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MATERIALS MATTER: AN ANTHROPOLOGICAL STUDY OF MATERIALS LIBRARIES

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Materials Matter: An Anthropological Study of Materials Libraries

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ABSTRACT

In this paper I propose that materials have been historically marginalised within social theory, art and science. I suggest that, since the nineteenth century, there has been a renewed interest in the social efficacy and value of materials as a result of the perception that materials are becoming more functional, autonomous and person-like, and the belief in their potential to effect social change for better or worse. I propose that materials libraries can be seen as a symptom of this concern, a means by which to determine the social value of materials, and a way to control their development.

I examine and evaluate two competing methodologies that exist for determining the social value of materials: one intuitive, experiential and performative, and the other "rational", analytical, and quantitative (Ashby and Johnson 2002: 49). I also investigate the hypothesis that there are two different kinds of knowledge about materials: that of artists and scientists. I explore how materials libraries disseminate specialist knowledge in the face of a perceived divide between the arts and sciences, and the role of the arts community in controlling what are perceived as the unruly and asocial technological developments of an isolated materials science community. I propose that restricting access to materials through patents and corporate secrecy increases their value, but hinders the transfer of knowledge about them in an attempt to control increasingly autonomous materials.

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INTRODUCTION

Despite the huge and unprecedented importance of materials in the economy of the twenty-first century, historically there has been a deficit of attention amongst producers, users and anthropologists alike to their social value. Although there has been a renaissance of interest in material culture over the last two decades, anthropologists have largely ignored the social importance of materials themselves. This neglect of materials by the social sciences owes much to the dominance of conventional Cartesian or Durkheimian distinctions between society and its objects (Latour 1993, Miller 2005). Much contemporary social theory relies on the notion that the material world of dead matter is separate from and subordinate to the animate human subject. Within anthropology, the material is often seen as an inert and receptive carrier of meanings imposed or projected on it by 'society'[1].

Similarly, there has been a history of 'de-materialisation' within art theory. Following a long tradition of preferring form over matter, the role of materials within the visual arts is often taken for granted. Within the theoretical discipline and working practices of architecture, for example, the material is often seen as "inert" or "chaotic" matter, and the mere vehicle for form, the imposition of which "serves to elevate it into the lofty realm of art" (Herrmann 2006: 952). This has resulted in the relegation of materials to the "practical underside" of architecture, while the status of the architect has been lifted to a "kind of mythic form-giver" (Lloyd Thomas 2007: 5).

Mark Miodownik also describes the contemporary climate of materials science as one that is missing out on the "tactile pleasures of materials" (In Byko 2005: 64). He describes materials science departments as "places of pure deductive reason" and states:

> "It's kind of weird that materials science departments are almost empty of the materials we study…What does that say about us as a community? We are becoming more and more theoretical; we are losing touch with the more physical side of what we do" (In Byko 2005: 64).

[1] For a more detailed discussion see Wilkes 2008

However, this paper proposes that there has recently been a shift in attention towards the material. Since the nineteenth century, there has been growing recognition of the economic importance of materials. According to the Department of Trade and Industry's (henceforth DTI) Materials Innovation and Growth Team, the Materials Sector currently has a turnover of around £200 billion, employs 1.5 million people directly, supports a further 4 million jobs, and contributes 15% to the GDP (Materials Knowledge Transfer Network Newsletter 2006: 3). Materials technologies are central to UK wealth creation, and underpin many areas of economic activity, not least the 'creative industries'. However, not all material developments are successful. Philip Ball (1997: 4) estimates that there are between 40,000 to 80,000 materials to choose from when fabricating an artefact. The pace of materials innovation is incredibly fast, and as a result of the overwhelming competition involved in making a new material commercially available, many simply do not reach the marketplace.

Following Mike Ashby and Kara Johnson, this paper hypothesises that the success of a material often depends on its ability to "attract a sequence of early adopters" (2002: 158). It investigates the notion that a material's "market share is won (or lost) through its visual and tactile appeal, and the associations it carries, the way it is perceived and the emotions it generates" (2002: 2). Materials are increasingly being recognised by producers and users as socially effective objects which have the potential to arouse interest, induce satisfaction or delight, resonate with the tastes and aspirations of a user, and contribute to their 'quality of life', or conversely to be dull, uninteresting, and have negative environmental and social consequences. This paper contends that there is a great concern within the materials industry about how to recognise socially effective materials in order to ensure their commercial viability.

My fieldwork suggests that materials libraries are one symptom of this concern. Since the 1980's, these new and innovative institutions have appeared, both in the UK and abroad, which are dedicated to collecting, displaying and educating people about materials and which play an increasingly important role in the selection and use of the materials we encounter on a daily basis. They also enable both artists and scientists to physically encounter materials, to gain an understanding of them and to develop a sensitivity to their social efficacy. In general, materials libraries aim to facilitate the

creation of personal and professional networks between artists, designers, architects, artisans, materials scientists and manufacturers, bridging or at least narrowing the great divide thought to exist between the arts and sciences[2]. This betrays a common perception that at least two different forms of knowledge about materials exist, and that institutions or networks need to be set up in order to transfer this specialist knowledge between materials producers (the materials science community and industry) and materials users (the arts community).

TWO DIFFERENT NETWORKS – SCIENCE AND ARTS

One of the reasons given for the development of materials libraries is the need for people and institutions that "can bridge the communication gap between disciplines", something seen as "increasingly vital" in the face of a perceived separation of science and art as "research takes specialists deeper and deeper into their fields - unable to see any overlaps or the bigger picture" (Jo, materials librarian, personal communication). The arts and sciences are now seen as largely "separated by their different relationships with materials", but this was not always the case (Miodownik 2003: 39). Although the Renaissance saw the first cracks in a holistic approach to materials innovation, the roles of artist, artisan, craftsperson, alchemist and savant continued to be intimately connected, often overlapping in the same person, until at least the eighteenth century (Klein 2005: 226).

Miodownik argues that it was at the end of the nineteenth century that things changed dramatically, when the development of materials became "a deductive science" (2005: 507). The eighteenth and nineteenth centuries witnessed fundamental changes in the pedagogic nature of science and "what publicly constituted chemical evidence and knowledge" as a result of the advent of new tools and systems of measurement based on ideas of optical consistency (Roberts 1995: 506). Existing qualitative, regional and "sensuous" forms of knowledge were replaced by a new chemical science, championed by Lavoisier, which relied on innovative abstractions of measurement such as the metric system which were "transportable across qualitative

[2] Whilst I recognise that the divide between 'arts' and 'science' communities might be considered merely an arbitrarily enforced border (Latour 1999: 2), these are the terms used by my informants, and as such this anthropological study empathises with their 'common sense' distinction (Miller 2005: 14).

and spatial boundaries" (Roberts 1995: 505-6). As a result of this shift in the knowledge-making process, tactile, olfactory and auditory senses were increasingly subordinated to the visual, and were disciplined by the material technology in the laboratory (1995: 507)[3].

This alliance of sensual abstraction and objectivity within dominant scientific practice has led to many materials scientists being loath to consider the senso-aesthetic properties of materials in their investigations. Miodownik asserts that there are very few university materials science or engineering departments that "aim to design materials with a combination of cultural and physical properties" (2005: 506). He puts this down to what he calls the "facts not opinions" effect of materials scientists being unable to justify researching the cultural properties of materials because of difficulty quantifying them (2005: 506). There is a worry that many materials scientists have distanced themselves from the cultural aspects of materials "in order to enshrine the notion of science as a value-free activity" (Miodownik 2005: 507). A historical tradition of privileging disembodied vision over the other, 'inferior' senses has led to an association between sight, "paper tools" and the production and dissemination of objective, scientific knowledge. This, coupled with the development of materials-by-design, whereby materials are conceived through computational modelling and the manipulation of atoms, has led to a marginalisation of materials even within the laboratories that produce them.

Similarly, whereas the early craft of the mason relied on direct manipulation and mastery of materials, the Renaissance saw the beginning of the intellectualisation and dematerialisation of architecture and the 'high arts'. Pablo Miranda Carranza proposes that a command of drawing, with its connection to geometry and the "newly discovered science of perspective", separated the craft of architect from that of the mason or craftsman (2007: 153). Carranza argues that "projective technologies", such as plans, elevations, sections and other geometric artefacts that represent future constructions allow the architect to gain insight by "detachment from the plane of sensual projection" (2007: 153). These projective technologies rely on linear perspective, whose invention allowed for the representation of absent things and their

[3] For a discussion of the role of paper in disciplining the senses see Wilkes 2008: 29

translation through time and space without corruption. The form of an object can be a utopian one and need not rely on the limitations of the material world. This contributes to the notion of the architect or designer as form-giver, able to translate his or her ideas onto chaotic matter.

The legacy of the intellectualisation of the high arts can be seen in the paucity of materials education that many design, architecture and art students receive. A materials consultant at a globally renowned design and engineering firm commented that the lack of materials knowledge displayed by many practising architects was a "perennial problem" since many "just don't learn much about the practical uses of materials, their properties, how to form them, their limitations" (Duncan, personal communication). Jo, a materials librarian, commented "I have even had to explain in the past that stone is not manufactured but quarried from the earth, and that metals are not quarried in sheet or lump form but extracted from ores" (personal communication). This lack of 'technical' knowledge about materials is often expressed in terms of a lack of 'vocabulary' or a 'problem of communication': "students come in [to the materials library] with a problem to solve, but they are limited by their materials vocabulary" (Jo, personal communication).

From my observations of conversations between students and materials librarians, there also seemed to be a reliance on 2-D drawings to 'test' materials intended for use. Some students made very little distinction between their drawing of the concept and the materialised end product. One student commented, "if you draw your product…that tells you a lot about its construction" (Doug, personal communication). This demonstrates the tendency to treat materials as the last stage in a linear process of design, as a kind of afterthought, rather than an integral part of two-way interaction between material and designer. One student described the materialisation of her design in terms of the "practical difficulties that I would have to get around in order to have the object made" (Simone, personal communication). With the introduction of rapid prototyping and Computer Aided Design (CAD) technologies, many designs can be created virtually on a computer, and can be transferred to many different materials. These new projective technologies lend themselves to Platonic concepts of the demiurgic artist, designer or architect (Carranza 2007: 153).

This lack of materials education within the arts is also compounded by the fact that "this century has seen a shift in the use of materials that is like nothing that has gone before" (Ball, 1997: 4). As a result of the fast pace of innovation in materials science, we have a far greater range of materials available to us than ever before. Furthermore, industrial designers express frustration that they do not have sufficient access to information of the sort they need to understand the "personality" of a material (Ashby and Johnson 2002: 2). Whereas many technical designers have ready access to "handbooks, selection software, advisory services from materials suppliers" (Ashby and Johnson 2002: 2), there is little by way of support to help designers determine which materials will "arouse interest, stimulate and…have a personality that resonates with the tastes and aspirations" of a user, aside from 'intuition' and trial-and-error (2002: 15). Designers are faced with a "jungle of choices" that they are ill-equipped to negotiate (Ball 1997: 10). Whereas designers in the past would have drawn on their personal experiences of materials in order to make decisions about them, the sheer quantity of new materials makes this personal encounter with all available materials problematic.

A parallel can be drawn with what Gottfried Semper saw as a crisis in art and architecture in the mid-nineteenth century. He claimed that "the present has no time to become familiar with the half-imposed benefits" of new materials such as rubber and gutta-percha which can be "vulcanised and utilised in a thousand imitations of wood, metal and stone carving" (Semper In Mallgrave 2005: 541). With the discovery of new "factotum" materials, such as rubber, in the nineteenth century there was no longer a correspondence between a function and a singular material. Since the properties of rubber could be changed chemically at the micro-structural level and with no physical effort, one material could perform radically different functions. Semper was at a loss as to how to integrate a material suitable for making inflatable boats, waterproof facades for buildings and solid statues into his "system of style-generating materials" (Wagner, personal communication). He argued that this abundance of new materials "confused" the industrial and "higher arts" (ibid).

Whereas "the founders of flourishing art once had their material kneaded beforehand, as it were, by the beelike instinct of the people", the rapid pace of technological innovation in the mid-19th century meant that mid-nineteenth century architectural or

sculptural practice beheld "its materials given over to constant reassessment and re-evaluation at the whim of science, without the possibility of developing a proper style through long historical exposure to popular use" (Semper in Harrison et al. 1998: 332).

Likewise, the arts community today is confronted with an overwhelming number of materials that already have a function inscribed on them, not by generations of artists or the "beelike instinct of the people", but by materials scientists in laboratories (Semper In Mallgrave 2005: 542). The scientists, engineers and businessmen involved in manufacture play a part in determining the form, function and 'personality' of the material. As Bruno Latour states with reference to sleeping policemen, "the speed bump is not made of matter, ultimately; it is full of engineers and chancellors and law makers, commingling their wills and their story lines with those of gravel, concrete, paint and standard calculations" (1999: 190). It is not just the arts community that makes choices about what constitutes our material environment. For example, 'smart' materials designed with self-cleaning or conductive qualities already embedded in them, or synthetic skin, blood and bone that heal themselves, explode the idea of the artist's materials as raw matter; these materials are inscribed with a function at the production stage (Küchler 2008: 102). Social commentators and commentators on scientific advancement point to not only the huge number of new materials, but their autonomous nature (Leach 2005). Often what is interesting about 'smart' or designed materials is not the way they look, but their ability to change as a result of environmental stimuli, to interact with other materials, or to perform some completely new function. As one informant commented "some of these materials have so much personality that they overshadow the design" (Sophie, personal communication). Contrary to Renaissance ideas of materials as inert matter to be moulded at will by the form-giver, many new materials have form and function already embedded in them.

Despite the fear that the arts community are now faced with a bewildering number of new, unfamiliar and autonomous materials to choose from, industrial designers and artists are commonly assumed to have intuitive expertise in understanding people's sensual, tactile, aesthetic and emotional needs, and the materials that fit those requirements. Miodownik, founder of the EngineeringArt Network and Kings College Materials Library (henceforth KCML), argues that it is the arts community who have

taken up the task of "sifting through the wealth of new materials created for performance…to find the ones that match society's cultural outlook" (2005: 507). The discourse surrounding materials libraries suggests that artists are "representatives of different social understandings" of materials, who can help to set straight the course of materials development today (Leach 2005: 148). For example, in their report on the relation of the arts and humanities to science and technology, the Council for Science and Technology asserts that "scholarship in arts, humanities and social sciences…is (or can be) a way to understand the world, and to improve the human condition" (2001: 11). They contend that the arts and humanities are "concerned with a reflective and disciplined inquiry into forms of human self-understanding and…are thereby of continuing importance for the expression and communication of individual and collective identities" (2001: 12).

The idea that artists have privileged access to knowledge of how best to use materials can be seen in the wider context of a proliferation of institutionalised and funded art-science collaborations (Leach 2005). Institutions such as The Calouste Gulbenkian Foundation, the National Endowment for Science, Technology and the Arts (NESTA), the Materials and Design Exchange (MADE) and the Materials Knowledge Transfer Network (henceforth MKTN), all of which have sponsored materials libraries, are committed to cross-disciplinary fertilization between the arts and sciences. These kinds of initiatives endeavour to "make institutional spaces or foster practices within which new kinds of knowledge production can occur" (2005: 142). Leach suggests that they are driven by the belief that scientists or 'technologists' are no longer in touch with society, or with the users of the materials or technologies they produce, and that as such the materials they produce no longer serve "social needs" (2005: 147). Scientists are thought to be restricted in their understanding of the "cultural" aspects of materials, and how they will be received and used, as a result of "the very specialisation of their knowledge" (Leach 2005: 148). In view of this perceived distance between society and science, collaborations between scientists and arts and humanities disciplines, like the materials library, are seen as a way of reintroducing "social knowledge" (Leach 2005: 148).

Maine, Probert and Ashby identify the "mismatch between designers' and entrepreneurs' understanding of market needs…exacerbated by the many layers of

separation between material and end consumer" as a factor in the slow uptake of new materials (2004: 16). Materials can take as long as 20 years to reach the marketplace due to factors such as "an initially high cost invention, cost barriers to materials substitution from entrenched materials, and *insufficient knowledge of market applications by inventors*" (2004: 16, my emphasis). The concern amongst many of my informants is that materials scientists and materials users have radically different expectations and understandings of materials. My informants displayed a widespread belief that scientists and artists spoke "different languages"[4], with the implicit suggestion that this displayed their radically different ways of thinking about the material (Jo, personal communication). Alex, a materials librarian with a materials science background, explains, "the problem is that designers will talk to you about 'texture', about something that 'feels like putty'. But you'd never hear a materials scientist describe a material like that. To a materials scientist that's the surface properties of the material" (personal communication). Scientists consider the structural, chemical and electrical properties of materials to be paramount, and the sensual and aesthetic properties as secondary, whereas industrial designers, for example, need materials that "please users" and "touch them emotionally in some way" (van Kesteren et al. 2007: 41). It is thought that characteristics such as smell and feel, which contribute to the 'attractiveness' of a material are almost completely ignored by many materials developers. Ashby and Johnson assert that material development is driven by technical needs, and not by "motives of industrial design" (2002: 41). Doug, a student and practitioner of industrial design, complained that "boffins don't want to do the kind of testing of new materials required by designers like me" (personal communication).

According to discourses surrounding materials libraries, the professional and social distance between materials developers and designers has resulted in several obstacles for the burgeoning materials market. Knowledge about materials is not transferred from maker to user, and materials needs are not relayed back to the manufacturers. As a result, many materials never find a niche. The worry is that the introduction of new materials by an "isolated materials-science community holds the prospect of a further

[4] For fuller discussion see Wilkes 2008.

deepening of the rift between scientists and society" (Miodownik, Leverhulme application 2008).

MATERIALS AS DRIVERS FOR SOCIAL CHANGE

The proliferation of institutions dedicated to collecting and classifying materials is a reflection of their importance to society, and I intend to examine some of the possible reasons for this in the following section. One reason is clearly a growing recognition of the economic importance of materials. The development of materials libraries is not only about wealth creation however. There is also a rhetoric surrounding materials that establishes them at the heart of social change, with the potential to alter society for better or worse. Miller (2005: 1-45) and Keane (2005: 184) both argue that questions of morality are strongly implicated in our stance on materiality in general, and I would extend this to our stance on materials. For example, the Institute of Materials, Minerals and Mining (henceforth IOM^3) aims to "demonstrate the importance and relevance of our subject area to affect important global issues such as quality of life, wealth creation and the environment" (sic) (IOM^3 pamphlet 2008). The "quality of life" and the "future of society" are phrases used at least once in every single report on the future or aims of the materials sector that I have read. For example, the DTI Materials Innovation and Growth Team believe in the "importance of materials to quality of life and protection of the environment" (2006: 32) and the Foresight Programme asserts that it is about "preparing for the future…deploying resources in the best way possible – for competitive advantage, for enhanced quality of life and for sustainable development" (DTI Foresight Report 1999).

Similarly, many in the design community display the notion that the 'correct' use of materials in design is essential for creating beauty, quality of life and 'sustainability'. According to Ashby and Johnson, the appropriate use of materials will lead to "satisfaction and delight" amongst consumers and a long "product life" for the design, whereas "unremarkable designs with dull or inappropriate materials are…transitory; we discard them without a thought" (2002: 16). They state that design carries with it the "heavy responsibility" of ensuring products are "well-designed" (2002: 63), thereby inducing emotional attachments in people and resulting in the well-being of the consumer and preservation of the environment. They assert that "quality of life" is

enhanced by "products that satisfy" (2002: 16). Conversely, products that "create expectations that are not fulfilled, add nothing to (or even detract from) self-esteem or sense of place in society, or give no sense of satisfaction" lead to a reduction in quality of life (2002: 16). They propose that the selection of materials is central to the construction of both self and society. They also argue that the design of pleasing products encourages conservation, with positive consequences for the environment (2002: 63-67). In a subchapter entitled 'Eco-Design' they advocate that designers "create products that can be adapted and personalised so that they acquire, like a house, a character of their own and transmit the message 'keep me, I'm part of your life'" (2002: 66). This implies that the materials choices that designers make not only have economic implications, but have moral and social consequences too. The designer has the potential to be "villain and hero" (2002: 64).

This imputes a great degree of power over social change to both materials and design. Leach posits that this is because "culture and technology have become so interdependent in current perceptions" that the human project of social development seems in danger of being hijacked by an autonomous technology (2005: 143). I would argue that Leach's observation rings true in the case of materials science. With the advent of performance specification, 'smart' materials and nanotechnology, culture and technology are seen as increasingly intertwined and materials increasingly seen as autonomous from the "human project of civilisation and social development" (2005: 143).

The development of performance specification in the 1960's and designed materials in the 1980's means we can now "specify behaviour in a material rather than simply selecting it from a range" (Ball 1997: 4). Philip Ball explains that "often the application, the requirements, come first – 'I want a material that does this and that'- and the material will then be concocted, invented if you will, to meet those needs" (1997: 4). Materials development no longer follows a "linear model", but the process requires a "systems approach", with continuous feedback from design specialists into the production of materials (Bensaude-Vincent and Hessenbruch 2004: 346). Function is inscribed in materials before they leave the laboratory or producer.

I propose that this new functionality of materials is affecting our notions of the relationship between material and mechanism, and material and object, which is in turn reflected in materials libraries. All the librarians I spoke to presupposed continuity between materials and objects, explicitly, or implicitly through their treatment of their collections. One informant described the relationship as a "materials-object continuum" (Emma, personal communication). Another remarked that "modern materials are so engineered, many of them are already crossing the line of being a mini product themselves…it's very hard to separate them" (Sophie, personal communication). The same informant suggested that information about fixings, coasters and bearings was "out of date" because "now there's very little use of parts, they're considered ugly…and with rapid prototyping for example, the material is the product" (Sophie, personal communication). Whereas materials used to be thought of as the inert adjunct to form, they are increasingly considered in terms of their performance as well as their appearance. Where classificatory systems are used to order materials libraries, for example at Central St Martins (henceforth CSM), London Metropolitan and Pentagram, paper information about materials is often classified according to an interesting function or property. For example information about a thermochromic plastic might be categorised under 'Colour Change Materials', rather than using a classification based on the structure of the material, such as 'Polymer'.

Leach proposes that "although it is humans who make technology, and are thus ultimately responsible for its trajectories and implications, there is an uncontrolled aspect to technological advancement" (2005: 148). Materials are seen as more of a human creation than ever before, and yet there is simultaneously a fear that these creations will "runaway" and "become autonomous" (2005: 147). Not only are many new materials inscribed with a function, but some, including the aforementioned colour change polymers, are capable of sensing and reacting to their environment. This "technological materiality", as Küchler calls it, has the potential to "challenge the dualist definition of humanity on which science has relied for so long" (2008: 103). For example, 'smart' materials like self-cleaning glass blur the divide between subject and object, since they incorporate into the material what would once have been the job of a man with a squeegee. One of my informants commented "most

of the nano-tech materials like self cleaning glass and stain resistant fabrics have such a character that they dominate the final product" (Sophie, personal communication)

I propose that materials libraries can be seen as part of a larger project to control this proliferation of material-mechanisms and material-objects. An interesting analogy can be made with Paula Findlen's account of museums and collecting practices in sixteenth century Italy. She states that natural history was a "form of enquiry designed to record the knowledge of the world for the use and betterment of mankind" and that collecting was one way of maintaining control over an empirical explosion of materials that resulted from "wider dissemination of ancient texts, increased travel, voyages of discovery, and more systematic forms of communication and exchange" (1994: 3). I would suggest that recognition that materials have the "potential to subtly alter the infrastructure of life" (Küchler 2008: 104) comes hand in hand with a fear that they will change too much. I propose that this can be seen in the complaints of many artists and designers who feel they don't have sufficient access to materials or education about them to discover their "personality", or know how best to use them. The discourse around materials libraries asserts that they play a crucial role in the production of this kind of knowledge by bringing the arts community into contact with materials technology.

PLAY, EXPERIMENTATION AND KNOWLEDGE PRODUCTION

One of the ways in which they facilitate this is through physical experience; the KCML website states that "generating physical encounters with matter…provides an often forgotten way into this technical knowledge". One of the basic tenets of all materials libraries seems to be that people can only gain an understanding of certain material properties, such as smell, feel and sound, by "experiencing the materials directly – touching them, manipulating and interacting with them in different ways" (Miodownik in Ward 2008: 2). Engineer and materials consultant Duncan also feels that sensory experience of a material is essential for the designers and architects he works with: "to really engage in a thought process of how you use a new material you really have to see it, hear it, feel it, break it…'scratch and sniff' sessions I like to call them" (personal communication).

This idea that knowledge can be gained through practical engagement with the world harks back to early modern notions of experimental philosophy (Stafford 1994). I would contend that some materials libraries are attempting to revive this forgotten notion that touch and experiment provide "essential…means of acquiring knowledge" (Classen and Howes 2006: 201). As I discussed earlier, sight and text-based learning have a long history of valorisation within the sciences, but I would also contend that there exists a counter-tradition which values the directness of touch over the distance of sight (Stewart 1999: 34). Stewart notes that before the Enlightenment, touch was often though to be "the most important vehicle for our access to reality" (1999: 34), since it directly involves thresholds of subject and object; as Kwint puts it, "the act of touching exerts pressure on both toucher and touched and therefore threatens the distinction between self and other" (1999: 6). Johann Gottfried Herder's conception of aesthetics, for example, recognises sensory knowledge as the fundamental mode of access to the world, and rejects Cartesian and Kantian accounts of knowledge as something that can be grasped in abstraction from the external world. In place of Descartes' "cogito ergo sum" he proposed the credo, "Ich fuhle mich! Ich bin!" (I feel! I am!) (Gaiger 2002: 9).

This emphasis on touch is not, however, intended as a condemnation of 'vision' per se, as, in connection with all the other senses, it is thought to play an important part in the work of the materials library. The sensual experience many materials libraries advocate does not exclude vision but rather encourages a synaesthesic and processual approach through experimentation and play. There is a sense that with some new materials, this kind of experimental engagement is necessary, since we cannot see what they do by just looking at them or touching them. For example, a meta-material is invisible to the naked eye, we cannot manipulate it to get a feel for it, cannot smell it like we would molten metal; we are sensually disconnected from it. Even with something like a magnetic liquid, "you can't just see what it does with your eyes or your hands. You have to actually have some equipment…if you take a magnet to it, it turns into a solid" (Miodownik, personal communication).

This idea that physical experience is necessary for a holistic understanding of a material resonates with Barbara Stafford's (1994) belief that we are currently seeing a revival of play and experiment in the learning process. She contends that during the

eighteenth century, "continual interaction with the external environment" was supplanted as an avenue of meaningful communication by text-based modes of communication (1994: xxi), but that "ocular, tactile, kinaesthetic and auditory skills" were central to the shaping of knowledge in the Rococo and Enlightenment periods (1994: xxii). She argues that, in contrast to the "nihilism of postmodernism with its text-based learning", the exchange of information in the early modern period was as much about pleasure and entertainment as learning; it was both "creative and playful" (1994: xxv).

Stafford also argues that since the eighteenth century, "material, affective or fleshy" experiences have been relegated to the domain of the "non-cognitive" as part of a tradition of separating the phenomenal, the manual, and the somatic from the noumenal, theoretical and intellectual (1991: 5). As a result, the "mind-shaping powers" of physical experience have been marginalised within the text-based epistemology of the nineteenth and twentieth centuries. However, she asserts that we are beginning to see a return of a form of knowledge which lies between entertainment and information, practice and cognition (1994: 14).

Certainly, some of my informants expressed the notion that direct, sensual experience of a material is linked with cognition: "with no hands-on knowledge of materials it's hard to have ideas about them…touching a material changes your way of thinking about it" (Emma, personal communication). According to Miodownik, experiencing new materials can help an artist "get refreshed, think new thoughts" (2005b). This conviction that the material is dynamically and intimately involved with cognition resonates with Susanne Küchler's suggestion that the "sensuous, performative and formal properties of things" play a role in shaping our thought (2005: 211): "It is things that create cognition, both as a Kantian subcategory that organises the way we experience the world, and as embodied aspects of past peoples from which we learn to think in particular cultural ways" (2005: 208).

The extent to which each of the materials libraries I studied emphasises the importance of play, touch and the senses in the production of knowledge varies. Some continue to rely at least partly on 2-D digital images, photographs and text to help them convey knowledge about materials, and hardly distinguish these from the 3-

D materials in their collections[5]. Despite differences in the practices of individual institutions, however, it is the implicit suggestion of all materials libraries that the role of the artist in contemporary society is that of a visionary whose "investigative and exploratory practice" enables them to gain an understanding of the social efficacy of materials (Creativity and Practice Research Group website). The discourse surrounding the work of artists and designers in materials libraries resonates with the idea that creativity, skill and knowledge somehow reside in the process of working with a material, and can be acquired through physical experience.

SUCCESS, VALUE AND THE PROBLEM OF ACCESS

The advent and popularity of the materials library demonstrates the conversion of materials into "desirable objects to own" (Findlen 1994: 3). But how does one determine the value or desirability of a material? Not all material developments are successful; some fail to reach the marketplace or fail to be specified by designers and manufacturers. Philip Ball comments that many of the new materials and technologies proclaimed as "breakthroughs" every week will never reach the marketplace as they are "seldom the final, critical step that will allow some fantastic new product to impinge on our lives…it can take years, decades, for an exciting new discovery to lead to a useful application – if it ever gets there at all" (1997: 11). Similarly, the success of a product can depend on the selection of the right material. The IOM[3] website asserts, "correct materials and process selection is fundamental to a product's success – get it right and profitability and product performance are maximised, but get it wrong and poor performance and product failure soon lead to a damaged reputation in the marketplace".

What factors affect the success of a material or product? Maine, Probert and Ashby (2004) have developed Investment Methodologies for Materials (IMM's), computer software that helps innovators and manufacturers to identify "promising materials innovations at an early stage" on the basis of "technical and economic viability" and "likelihood to capture profits" (2004: 15). However, these IMM's only take into account the 'technical' or 'economic' limitations of materials. I would argue that there

[5] See Wilkes 2008: 43 for elaboration

is more to a material's success than whether it can be put to use and make a profit. In fact, Miodownik has observed that "artists are often more interested in materials that don't work, that slightly fall over and get tired" (2005b). Ashby and Johnson contend that a product's "market share is won (or lost) through its visual and tactile appeal, and the associations it carries, the way it is perceived and the emotions it generates" (2002: 2); what I would call its social value. I argue this is equally true of materials.

One of the problems that designers encounter with new materials, according to Ashby and Johnson, is that they are often "imperfectly characterised" (2002: 159) and that the greater a designer's "familiarity" with a material, the broader its chances are of being used (2002: 157). Several of my informants asserted that many professional architects and designers are loath to use new materials as they are considered 'too risky' (Carol, Jo, Helen personal communication). The perceived "risks" involved in using new materials are often due to a "lack of design or manufacturing experience", since "there is no historical body of design experience on which to draw" (Ashby and Johnson 2002: 158). Carol, a freelance materials consultant, remarks that architects "often need to use materials that are already proven in practice because they are bound by strict regulations and requirements", as well as the limits of time and money imposed on them by professional practice (personal communication). Duncan, an engineer and materials consultant, explains, "building owners often don't want to be the first to use a new material, they want to be the second, or they'd like to be the first to use a material with a ten year track-record" (personal communication).

There are two competing and yet complementary methodologies that currently exist to determine the potential value or success of materials: one intuitive, experiential and performative, of which the materials library or workshop are examples, and the other "rational", analytical and quantitative (Ashby and Johnson 2002: 49). Ashby and Johnson represent the school of thought that emphasises the role of quantitative analysis in understanding materials. Their argument is that existing methods, software, and books on materials selection have focussed on matching material properties and the 'technical' requirements of a design. But these methods ignore what they call the "art of materials", their aesthetics and "personality", and their appropriateness for particular applications. They propose that a structured method can

be formulated whereby the aesthetic, associative, perceived and emotional aspects of materials can be captured and communicated (2002: 169).

Ashby and Johnson argue that "the simplest of aesthetic distinctions…can be quantified" in an approximate way. They do accede that there are "obvious limitations" to their approach but state that "within these [limitations], it's worth a try, since it could allow a first-level screening of materials to meet specified aesthetic requirements" (2002: 68). They attempt to quantify visual, tactile and acoustic attributes of materials through description, constructing a "vocabulary of perception" (2002: 77). For example, for the purposes of analysis they limit to six the number of words to describe those attributes of materials that relate to touch: warm, cold, soft, hard, flexible and stiff (2002: 68). One or two of the attributes of a material or family of materials, for example, softness and warmth, are then measured and plotted on a Multi-Dimensional Scaling (MDS) map which presents their "pattern of behaviour" visually (2002: 51). This allows the designer to see similarities and differences between materials.

Although this approach saves considerable time and effort on the part of the designer, it has several limitations. Ashby and Johnson themselves recognise that these MDS maps have to be interpreted with caution, since the differences or 'distance' between materials "rolls many attributes into a single number, and in doing so…throws away a great deal of information" (2005: 54). Firstly, the immense complexity of tactile experience of material is simplified to six descriptive terms. Since much of the expressive potential of materials lies in their "being other than verbal" (Young 2006: 178), in reducing materials to a vocabulary of perception we always lose something of the quality of that material. In the words of Chris Tilley, "similarity and difference can often be much more subtly conveyed through the colours, textures, shapes and smells of things than through words" (1999: 263) as the material "does the talking in a much more profound, succinct and vivid manner" (1999: 130).

MDS Maps present one or two attributes of a material, like softness and warmth, to the designer, in isolation from all its other attributes. In his critique of Nancy Munn's iconographic approach to materiality, Webb Keane notes that individual "qualities must be embedded in something in particular" and as soon as they are, "they

are…bound up with other qualities". He gives the example of redness in an apple, which is bound up with its "spherical shape, light weight, sweet flavour, a tendency to rot, and so forth" (2005: 188). Similarly, in practice materials are 'bundles' of qualities. The social effects of one sensuous quality or icon, like softness, redness, or lightness, cannot be abstracted from the "cultural totality" of the whole material in its context of use: "icons in and of themselves are only unrealised potential" (2005: 188).

Ashby and Johnson also consider the aesthetic, technical and personal qualities of materials separately; however, I would argue that the social value of a material cannot be judged by considering sensuous qualities in isolation. I would question the assumption that the 'aesthetic' properties of a material or object can be separated from its 'technical' properties. Alfred Gell contends that the "psychological functionality" of an artefact cannot be disassociated from other kinds of functionality, such as practical or social functionality (1998: 74). Equally, I would argue that 'technical' qualities should not be precluded from a study of the personality of materials just as aesthetic qualities should not be considered as "mere decoration" (Gell 1998: 74). For example, it is the behaviour of a piece of self-cleaning glass that makes it interesting in the eyes of a designer. As one of my informants states: "most of the nano-tech materials like self cleaning glass and stain resistant fabrics have such a character that they dominate the final product…what makes the window or jacket special is the materials they are made of" (Sophie, personal communication). One of the obvious, but important qualities of a material is that it is not merely a collection of abstract and separate qualities, but that these qualities are bound together in material form, and although these qualities will shift in their "salience, value, utility and relevance across contexts", they all have the potential to be socially significant and to make a material attractive (Keane 2005: 189).

Despite their attempts to analyse the aesthetics, function and form of a material separately, Ashby and Johnson assert that there is a character or personality "hidden in a material" (2002: 76), but argue that analysing the ways in which people perceive materials is difficult, as they depend on "time, culture, demographics, taste, and more" (2002: 169). They don't propose a deductive method for analysing these 'perceived' attributes of materifals, and assert that inductive thinking, in the form of "previous experience and analogy", "directed curiosity" or "interaction with

materials" can be very productive of "creative thinking" (2002: 128). This interactive approach is the one taken by materials libraries and workshops, when they encourage encounters with materials and with specialists from other disciplines. Ashby and Johnson describe communication between materials scientists and designers as meetings which "break down many barriers and open channels of a sort that even the best profiles cannot achieve" (2002: 165).

They do assert that "words can be attached" to products with a significant degree of agreement between people; the "shy" personality of a material becomes apparent when it is given form by the designer (2002: 170). Although they skirt around the issue of how to approach an understanding of the personality of a material, they do suggest that the associations of a material are linked not only to its intrinsic qualities but also to its potential uses, and context of use. I would go further and argue that the social value of a material cannot easily be evaluated outside of the social context in which it is used, and this includes the associations it has with particular products or forms. For example, one CSM student came in looking for "suitable materials for an e-book" and stated that his mind kept "wandering back to the material used on the i-pod". He wanted a material with "similar emotive qualities" (Tim, personal communication). The material in question is a relatively ordinary high quality plastic, but for the student, it was the association between this material and the i-pod that made it particularly attractive. When selecting the materials they think to be 'interesting', materials librarians rely to a certain extent on "intuition about what can be done with a material" (Sophie, personal communication), demonstrating the importance of the relation of the material to an imagined product. I would therefore argue that social efficacy is not just dependent on qualities intrinsic to the material, but on the relationships between one material and another, between materials and objects, and between materials and people.

Observing meetings with materials manufacturers at a professional design practice, I noted that both the personal relationship between the librarian and supplier, and the relationship between a material and a set of objects or imagined contexts, affected the librarian's reaction to a particular material. Louise, a new sales representative for a high-end fabric company, presents Carol with their new collection of patterned fabrics and they are rejected as "too busy" (personal communication). Carol states that this

kind of patterned fabric is “not our style”, which she describes as “natural, tranquil, subdued, timeless materials, nothing too fashionable…earthy colours” (personal communication). A week later, Anna brings in some samples to show Carol. They have worked together for a long time and have a friendly and chatty relationship. Conversation strays from the topic of fabric swatches to design competitions, television programmes, Margaret Howell’s clothing and furniture, ironing and Vanish. Anna presents the same collection of fabrics as Louise, describing the “inspiration” for them as “Calder’s wire sculptures, Kandinsky’s line theory” and other modern artworks. Carol selects the fabrics for the materials library. Equally, a sample of “wet-look leather” is rejected when presented by Louise on its own. Anna presents a smaller swatch of the same material, in combination with a selection of coloured and patterned “snazzy” leathers and furs (personal communication). She describes what she imagines it might be used for: “I can really see this material in a shop behind a cash desk or used as a small panel to liven up a counter” (personal communication), and the material is selected for inclusion in the library. The success of these materials therefore depends on both the relationship between supplier and librarian, and the association of the materials with real artworks or artists and imagined spaces.

CORPORATE SECRECY, COPYRIGHT AND CONTROL

Ashby and Johnson also assert that the success of a new material often relies on its ability to “attract a sequence of early adopters” (2002: 158). I would argue that this ‘attraction’ often takes the form of property rights being imposed on a material by manufacturers and technologists in the form of patents and copyrights. Many of my informants felt that this concern with corporate secrecy and ownership was a hindrance to both creativity and technological progress. At the Materials in Art and Design Education Conference, many participants complained that today’s relationships between academia and industry were “not effective”, and they felt that “industry was insufficiently willing to make materials, particularly new materials, available to students for experimentation” as a result of “budgetary reasons” and “worries about control of intellectual property” (Ward 2008: 6).

From my discussions with designers, it seems that they often want to use materials for purposes other than the ones for which they are intended. In fact, one of the explicit

aims of the materials library is to find new and exciting applications for existing materials through dialogue between arts and science communities. Several materials librarians commented that "it is exciting when students use a material for some purpose other than its intended one" (Jo, personal communication). However, some manufacturers want to control the uses, objects or products produced from their materials, and they do this by patenting them, or by restricting the circulation of these materials amongst designers.

Journalist Cathy Newman has suggested that this "closed-mouth syndrome" is, "at heart, a matter of money" (2003: 57). It is certainly true that the materials business is competitive on a global scale, but I would argue that corporate secrecy is not just about the creation of monetary value, but social value as well. Methodologies for successful investment in new materials, like the one authored by Maine et al., talk of the control of intellectual property as "key to value capture in the materials industry" (2004: 17). They state that this ability of developers to "capture value" relies on "their ability to limit competition by retaining control of intellectual property and of key assets (people, trade secrets, licensing or partnership agreements)" (2004: 13).

There is an interesting analogy to be made here with Weiner's discussion of *kula* exchange systems in the Trobriand Islands. Weiner argues that the restriction of access to socially valuable objects or to specialised knowledge is a strategy employed by people as a means of enhancing value and status (1994: 394). She notes that shells and other exchange items are hierarchically valued, from "socially dense" objects, replete with cultural meaning and value, to less socially dense ones, which can be "exchanged sold, or traded with impunity" (1994: 394). Socially dense objects like chiefly shells have the highest "symbolic density" by virtue of their size, aesthetic appearance and long, prestigious genealogies, and they are also highly restricted in their availability and movements so that others have difficulty prying them away from their owners. Analogous materials within the materials community might be new and "innovative" materials like shape-memory polymers. Other materials have little symbolically dense value and are in fact expendable. Two librarians I spoke to singled out carpets as "uninteresting" materials that are "very easy to get hold of", and one of the materials that they would throw away or refuse to accept (Jo and Sophie, personal communication). One librarian stated that "there's a hierarchy of difficulty in

obtaining samples and swatches…it's usually easier to obtain samples from textile companies, followed by leather tanneries, and then components suppliers" (Sophie, personal communication).

Weiner contends that the ranking of objects creates and legitimates hierarchical differences between persons, and I would argue between institutions. She asserts that keeping a highly prized object out of circulation despite demand for it "defines and even entrenches the owner's difference" and "confirms the establishment of hierarchical difference" (1994: 395). For example, Anna wanted "installation shots" of materials that had been specified for use in an airline lounge by a prestigious design studio, to encourage other "high-end" customers to use their product (personal communication). However Carol advised Anna that the design practice and airline involved wouldn't want their competitors knowing who their suppliers were. She informed Anna that it would be a "turn off" to know competitors had used a particular material, as a designer would see this as their great idea "going out of the window" (personal communication). The fact that the material is in wide circulation would, according to her, "lessen its value", as designers want to know they are "breaking boundaries" (Carol, personal communication).

Some materials libraries also have greater access to materials than others. Prestigious design companies like Pentagram have no problem getting hold of some of the more sought-after materials, and are in fact inundated with suppliers wanting to bring them samples. Materials libraries like KCML manage to get materials through their personal and professional contacts within the materials science community, with items such as Aerogel from NASA to boast of. On the other hand, many university materials libraries find that materials are "harder and harder to get hold of" (Sophie, personal communication). This is partly because students do not have the spending power of large professional practices, and many of the materials librarians at design-oriented materials libraries don't have contacts within the materials-science community. As Miodownik notes, "it's very hard to get hold of these materials if you're not in the business" (2005b). I would argue that the exchange of objects within materials libraries establishes a hierarchy of sorts, from powerful and prestigious design studios and representatives of the materials industry down to academic institutions and design schools. Just as with the *kula*, at one end of the continuum the

exchange of materials is an open system in which most players can participate, but the other end is tightly controlled, and materials become the "objectification of hierarchical difference" (Weiner 1994: 397).

I would further suggest that asserting ownership over a material is another way of controlling 'runaway' technologies. Leach argues that the attribution of ownership or in fact authorship to an object or idea "brackets those things from the common pool of resources and attaches them…to individual subjects" or corporations (2005: 150). Within this property logic, if an object has a relationship to a particular person or corporation, that relationship gives it fixity or solidity, and the person has the right to deny access to others (Miller 2005: 18). This idiom of ownership or private property is a distinctly Western institution (Middleton in Carsten 2000: 106), based on an assumption about the radical difference between subject and object (Myers 2005: 89), and characteristic of a "possessive individualism" whereby persons are thought of as individuals naturally owning themselves and the products of their own labour (Leach 2007: 181). The idiom of ownership allows materials to be seen as external objects attached to a person or corporation, thereby elevating the subjectivity of that person or corporation, and objectifying the material product (Leach 2005: 150).

In the face of increasing recognition of person-like qualities in materials, for example in self-cleaning glass, this could be seen as an attempt by corporations and individuals to take control of technology again. I would suggest that companies are becoming less and less willing to disseminate their materials today precisely because, as I discussed earlier, some materials are more person-like than ever before. Materials are becoming more and more autonomous, and as a result they cannot be "domesticated, and thus are not readily possessed by corporate institutions in the same way as earlier machine-generated prototypes were" (Küchler 2008: 105). Librarian and materials scientist Alex explained to me that companies are sometimes loath to donate materials for fear of breaching the patent (personal communication). He explained "for example, we recently dealt with a manufacturer who sourced their materials from a materials company…the manufacturers were willing to give us the product, but the materials company wouldn't allow it". They bought the product, and using his "materials knowledge", and information in the public domain, Alex was able to work out what the product was and how it was made. This demonstrates that knowledge is

sometimes inherent in the material, and cannot always be controlled by manufacturers, despite their best efforts.

CONCLUSION

This paper explores the recent proliferation of materials libraries[6], and suggests some reasons for their development. These include the increasing importance of materials to the economy and creative industries; a distinct lack of materials education within the arts community; the recognition of the potential for materials to affect quality of life; the conviction that those currently entrusted with their development and dissemination have little social knowledge or no sense of social responsibility; and a belief that interdisciplinary initiatives hold the key to controlling and 'bettering' said development. There is a common perception that a divide exists between the science and arts communities, whose origin lies in the cumulative process of disciplinary specialisation and the abstraction and rationalisation of the sciences. I have suggested that this results in the conception of two different kinds of knowledge about materials: one technical, objective, text-based and rational, and one aesthetic, intuitive, material and performative. These are the domains of two different kinds of people: scientists and artists. This division of knowledge is thought to have adverse effects on both the economy and society as a whole: it influences the satisfaction of consumers, beauty, sustainability, and quality of life.

The work of materials libraries is to share this knowledge by transferring it between communities that are thought of as socially and professionally divided. Whereas text-based learning has been the dominant mode of knowledge transfer since the mid-eighteenth century, my research also suggests that we are starting to see a change in the nature of knowledge communication. However, each materials library encapsulates slightly different combinations of these text and performance-based knowledge transfers, and I would suggest that this leaves us, as Stafford (1994) argues, stuck between a largely text-based mode of learning and knowing and one that emphasises play, experimentation and performance. It is hard to speculate where this will lead in the future. Some of my informants' actions suggested that we might see a return to text or image-based knowledge transfer. For example, some seemed keen to set up digital archives of materials, and others

[6] For discussion of the historical precedent to the contemporary materials library see Wilkes 2008: 33

encouraged “more material data sheets” (Tim, personal communication). Others emphasised the importance of theatricality and performance in the future of materials education. For example, the KCML events are theatrical, magical, and about the revelation of mystery through performance. These competing ideas about how knowledge is most effectively transferred are not only interesting anthropologically, but have important implications for pedagogic theory and knowledge production within the arts and sciences.

I have also emphasised the instrumental role of new materials ‘inventions’ or discoveries in this changing understanding of material and knowledge production. Materials that are both ‘technical’ and ‘aesthetic’ have encouraged a conflation of two ways of understanding the material as both a scientific and an artistic product, and materials libraries reflect or enable this changing ontology of the material by bridging the divide between the arts and sciences to reach a holistic understanding of their social efficacy. The work of materials libraries also has implications for the study of cultural transmission, since it suggests that materials and memory are intertwined, exploding the notion that memory resides purely in the mind. Materials are increasingly seen as active and generative. The rhetoric surrounding materials libraries identifies physical experience with materials as a source of the production and transfer of information, increasingly implicating materials in both the knowledge-making process and in cognition. Recent developments in neuroscience which indicate the complexity of the relationship between mind and matter (Stafford 2007) could have interesting implications for theories that it is the interface between people and things that creates society.

This study of materials libraries has also revealed the increasingly common recognition that art is a knowledge practice. Whilst the history of knowledge making processes within the sciences is fairly well researched (for example Knorr-Cetina 1999), there has been less work within anthropology on the knowledge practices of the arts community. I would suggest that this reveals the existence of an entrenched dichotomy between higher cognitive functions and mere physical manipulation, which is challenged by the work of interdisciplinary institutions like materials libraries. In the context of materials libraries, innovation and creativity are thought to be bound up with each other and intimately connected with social change. The implied idea that the arts community is capable of controlling the unruly and asocial development of materials suggests a perceived connection between creativity and social and technological progress and morality.

Creativity works to effect changes: it doesn't just record events, but asserts rights and makes interventions for social good.

To conclude, I would like to reiterate the relevance of the study of materials to many themes of current anthropology and suggest that further study could not only facilitate a greater understanding of the importance of materials to contemporary society, but could encourage directed action in the fields of materials and design education and knowledge transfer.

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This paper is an abbreviated and revised version of my dissertation completed for MA Material and Visual Culture and submitted to University College London in 2008. In September 2009 I will be starting an MPhil at UCL on the state of materials awareness and education in contemporary British society. The study will use as its starting point the various networks of people encompassed by the Institute of Materials, Minerals and Mining in London.