned (client or team) presentations.

Introverts are less comfortable with large group meetings than one-to-one interactions. Like their conscientious and neurotic colleagues (or sensing and thinking types) they also prefer time to think things through and develop their ideas before sharing them publically. The participation in collaboration of these personality types might therefore be enhanced by providing more discrete and private spaces adjacent to the main collaboration space, where one-to-one interactions can naturally and quickly take place after the more formal meeting. Evolutionary psychologists note the importance of sharing food and drink, and Tom Peters the importance of intermingling, so these spaces could be nearby coffee/vend/breakout interaction points. Furniture arrangement will affect how a team interacts with each other; the space and furniture therefore needs to easily reconfigurable to support different types of interaction e.g. one-to-one meetings, small group work or larger brain-storming sessions. Introverts and neurotic team members are likely to prefer more private, cosier and one-to-one settings than their gregarious counterparts. Organisational structure and project teams are constantly shifting in organisations, thus the space also needs to be adaptable to meet the needs of new teams as well as changing team requirements. The formality of the space has been shown to affect the depth of interaction and different personality types may prefer different levels of formality. For example, one research recommends mixing up seating options by taking the table out of the room or varying seat heights, plus creating cosy nooks for teams.

Collaboration involves capturing and displaying ideas and so designers need to acknowledge the importance of providing a means of generating, capturing and displaying information within collaborative teams. Those of an introverted and conscientious persuasion (or sensing and thinking types) are likely to appreciate the display of information more than their extroverted and disorganised (or intuitive and feeling) counterparts. Any non-porous surface could be designed as a whiteboard and used for capturing information but whole whitewalls can be created relatively inexpensively using magnetic vinyl sheeting and will provide more display space and versatility than whiteboards. Furthermore, filing cabinets can be clustered together and fitted with a top to provide layout space for sharing drawings and other large format information. Alternatively, inexpensive flat screen panels can be fitted in breakout spaces and team areas to provide a continuous display of rolling, historic or real time, information for one or a number of teams. It is not always practical or considered space efficient to provide dedicated project rooms for teams, especially if they are not utilised for the majority of the working week. One solution to this is to provide layered display boards in the project room so that the room may be used by multiple teams who can bring their displays to the front when using the spaces. An alternative (more expensive) technological solution is to provide multiple flat screens or projectors for displaying a team's information.

To facilitate virtual collaboration, the latest video-conferencing suites simulate face-to-face interaction much better than their predecessors, and this new technology is becoming more affordable (especially when considering savings in travel cost, time and carbon). On a smaller scale new personal technology, such as Skype on laptops and FaceTime on phones, means that

some elements of face-to-face meetings are now available anytime and anywhere for one-to-one interactions. The importance of sharing information in collaborative teams, particularly for introverted, conscientious (or sensing and thinking) types has already been raised. Whether co-located or virtual, collaboration spaces require seamless and intuitive technology so that information can be captured and shared. At minimum the spaces require essential basic audio-visual equipment such as display panels and teleconference phones , plus ample power and data points (preferably wireless broadband) all with well-designed controls and sufficient instruction in how to use it.

Our personality impacts on our preferred means of interaction and the tasks that we prefer to carry out and the tasks we are particularly good at. Teams with a mixed group of personality types generally collaborate more effectively than those with team members of the same personality. It therefore follows that environments that support true collaboration need to recognise the different personality types and their preferred means of communication and interaction, which will ultimately contribute to successful collaboration. Spaces for collaboration must consider how the design, layout, furniture and technology can support various modes of interaction. The main design challenge is providing space-efficient display and collaboration spaces that are available to the team (whether co-located or virtual) as and when required.

1.0 Objectives of study

Herman Miller commissioned Workplace Unlimited to conduct a brief review of the psychology of collaboration space. The objectives of this study were to:

- Carry out a literature review of the research into the psychology of collaboration spaces;
- Highlight the implications of psychological factors on collaboration and the implications for workspace layout, design and furniture;
- Comment on how to design collaboration spaces that accommodate different preferences for individual users and teams as a result of their personality profiles;
- Consider the implications of psychology on collaboration and propose initial ideas on how collaboration spaces should be designed and equipped;
- Provide a paper, and the basis of a presentation, which is of interest and relevant to an audience of interior designers and workplace strategists.

2.0 Literature review of research

The literature review revealed that much of the research on the psychological aspects of collaboration focuses how to maximise the performance of teams. These studies examine the psychological profiles of team members and the best combination of them, or how to motivate and develop teams so they are performing to their maximum potential. Cohen & Bailey (1997) observed that "group effectiveness is a function of environmental factors, design factors, group processes and psychosocial traits". On first appearance this observation seems pertinent to designing collaboration space; however their "environmental factors" actually refer to the external economic market and their "design factors" refer to the features of the group that can be manipulated by managers to create the conditions for effective team performance.
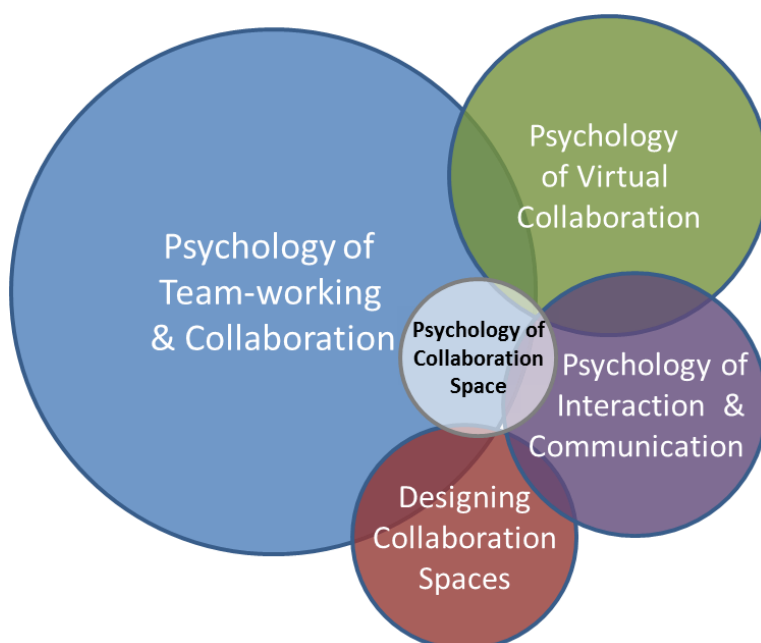

Figure 1. Four core areas of collaboration research

There also appears to be a growing body of literature on the psychology of virtual collaboration, in particular how to maximise the performance of dispersed teams and replicate the benefits of co-location. Although this research is mostly focussed on the management of collaboration teams, the possible implications for design will be explored in more detail later.

Much research has also been carried out on the psychology of interaction and communication. However, although relevant, interaction is not quite the same as collaboration and the implications of the research therefore differ. These differences are also explained in detail later.

Another area of relevant research, and associated guidance, which is emerging is that specifically exploring how to design collaboration spaces. It is mostly based on from case studies, i.e. the feedback from best practice workplaces, rather than empirical research or established theory. Despite this emerging research, Hua (2010) commented that "the effects of the physical environment on collaboration at work tend to be overlooked in theoretical models of group performance". His sentiment is supported by Heerwagen *et al* (2004) who point out "given the high interest in the topic of collaboration, there is a surprising dearth of research on the link between collaborative work processes and space".

So, although research into the psychology of collaboration uses the same language as the workplace design and strategy community, the impact of psychological factors on design of collaboration space has not been previously explored in any detail. The lack of studies into the psychology of collaboration space, illustrated as a gap in the research in Figure 1, on the one hand highlights the originality of our study and justifies its need. On the other hand, the lack of specific research into the psychology of collaboration space means that inferences must be drawn from the assorted complimentary research studies found through the literature review.

3.0 Collaboration or interaction

In order to improve the design of collaboration spaces we first need to understand what is actually meant by collaboration. Marinez-Moyano (2006) capture the common interpretation of collaboration which "is a recursive process where two or more people or organizations work together to realize shared goals". Indeed "if tasks are not interdependent then there is no need nor reason to collaborate. Individuals working alone can do the work" (Cohen & Mankin, 1998).

Whilst the notion of interdependency is key to collaboration, many experts in the field believe that true collaboration is about creating something new beyond the capability of the individual collaborators. For example, Cohen & Mankin (1998) suggest that "collaboration enables parties to reach a synthesis i.e. a new conclusion or idea that incorporates the insights of each party but goes beyond each" and similarly Schrage (1998) argues that collaboration is an "act of shared creation" which involves "two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed who could have come to on their own".

Oseland *et al* (2011) in their *Interaction-Innovation Cycle* note that "if the same or other information is exchanged between two or more people, then an interaction has occurred … Colleagues may choose to collaborate and work together to further extend their knowledge. Through a combination of collaboration, sharing of knowledge, and through personal reflection and insight, new ideas may then be created which go beyond existing knowledge". The notion of shared goals and joint creativity means that collaboration goes beyond basic interaction.

Based on his observations of large organisations, Schrage (1998) proposed that most organisations actually do not have the conditions in place to support people working together to achieve a common goal and therefore diluted notions of "teamwork" often mask genuine

attempts at collaboration. The need for trust to foster collaboration is a well-documented basic condition. For example, Cohen & Mankin, (1998) note that in conflict resolution research "collaboration involves personal relationships between people … it involves willingness to trust someone enough to work through a conflict". Similarly, Jarvenpaa, Knoll & Leidner (1998) note that "collaboration is a social process and trust is an important contextual factor for both collaborative and virtual relationships"; the conditions for virtual collaboration are explained in more detail later.

Heerwagen *et al* (2004) explain that "researchers differentiate between 'team' and 'group' work. In general, teams have a high degree of interdependence between members, a specific goal that all are working toward and the need for frequent coordination among actions, responses, activities and tasks ... Teams work jointly to solve problems, develop plans, discuss new ideas, coordinate efforts and deal with emerging crises ... Teams benefit from co-location, which aids on-going interaction, information sharing, crisis management and spontaneous meetings. In contrast, work groups tend to rely more on individual tasks that are integrated at specific points … their interactions are largely electronic or take place in scheduled meetings". The notion of a team is therefore fundamental to collaboration and its development goes beyond creating points of interaction.

In conclusion, effective teams are characterised by trust and collaboration, and "essentially collaboration is about creating a community. Collaboration should engender the commitment and trust essential to knowledge working" (Davies, 2010). So, building trust through building a community, interaction and socialising is important for nurturing collaboration. Management guru Tom Peters (1992) once commented "while we fret ceaselessly about facilities issues such as office square footage allotted to various ranks, we all but ignore the key strategic issue – the parameters of intermingling". Therefore whilst collaboration is more complicated than interaction *per se*, interaction helps build trust and is therefore a prerequisite for true collaboration.

4.0 Personality, behaviour and teams

The focus of this paper is on the implications of psychological factors, primarily personality, on the design of collaboration space. It is well understood that personality is derived from *persona* which is Latin for "mask" – this etymology implies that personality is the mask we present to the world. In contrast, there is no consensus amongst psychologists on a single all-encompassing definition of personality (John, Robins & Pervin, 2008); this is partly due to the many different approaches to personality theory and breadth of the subject area. However, in the literature (e.g. Pervin, 1980 and Jonnson, 2006) there are several reoccurring elements of personality which are captured in the following definition:

> An individual's unique set of traits and relatively consistent pattern of thinking and behaviour that persists over time and across situations.

It is recognised that many factors influence personality including heredity, culture, family background, a person's experiences through life, and even the people they interact with. As a consequence of these factors and the core elements of personality, it seems that personality is stable but not fixed. Personality is a bias towards particular traits (characteristics) that in turn affect behaviour. This embedded proclivity for behaving in a particular way means that it is also likely that people have a preference for and seek out environments that support their natural mode of behaviour and underlying personality.

Upon starting this study, one hypothesis mooted was that by determining the personality of team members we could in turn understand the best environment required to support their

collaboration. The flaw in this hypothesis is that it assumes that all team members will have a similar personality allowing a single ideal collaboration space to be created.

Much research has been carried out comparing the performance of teams where the members have either similar personality profiles (homogenous group) or quite different personality profiles (heterogeneous group). Research has shown that different personalities are better at different tasks, for example extroversion (the most fundamental personality dimensions) is good for creative tasks but can be detrimental for more routine tasks. Heterogeneous groups convey a more varied style of problem-solving and interact more; furthermore they discuss alternative solutions, devise more creative ideas, and are found overall to be more effective (Rutherfoord, 2006).

It has been found that high cohesiveness, through homogeneity, can also lead to "groupthink". This is when team members shut themselves off from outsiders with conflicting views and develop an unrealistic sense of righteousness and blinkered views and solutions (Janis, 1972). In contrast, heterogeneous groups challenge each other but are more likely to develop a more unique, effective and creative solution. In conclusion, Briggs, Copeland & Hayes (2006) surmise "a heterogeneous mix is actually preferable in most organizations".

5.0 Personality theories

5.1 Origins

Personality theories possibly date back to ancient Egypt or Mesopotamia but the Greek physician Hippocrates (circa 400 BC) is recognised as developing the first structured theory of personality. He proposed that different personality types are caused by the (in)balance of bodily fluids, termed the four humours. Galen (circa 150 AD) refined Hippocrates' four humours as the four temperaments. Together they believed that phlegmatic (or calm) people have a higher concentration of phlegm; sanguine (or optimistic) people have more blood; melancholic (or depressed) people have high levels of black bile; and irritable people have high levels of yellow bile. Interestingly, these Greek categories are still sometimes used today to describe personality characteristics, for example see the super-trait theory of Eysenck & Eysenck (1975) overleaf. Furthermore modern-day neuropsychologists acknowledge that the presence of certain chemicals in the brain affect mood and behaviour, so the notion of bodily fluids affecting behaviour is not as bizarre as it initially sounds.

5.2 Psychoanalytical theories

The next significant stage on the development of personality theories was the turn of the 20th century. Sigmund Freud was a psychoanalyst that developed the psychodynamic theory of personality. Freud highlighted the influence of unconscious factors, our past experiences and our libido, i.e. sexual drive, on behaviour. However, Freud's theories have been criticised as pseudo-scientific and even sexist, and there are mixed views amongst psychologists of the current relevance of his work.

One of Freud's critics was Carl Jung, an analytical theorist, who developed his own psychodynamic viewpoint. Jung emphasised the future and the unconscious even more so than Freud but without a strong emphasis on sexuality. He also developed the idea of the collective conscious, which is the belief that all people have the same basic patterns of behaviour. Of more significance, was that Jung grouped people into two broad types based on their general attitude namely introverts and the extroverts. Jung considers an attitude to be a person's predisposition to behave in a particular way. Categorising personality on an extroversion scale has influenced most subsequent theories of personality and is still very much referred to in organisational psychology and business management theory.
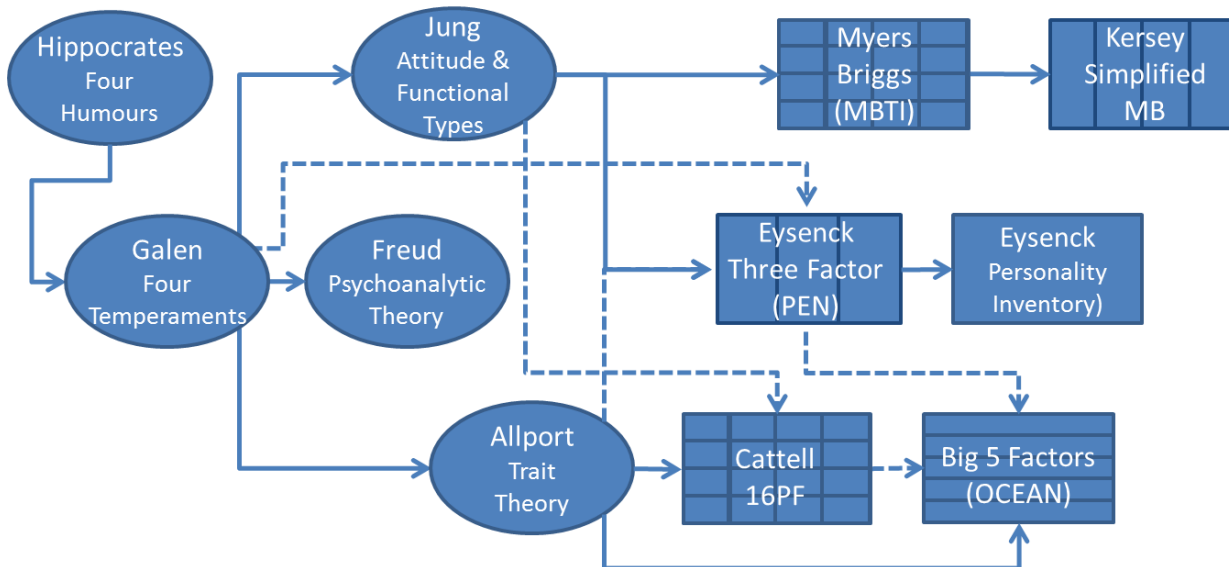
Figure 2. A historical perspective of the development of modern personality theories

5.3 Trait theory

As an alternative to psychodynamics, another approach to understanding personality was to identify and describe it in terms of traits, or characteristics. The problem with trait theory is there are so many descriptors of personality that it is difficult to make sense of them. For example, Allport & Odbert (1936) conducted a lexical approach to the dimensions of personality and initially found some 17,953 related descriptors. However, they went on to reduce this gigantic list down to 4,504 personality traits. Around the same time a group of psychologists began using new statistical techniques to develop personality theories. Cattell managed to reduce Allport & Odbert's list down to 171 descriptors and through further research, including factor analysis, he developed a model of personality describing 16 trait dimensions (Cattell, 1947). He later developed the Sixteen Personality Factors (16PF) questionnaire to measure these traits.

Eysenck's (1967) two super-traits model is derived directly from Jung's theories and even refers to the four temperaments of Hippocrates and Galen (Figure 3). However, the model is also a rebuttal to Cattels' 16PF model which Eysenck thought had too many superfluous dimensions. So he proposed two personality dimensions: extraversion (E) and neuroticism (N). Full extroverts and introverts sit on opposing ends of the extroversion dimension: an "extrovert is a friendly person who seeks company, desires excitement, takes risks, and acts on impulse, whereas the introvert is a quiet, reflective person who prefers his or her own company and does not enjoy large social events" (Eysenck & Eysenck, 1975). Neuroticism is a dimension of emotional stability that ranges from fairly calm and collected people to ones that experience negative emotional states such as anxiety and nervousness. Psychoticism (P) was added to the model following collaboration between Eysenck and his wife resulting in the three factor (PEN) personality theory.
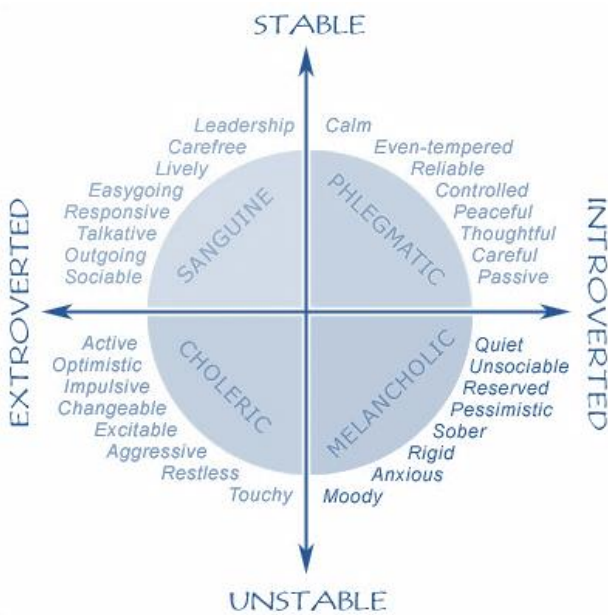
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Figure 3. Eysenck's super-trait mode of personality

5.4   Myers Briggs Type Inventory (MBTI)

Regardless of whether people are introverted or extroverted, they need to cope with the world and will have a preferred way of doing this. Jung suggested there are four basic ways of coping, termed functions, and when combined with one of his two attitudes they form eight different personality types. The sensing (S) and intuition (N) function relates to the way individuals perceive and acquire information. Sensing individuals carefully examine information and employ all of their senses in their investigations; whereas those who are intuitive rely more on their instincts and gut-feeling. The two functions related to reaching decisions are thinking (T) and feeling (F). Thinkers are objective, analytic and logical, and consider facts in reaching conclusions; in contrast, feeling individuals are subjective and consider how their decisions will impact others.

| | | Sensing (S) | | Intuitive (N) | |
		Thinking (T)	Feeling (F)	Feeling (F)	Thinking (T)
Introversion (I)	Judgemental (J)	Traditionalist/ Inspector (ISTJ)	Protector (ISFJ)	Guide/ Counselor (INFJ)	Visionary/ Mastermind (INTJ)
	Perceptive (P)	Problem-solver/ Craftor (ISTP)	Harmoniser/ Composer (ISFP)	Humanist/ Healer (INFP)	Conceptualist/ Architect (INTP)
Extroversion (E)	Perceptive (P)	Activist/ Promoter (ESTP)	Fun-lover/ Performer (ESFP)	Enthusiast/ Champion (ENFP)	Entrepreneur/ Inventor (ENTP)
	Judgemental (J)	Co-ordinator/ Supervisor (ESTJ)	Supporter/ Provider (ESFJ)	Developer/ Teacher (ENFJ)	Reformer/ Fieldmarshal (ENTJ)

Figure 4. Myers Briggs personality types

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Myers & Briggs (1987) elaborated on Jung's personality theory by adding a function which indicates the manner in which people interact with the environment. Judgers (J) prefer an organised, stable environment and strive to regulate their lives, whereas, perceivers (P) are flexible and spontaneous preferring to stay open to new opportunities. Adding these dimensions to those of Jung creates a 4 x 4 matrix of functions resulting in sixteen personality types (Figure 4). The table identifies the sixteen personality types, usually referred to by the dimension acronym, and common descriptors (stereotypes) for the types.

Table 1 shows the implications of the four extremes of the MBTI functions on communication style and collaboration space. These conclusions are based a literature review and drawing inferences from research into personality and research into collaboration.

Function	Implication
Extroversion – focus on the outer world of people and activity.	Prefer F2F and socialising, large social groups plus impromptu, informal, off-site meetings.
Introversion – focus on the inner world of ideas and impressions, listeners.	Prefer written communications, distributed information, small groups and teleconferences.
Sensing – take in information through the five senses and focus on the here and now.	Prefer information and detail, plus planned and minuted meetings.
Intuition – take in information from the big picture, focus on the future.	Prefer graphics and concepts, group brainstorms, and F2F meetings.
Thinking – make decisions based primarily on logic and on objective analysis.	Prefer data and lists, plus like to challenge and discuss at meetings.
Feeling –decisions based on values and subjective evaluation of people concerns.	People focussed so prefer, F2F informal, cosy, chatty and 1:1 meetings.
Judging – a planned and organised approach to life and like to have things settled.	Prefer local planned, chaired and minuted meetings.
Perceiving – like a flexible and spontaneous approach to life keeping options open.	Prefer local, impromptu, informal, and convenient meetings.

Table 1. Myers Briggs personality functions

The MBTI, and its corresponding personality types, is popular in modern business management. For example, the MBTI is used for evaluating and developing teams, and for improving communication between different personality types. However, like the 16PF it has been criticised of having too many distinct personality types. Kiersey (1988) simplified the MBTI and attributed four basic outlooks to the sixteen types (se Figure 4): Artisans (SP in red) are in the moment, fun, mentally agile, unconventional and make an impact; Guardians (SJ in gold) are cooperative, diligent, responsible and like to belong; Idealists (NF in blue) are imaginative, individualists and seek meaning; Rationals (NT in green) are problem solvers, acquiring knowledge and mastery.

5.5 The Big Five

The Big Five, or Five Factor Model (FFM), is the most recent well known methodology for determining personality profiles. Its increasing popularity is due to the manageable number of personality traits, the practicality of its relatively short questionnaire, the robustness of the approach across time and cultures, and that the five factors were determined by a number of psychologists conducting research independently and in parallel. The initial model was originally developed by Tupes & Christal in 1961 but did not gain popularity until the 1980s, mostly due to the work of Costa & McCrae (1992).

The Big Five has its origins in trait theory verified by statistical analysis. The researchers all began by studying known personality traits and then used factor analysis on hundreds of measures of these traits in order to find the underlying five factors of personality. The Big Five factors are Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism, often referred to as OCEAN (or CANOE). Interestingly, Eysenck's dimensions of extraversion and neuroticism are both included in the FFM.

- *Openness (to experience)* – reflects the range of interests and fascination with novelty; open people are creative, curious, and artistically sensitive whereas those not open are conventional and like the familiar;

- *Conscientiousness* – reflects a measure of reliability; a highly conscientious person is responsible, organised, dependable, and persistent whereas unconscientious or undirected people are easily distracted and unreliable;

- *Extraversion* – reflects the comfort level with relationships; extraverts tend to be gregarious, assertive, and sociable in nature, whereas introverts tend to be reserved, reflective, and quiet, preferring their own company;

- *Agreeableness* – reflects an individual's tendency to defer to others; highly agreeable people are cooperative, affectionate, and trusting whereas others are disagreeable and antagonistic;

- *Neuroticism (emotional stability)* – reflects a person's ability to bear up stress; people with positive emotional stability tend to be calm, self-confident, and secure whereas the more neurotic are nervous, anxious and insecure.

Reilly, Lynn & Aronson (2001) note the key contributions of the Big Five to collaborative tasks. Table 2, overleaf, provides a description of the five factors along with the potential implications for communication style and collaboration spaces.

6.0 Other psychological factors

This paper has primarily focussed on the effect of personality on collaboration. However, there are many other psychological theories that impact on how we interact, collaborate and use space. For example, see Oseland (2009) for a review of the implications of psychological and personal factors on the design of office space, and see Heerwagen *et al* (2004) for a review of the social aspects of "collaborative knowledge work environments".

Environmental psychology is the field of psychology that explores the interrelationship between people and their physical settings. Early psychologists believed that behaviour is simply a deterministic response to the physical world, but Lewin (1943) proposed behaviour is a function of the person as well as the physical environment such that individual experiences will affect how people interact with and behave in a space. Later Barker (1968) introduced the notion of behavioural settings where pre-conceived ideas of a particular space unconsciously influence the behaviour in that space, for example consider the normal behaviour in churches and libraries. It therefore follows that our personal experiences and expectations of various interaction spaces (formal meeting room, breakout, war room, café) will affect how we behave in them and potentially impact on the commitment to collaboration. From a practical perspective the design and layout of the space will act as a visual clue of the activities usually expected to occur in it. The inclination to behave in a space based on its design and preconceptions may possibly help overcome any inhibitions due to primary personality traits and allow other dormant or submissive traits to break through. For example, although introverts may not have a natural leaning towards funky brainstorming areas, once in them they may be encourage to be more social and vocal.

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Implication for task performance	Implication for collaboration
Openness (to experience) vs Not Open Evidence supports the importance of openness for creative and imaginative tasks but suggests that openness is less important, or even detrimental, when the task is of a more routine nature.	**Open** people prefer F2F meetings, brainstorming, plus stimulating, different and new spaces. **Not open** people prefer formal, familiar, conforming and traditional spaces.
Conscientiousness vs Undirected Should be positively related to team performance across a wide variety of tasks and settings,	**Conscientious** people prefer planned, formal, well-organised, minuted meetings. **Undirected** people prefer impromptu and informal meetings, idea generation, and quick interactions.
Extraversion vs Introversion Extraversion is related to team performance when tasks involve imaginative or creative activity but may inhibit performance when tasks call for precise, sequential and logical behaviour.	**Extraverts** prefer F2F and socialising, large social groups plus impromptu, informal, off-site meetings, and stimulating spaces. **Introverts** prefer written communications, distributed information, small groups, teleconferences, and subdued spaces.
Agreeableness vs Antagonism Agreeableness may be important for performance in long-term teams with tasks that involve persuasion, or other socially related dimensions; when tasks do not require a high degree of social interaction, agreeableness may actually inhibit performance.	**Agreeable** prefer large meetings with structure and distributed information to help gain group consensus. **Antagonistic** prefer unstructured F2F meetings where they can challenge/derail.
Neuroticism vs Emotional Stability The level of emotional stability in the team correlates with team performance for a wide range of tasks.	**Neurotic** people prefer well-planned formal meetings with advance notice and information; also subdued environments. **Stable** people are comfortable with large, impromptu or informal meetings.

Table 2. The Big Five personality factors implications for performance and collaboration

Much of the environmental psychology research has focused on aspects of space such as territoriality and privacy. Osmond (1957) introduced the term sociofugal space, a space designed for social interaction, and sociofugal space, which discourages social interaction. This categorisation applies to the layout of buildings where sociopetal layouts stimulate interaction as routes merge and overlap but, in contrast, buildings with lots of enclosed space, corridors and little common space may be considered sociofugal. Another basic application of this theory is how a room is designed and arranged for different types of interaction. For example, breakout spaces that do <u>not</u> offer some level of privacy, drinks, comfortable seating or a pleasant design are sociofugal and will discourage interaction. Seating arrangements also appear to influence the interaction patterns of the group, for example participants of a group generally welcome one into the group by repositioning themselves to form a circle thereby including the new member. In contrast, Steinzor (1950) observed that people will reposition themselves to avoid interaction with specific individuals; he also found that individuals in a circular seating arrangement interact more with individuals opposite rather than adjacent. It was also shown that more conversation occurs among people seated closer together and facing one another.

Oseland (2009) notes that environmental psychologist Irwin Altman (1975) "brought the various theories of personal space, territoriality and crowding together into one unifying theory. Rather than regard privacy simply as a state of social withdrawal, he conceptualised privacy to be a dialectic and dynamic process for controlling the level of availability to others. By 'dialectic'

Altman means whether people are actually seeking or avoiding social interaction, and by 'dynamics' he means that the desired level of interaction varies according to individual differences and circumstances over time. Altman proposed that not achieving the desired level of privacy will result in discomfort and stress with too little privacy leading to feelings of overcrowding and too much privacy creating social isolation". Fayard and Weeks (2005) found that privacy is a condition for interaction (and so in turn collaboration). Altman tells us that personality factors such as extroversion will affect perceived privacy. So interaction spaces will require different levels of privacy to cater for different personality types, for example introverts may prefer to interact and collaborate in more private spaces. Virtual collaboration such as video- and web-conferencing provides more control over the level of interaction, so better privacy, which will appeal to the more introverted.

Evolutionary psychology is one of the newest fields of psychology and proposes that innate human behaviour is governed by adaptations of psychological processes which evolved to aid our survival and well-being. Man has spent relatively little time as a knowledge worker, compared to the eons spent as a hunter/gatherer, and it could be argued that our psychological processes are more evolved to "working" out in the African Savannah than sitting in an office. The implications of evolutionary psychology relate more to creating comfortable and productive work spaces but the general principles also apply to fostering collaboration.

Oseland (2009) summarises the key themes and principles of evolutionary psychology:

- biophilia is a tendency to be affiliated with life and the natural environment, and this is why people sometimes feel refreshed after sitting in a more natural environment;

- our affinity with nature means that people like daylight, natural ventilation and a clear connection to the outside world and greenery;

- people also prefer noise to be at a similar level to that found in the natural world, with a slight buzz of activity and not too quiet or noisy;

- we seek places that support social gathering where they can share stories and food (the hearth mentality) but we also seek private spaces to simply relax and restore;

- humans are inquisitive animals that like to explore and forage, varying their sensory stimulation rather than remaining static;

- our sense of direction is based on natural clues such as the sun and landmarks, and people like to be able peruse what is around them and have a clear view of all directions.

The design implications for evolutionary psychology are self-explanatory, but nevertheless many offices would fail to meet these basic psychological needs. Providing spaces with good daylight, views to the outside world, refreshments, stimulating environments will all enhance natural interaction and help collaboration.

7.0 Virtual collaboration

The increasing globalisation of organisations, and business initiatives such as off-shoring, may lead to team members being more dispersed resulting in a decrease in face-to-face interaction and an increase in virtual, collaboration. The effectiveness of an organisation is based on how quickly teams can come together to respond to changing business needs (Cohen & Mankin, 1998) and if this coming together cannot be quickly achieved physically then it will happen virtually. Much research has therefore been conducted on the performance and effectiveness of virtual collaboration. From a psychological perspective the research has focussed around how different personality types use social media and how teams communicate and behave in face-to-face interactions.

Research has shown that introverts may suffer from Communication Apprehension, "an individual's level of anxiety associated with communication with another person", which increase in face-to-face situations. In contrast, other research has shown that extroverts excel at promoting face-to-face interactions. It is therefore expected that whilst gregarious extroverts relish face-to-face interactions, introverts prefer to communicate through alternative means such as email, text, social network sites and other software applications. Surprisingly then, some studies discovered that extroverts use social networking sites such as Facebook more than introverts. However, some researchers suggest this is because extroverts generally seek more interaction than extroverts regardless of whether it is on-line or face-to-face. More detailed studies that explored the content of the interactions on social media found that introverts do indeed use online interactions as a replacement for face-to-face ones, behaviour that psychologists have termed Social Compensation Theory. It therefore follows that in team collaborations, extroverts will prefer face-to-face interactions whereas introverts prefer written communications. Introverts may also feel more comfortable with teleconference calls where they are not directly face-to-face, but they may be quieter, less interactive, in large group teleconference calls. Web-conference (Webinar, WebEx) applications may provide a good balance of data and voice for introverts participating in virtual collaborations.

Studies comparing the performance of virtual and co-located teams found that virtual teams tend to be more task oriented and exchange less social information than co-located ones (Walther & Burgoon, 1992, Chidambaram, 1996). The researchers suggest this would slow the development of relationships and strong relational links have been shown to enhance creativity and motivation. Other studies conclude that face-to-face team meetings are usually more effective and satisfying than virtual ones, but nevertheless virtual teams can be as effective if given sufficient time to develop strong group relationships (Chidambaram, 1996). This research implies the importance of facilitating social interaction in the workplace, and between team members (virtual and co-located) when the team is initially forming. Hua (2010) proposes that repeated encounters, even without conversation, help to promote the awareness of co-workers and to foster office relationships. McGrath (1990) recommends that in the absence of the ability to have an initial face-to-face meeting other avenues for building strong relationships are advised to ensure the cohesiveness and effectiveness of the team's interaction. So although interaction alone is not a sufficient condition for successful collaboration, it does indirectly support collaboration.

Nova (2005) points out that physical proximity allows the use of non-verbal communication including: different paralinguistic and non-verbal signs, precise timing of cues, coordination of turn-taking or the repair of misunderstandings. Psychologists note that deictic references are used in face-to-face meetings on a regular basis, which refers to pointing, looking, touching or gesturing to indicate a nearby object mentioned in conversation. Newlands *et al* (2002) analysed interactions of two groups performing a joint task in either face-to-face or a video conference system. They found that deictic hand gesture occurred five times more frequently in the face-to-face condition the virtual interaction. More recent research has found that extroverts gesticulate for longer and more often in meetings than introverts (Jonnson, 2006). Barbour and Koneya (1976) famously claimed that 55 percent of communication is non-verbal communication, 38 percent is done by tone of voice, and only 7 percent is related to the words and content. Clearly non-verbal communication is a key component of interaction and virtual interaction systems need to replicate this basic need, especially in the early stages of team forming or when the team consists of a high proportion of extroverts.

The physical co-location of teams also facilitates collaboration. A seminal piece of research carried out by Allen (1977) demonstrated that the probability of two people communicating in an organisation is inversely proportional to the distance separating them, and it is close to zero after 30 metres of physical separation. Furthermore, proximity helps maintain task and group awareness, because when co-located it is easier to gather and update information about the task performed by team members (Dourish & Belloti, 1992).

A recent survey of workers at highly collaborative companies (Green, 2012) found that most "collaborative events" are short (with 34% lasting fewer than 15 minutes) and the majority take place at the desk. It is likely that these impromptu interactions relate to sharing information (perhaps on the PC) or answering queries rather than lengthy intense discussion and development of joint ideas. Interactions at desks may facilitate tacit knowledge sharing by overhearing relevant conversations between team members, but such interactions can also be considered a distraction if not relevant. Indeed the researcher observes "people seek out meeting spaces when they need more privacy or different tools or because they are worried that the meeting will take long enough that it will constitute a real disruption to colleagues around them".

8.0   Designing spaces for collaboration

8.1   General design principles

A comprehensive review of the social science literature (Fayard & Weeks, 2005) revealed several general conditions for creating successful interaction and collaboration spaces, regardless of the personality of the users:

- *Proximity* – as the frequency of all forms of communication decreases over distance, the proximity of spaces for interaction is of utmost importance;

- *Accessibility* – ease of accessibility and the known availability of spaces for interaction is key, they need to be conveniently located with appropriate visual access and easily located;

- *Privacy* – interaction spaces should provide a sense of perceived visual and aural privacy, which does not necessarily mean that full enclosure is required for privacy;

- *Legitimacy* – people need a valid reason for being in the space where interactions may take place, e.g. a copy/print area or stairwell/corridor;

- *Functionality* – the layout of the furniture, equipment provided, environmental conditions, amenities, and capacity all impact on the suitability for different types of interaction.

Hua *et al* (2010) identified three categories of collaboration space, each of which offer a high level legitimacy and varying degrees of functionality, see Table 3. Coffman, Smethurst & Kaufman (1999) categorise collaboration spaces according to their functionality, in particular how they support sharing real time information or facilitating creativity.

Legitimacy based categorisation (Hua *et al*, 2010)	**Functionality based categorisation** (Coffman, Smethurst & Kaufman, 1999)
Teamwork-related include conference rooms, formal settings, open meeting areas, and team rooms in which groups have priority.	**War rooms** represent attempt to improve the collaboration between people and real time information.
Service-related spaces refer to shared service areas in which copiers, printers, and other shared office equipment are located.	**Creativity centres** where play, visualisation, and out-of-the-box activities create lateral shifts in thinking.
Amenity-related spaces include kitchens, coffee areas, and lounges.	**Collaboration centres** hold the middle ground, a balance of the need for creative thinking and access to real time information.

Table 3. Categorisation of collaboration space

Fayard & Weeks do not mention aesthetics in their general principles of interaction spaces. For example, much research has been carried out on decoration and colour and how it affects mood, inspiration and performance. The results of such research is contradictory, possibly because much of it takes a simple stimulus-response (architectural determinist) approach and ignores the impact of personal factors and the task being carried out. For example, Mehta and Zhu (2009) point out that "some research suggests that blue or green leads to better performances than red; other studies record the opposite ... We demonstrate that red enhances performance on a detail-oriented task, whereas blue enhances performance on a creative task". That introverts are usually better on detail-orientated tasks and extroverts on creative ones will undoubtedly affect the results and colour preference.

Acoustic design may be considered more of a functional than aesthetic design principle but it is worthy of note. Much research has been conducted on the impact of noise on task performance, notably by Donald Broadbent (1958). Broadbant's research is grounded in *Arousal Theory* which postulates an inverted U-shape relationship between arousal (excitement) and performance. The theory states that people can perform better if they are stimulated or motivated (which increases their level of arousal) but only up to a limit as too much stimulation can lead to stress and thus reduce performance. Furthermore, extroverts have a low natural level of arousal and therefore naturally seek excitement whereas introverts have a high level of arousal and prefer the quiet life.

As a consequence, stimulating environments with vibrant colours, music or noise, and a buzz of activity may enhance the performance of extroverts but more calming environments will better suit introverts. For example, Graetz (2006) reported research which found that noise appears to slow reaction time and degrade learning performance in introverts more than it does extraverts. Research has also shown that complex tasks increase our level of arousal and thus may be better done in calm environments whereas mundane repetitive tasks may benefit from a stimulating environment. The design trick is to provide the correct balance of stimulating (noisy or colourful) interaction spaces versus calm (quiet and subdued) ones to support different personalities and tasks.

Personality type	Task	
	Simple	Complex
Introvert	Calming	Very calming
Extravert	Very stimulating	Stimulating

Table 4. Preferred environment by personality and task

Anthropologists and psychologists make a distinction between space and place. Erickson (1993) concludes that "place is space with meaning", space becomes a place when it has acquired meaning as a result of human activity and built up a history of experiences. Yates (1969) suggests that one of the most important roles of space is its use as memorial structure where people remember a list of elements by attaching each to a specific location. Designing spaces so they are distinct landmarks may therefore assist the recall of events and action in interactions. Graetz (2006) research on students found that "environments that elicit positive emotional responses may lead not only to enhanced learning but … may become a place where students seek out when they wish to learn, and a place they remember fondly when they reflect on their learning experiences" – the same effect might apply to team collaboration spaces.

8.2   Space planning and layout

The research Fayard and Weeks and others, above, stresses the importance providing a range of spaces for collaboration that are close to the team. These spaces do not all need to be dedicated collaboration spaces but can be other legitimate and accessible spaces for interaction (and intermingling) such as service and amenity spaces. Brager *et al* (2000) suggest that innovation thrives on all sorts of interaction so we should "increase opportunities for spontaneous encounters ('casual collisions') through the use of internal 'streets' and 'neighbourhoods' with cafes and coffee bars". Good interaction spaces should offer the appropriate level of privacy, which will depend on the content of the interaction and the personality. Interaction spaces do not need to be totally enclosed but in addition to open and public breakout spaces and cafes etc we need to provide semi-hidden spaces which are slightly remote from the main team area e.g. "nooks and crannies". Green (2012) reminds us that behavioural norms are as important as the deign of the spaces: "people must feel they have permission to linger in informal collaborative areas and that comes from watching how other people, especially managers and executives, use or ignore those areas".

However, these interaction nodes alone are not sufficient for collaboration and dedicated collaboration spaces, with good functionality and privacy, are required such as teamwork, project and war rooms. Indeed Brager *et al* (2000) also argue that "teams need 'team spaces' because team members need to meet frequently, and often in unplanned sessions, facilities should devote more space to group work areas and group tools and should have team members co-located to enhance ease of meeting". They propose that an increase in space devoted to teamwork will decrease reliance on the personal workspace and ultimately lead to the demise of the private office.

Hua & Loftness (2010) conducted original research on the preferences for collaboration space and, in particular, the location of such spaces in the office. They recommend that uniformly distributed clusters of shared spaces, i.e. local hubs, are provided rather than banks of centrally adjacent spaces. However, from a practical point of view central banks of collaboration spaces are likely to have better functionality and be better managed and maintained than local spaces. A balance is required of distributed nodes for spontaneous interaction, local hubs for team collaboration plus central resources for planned (client) presentations and internal training.

Interaction and collaboration spaces need to be accessible. If a variety of spaces are provided around the building, then they need to be easily identified and found. Adopting good way-finding techniques based on the psychological principles of Tolman (1948), locating rooms at key nodes and providing clear labelling will all improve accessibility.

The research on personality, reviewed earlier, indicates that introverts are less comfortable with large group meetings than one-to-one interactions. Like their conscientious and neurotic colleagues (or sensing and thinking types according to Myers Briggs) they also prefer time to think things through and develop their ideas before sharing them publically. The participation in collaboration of these personality types might therefore be enhanced by providing more discrete and private spaces adjacent to the main collaboration space, where one-to-one interactions can naturally and quickly take place after the more formal meeting. Evolutionary psychologists note the importance of sharing food and drink, and Peters the importance of intermingling, so these spaces could be nearby coffee/vend/breakout interaction points.

8.3   Furniture and flexibility

The literature review confirmed that the furniture arrangement will affect how a team interacts with each other. The space and furniture therefore needs to easily reconfigurable to support different types of interaction e.g. one-to-one meetings, small group work or larger brain-storming sessions. Introverts and neurotic team members are likely to prefer more private,

cosier and one-to-one settings than their gregarious counterparts. Organisational structure and project teams are constantly shifting in organisations, thus the space also needs to be adaptable to meet the needs of new teams as well as changing team requirements.

The formality of the space has been shown to affect the depth of interaction and different personality types may prefer different levels of formality. Tischler (2010) recommends mixing up seating options by perhaps taking the table out of the room or varying seat heights, and creating cosy nooks for teams. The collaboration spaces will also need to be sufficiently sized to allow for a change in layout; they should also be appropriately shaped as, for example, long-thin rooms are not good for interaction. Furthermore storage areas may be required for the different (portable) furniture styles unless the furniture itself is readily adaptable.

8.4   Display of information

Several researchers have observed that collaboration involves capturing and displaying ideas and so designers need to acknowledge the importance of providing a means of generating, capturing and displaying information within collaborative teams. For example, Schrage (1998) comments that "there needs to be a space – physical or electronic – where the ideas and symbols are displayed and shared so that everyone can participate on an equal footing" and Brager *et al* (2000) recommend "displayed thinking spaces to make ideas visible to all". Yates (1969) goes on to say that one of the most important roles of space is its use as memorial structure – he considers space to be a powerful organiser of memory. In terms of personality types, those of an introverted and conscientious persuasion (or sensing and thinking types) are likely to appreciate the display of information more than their extroverted and disorganised (or intuitive and feeling) counterparts.

Some might argue that any non-porous surface could be designed as a whiteboard and used for capturing information (Tischler, 2010). Whole whitewalls can be created relatively inexpensively using magnetic vinyl sheeting and will provide more display space and versatility than whiteboards. Furthermore, filing cabinets can be clustered together and fitted with a top to provide layout space for sharing drawings and other large format information. Furthermore, inexpensive flat screen panels can be fitted in breakout spaces and team areas to provide a continuous display of rolling, historic or real time, information for one or a number of teams.

Ross (2011) reported that "research from Washington University has found that dedicated project rooms which allowed 'displayed knowledge' resulted in 'latent memory' and "in another study, a leading technology company found that providing dedicated project rooms to software teams accelerated development time by a factor of 10". However, it is not always practical or considered space efficient to provide dedicated project rooms for teams, especially if they are not utilised for the majority of the working week. One solution to this is to provide layered display boards in the project room so that the room may be used by multiple teams who can bring their displays to the front when using the spaces. An alternative (more expensive) technological solution is to provide multiple flat screens or projectors for displaying a team's information.

8.5   Technology

To facilitate virtual collaboration, the latest video-conferencing suites simulate face-to-face interaction much better than their predecessors, and this new technology is becoming more affordable (especially when considering savings in travel cost, time and carbon). Green (2012) found that "rooms with technology tools are used five times more often than rooms without; people are increasingly using flat screens as a collaborative tool, rather than just for presentations".

On a smaller scale new personal technology, such as Skype on laptops and FaceTime on phones, means that some elements of face-to-face meetings are now available anytime and anywhere for one-to-one interactions. Lomas, Burke & Page (2008) group these new tools based on the activities and opportunities they enable, including: immediacy, enhanced voice and ambient communications, image sharing and document construction, social interaction and geographic richness.

The importance of sharing information in collaborative teams, particularly for introverted, conscientious (or sensing and thinking) types has already been raised. Whether co-located or virtual, collaboration spaces require seamless and intuitive technology so that information can be captured and shared. At minimum the spaces require essential basic audio-visual equipment such as display panels and teleconference phones , plus ample power and data points (preferably wireless broadband) all with well-designed controls and sufficient instruction in how to use it.

A current trend is to use under-utilised staff restaurant spaces for meetings outside of the lunch period. Small group meetings are facilitated by providing semi-private banquette seating and the performance of these meeting booths may be enhanced by providing power and data ports and possibly an inbuilt display screen.

9.0   Conclusion

Personality refers to an individual's characteristics that lead to a relatively consistent pattern of behaviour. Our personality impacts on our preferred means of interaction and the tasks that we prefer to carry out and are particularly good at. Research has shown that the most effective collaborations are as a result of teams with a mixed group of personality types. It therefore follows that environments that support true collaboration (i.e. creating new ideas and solutions that extend beyond existing knowledge) need to recognise the different personality types and their preferred means of communication and interaction, which will ultimately contribute to successful collaborations.

Spaces for collaboration must consider how the design, layout, furniture and technology can support various modes of interaction. Key components of collaboration spaces are: continuous display areas, flexible team spaces with adaptable furniture, and providing a variety of nearby spaces which facilitate real-time knowledge sharing, creative output and social interaction. The main design challenge is providing space-efficient display and collaboration spaces that are available to the team (whether co-located or virtual) as and when required.

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