Externalisation and Design

Alan Dix[1,2], Layda Gongora[1]

[1] InfoLab21
Lancaster University
Lancaster, LA1 4AW, UK

[2] Talis
43 Temple Row
Birmingham, B2 5LS, UK

alan@hcibook.com, l.gongora@lancaster.ac.uk

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ABSTRACT

External representations are ubiquitous in design from blue-foam models, to formal requirements documents. This paper seeks to explicate the role of externalisation in the light of literature in philosophy, psychology, and design practice. The apparent conflict between theories of embodiment, which emphasises tacit action, and the ideal of reflective practice is resolved in a rich interplay between tacit and explicit knowledge and reasoning. By understanding the kinds of external representation in design their properties, and functions, we are able to make sense of tools and techniques for reflection and creativity and we hope ultimately improve them and design itself.

Keywords

design, embodiment, reflective practice, external representation

INTRODUCTION AND MOTIVATION

In this paper we seek to unpack different forms of externalisation and in particular the role it plays in design.

Ethnographies often emphasise shared representations as enablers of collaboration. External representations are also central to distributed cognition, where they act to augment of processing or memory, and in philosophical theories of embodiment. Furthermore, we all make use of notes and calendars, wall-planners and blogs; and even this paper acts as a critical externalisation of the authors' own thinking.

Externalisation is ubiquitous and important to understand as it is often a critical part of the domains we study in designing for interaction. However, it is also central in the process of design itself, as evidenced by blue-foam models, architectural plans and UML diagrams; and furthermore to our own intellectual processes as researchers.

What is externalisation?

We all interact with external environments and artefacts as part of our day-to-day lives, as emphasised in various approaches including ecological perception [25] and situated action [54]. Often these are given by the world:

waiting for a kettle to boil, digging the earth, or the movements and activities of those studied in field studies. We are not isolated; being human means interacting with the impingements and resistances of the outside world from stones to people to computers.

Of course, we do not simply react to the external world but actively shape it to serve our needs: building walls and roofs for shelter, weapons for hunting and war, cars to drive, and fields to feed.

Externalisation is the step beyond, the active shaping of the world as an *intellectual* resource, maybe a uniquely human ability and certainly the foundation of culture and civilisation. Externalisation involves the embodiment, representation and exploration of our own thoughts, feelings and interior life. As we shall discuss further, this takes many forms and serves many overlapping purposes from communication to elaboration of our nascent ideas.

The term externalisation itself reflects a philosophical and practical tension: it suggests both embodied interactions with external artefacts, but also the process of making internal representations external. In art and design this reflects dual views of creativity as internal muse or embodied engagement.

This paper

This paper builds on previous analysis of the practical use of externalisation [17], and on literature on embodiment and reflection, notably Schön's studies of different forms of reflection [47], which is often facilitated by external representations. We will illustrate an unfolding framework of dimensions and categories using examples from our own past studies, published data of others and reflective anecdotes, which we hope will be familiar in the readers' own experiences.

We also seek to understand the role of externalisation at a more theoretical level. In particular, we will make use of cognitive models that attempt to deal with both more explicit, conscious (rational) thinking and also more tacit, unconscious, associative processes.

By doing this we add another dualism to the interior/exterior dualism already implicit in the term externalisation. Both distinctions risk offending many who work in the areas most central to our concerns, who often seek to breakdown such distinctions and take a more

holistic view of self and action. However, we believe that by making such distinctions, however problematic and nuanced, we are better able to understand the whole.

This structured and theoretical analysis will, we hope, offer grounding for more practical interventions. However, it is part of an ongoing process; we do not expect it to be complete and final, neither theoretically or practically.

This paper will begin by considering some of the theoretical roots of externalisation and reflection. This is followed by a section focussed more on practice, and the different forms of externalisation in design. The fourth section discusses the kinds of interactions facilitated by externalisation: with the world, with other people and with oneself. Finally, we consider what externalisation does: its functions and the way these can be enhanced in tools and techniques for design and creativity.

THEORETICAL ROOTS

Embodiment

Externalisation most obviously connects with theories of embodied or external cognition, which in different ways emphasise the role of the external environment in human cognition. These have become popular in recent years drawing on a number of sources.

In philosophy, Heidegger's "*Being and Time*" [30] and Merleau–Ponty's "*Phenomenology of Perception*" [38] have both been influential focusing on our unconsidered, yet artful, interactions with the world in contrast to more traditional dualistic/mentalistic models from Descartes onwards that prioritised the interior self [11]. Many modern philosophers draw on concepts of embodiment, albeit with very different emphases, including Clark [7], Gallagher [22] and Varela [56].

In psychology, Gibson's "*The Ecological Approach to Visual Perception*" [25] suggested that perception was far more intimately tied to action than had previously been considered and his concept of affordance has become heavily used within human-computer interaction (HCI) research and user-interface design [23,28,41]. Also ideas of embodiment are being explored within neuroscience using a combination of traditional experimentation and brain scanning technology to investigate to what extent perceptions are represented directly within motor areas of the brain [6].

Building on roots in social anthropology and ethnomethodology respectively, the concepts of *distributed cognition* [33,31] and *situated action* [54] have been influential in HCI since its beginning as a discipline. Distributed cognition emphasises that we do not simply think in our heads, but actively use the world in 'problem solving', for example, moving the pieces of a jigsaw puzzle not just staring at them. Furthermore, cognition may be

"How does something that begins as an idea or image in the mind become material? How is the work of the hand influenced by movements of the mind and vice versa?"

David Levi Strauss, *From Head to Heart* [53]

socially distributed; for example an early study examined Peloponnesian navigators who traverse vast areas of sea without modern aids, yet no single individual holds everything in their head, instead, through working together as a group, navigation happens. Situated action is similar, emphasising the way we do not come to situations with pre-made plans, but instead work out what to do based on the exigencies of the moment.

Most of these positions focus on the largely unconsidered moment-to-moment interactions with the world. As we lift a cup, or walk down the road, we are not actively and consciously lifting our arm, or swinging our leg, we just do it. Heidegger calls this *thrownness* and contrasts it with *breakdown* when we become explicitly aware of the actions we perform and tools that we use. While at one level this is merely descriptive, there is often also an implicit or explicit value judgement, whereby breakdown has pejorative or, at best, undesirable connotations.

It is clear that thrownness and artful interaction is crucial when dealing with many forms of external representation. For example, in drama and dance, while expert improvisers are able to reflect whilst improvising, most performers will not move as fluidly when thinking about their own actions. Similarly an interface designer may want to walk through an interface as she would imagine a user will do, but, if she thinks about what she is doing, she will simply make the same assumptions as she did while building the prototype.

However, we will see in later sections that breakdown is also an essential part of externalisation and reflection, and we will present a class of practical techniques aimed at *engineering* breakdown at appropriate points.

Kinds of Knowing: Tacit and Explicit

This distinction between thrownness and breakdown, can be seen as essentially that between tacit compared with more explicit understanding and cognition.

There are a variety of closely overlapping terms used in this area, and the distinctions are often less hard-edged when examined in detail. However we can characterise these modes in terms of common attributes.

Tacit knowledge and action is unconscious, in the sense that we act without consciously thinking about it, although the term 'unconscious' has many Freudian connotations, so is often avoided. Gallagher use the more neutral term *pre-noetic* [22]. It is the more ancient mode of reasoning we share largely with animals, based on associative/analogical reasoning and builds naturally on neural mechanisms. Learning tends to be slow requiring many examples and trial and error, and is heavily affected by strength of emotion. However, the slow building through multiple exposures means tacit knowledge often has a probabilistic nature, which we are particularly bad at consciously

without external aids. The strength of this tacit probabilistic learning was demonstrated in simulated gambling experiments where participants showed galvanic skin response to card stacks with different payoffs well before they were able to explicitly distinguish them [2].

Tacit knowledge tends to be relational rather than categorical/denotational, however that is not to say there is no categorisation. As is evident in Lakoff 's work [34], categorisation of some sort is essential for associative thinking, otherwise we could not generalise from past actions. However, associative 'categories' may be more soft-edged bundles of related things that tend to activate together – that is no 'grandmother' neuron ... even though there is a 'grandmother' word.

In contrast **explicit** knowledge and action, is consciously available, we know we are doing it. It tends to be more rational/logical and based on discrete categories that are typically associated with words. Indeed there is a close relationship between this kind of thinking and language; however, while language appears to be necessary for 'higher' thought (as is evident from wild children brought up with no language), it is also evident that we are not limited to thinking within the existing vocabulary [12]. Furthermore, the categories of explicit thought, while being available for discussion, are often based as much on fuzzy (tacit) connotations as on precise denotations. While learning itself is tacit (we cannot simply tell ourselves 'remember'), explicit conscious thinking tends to lead to single-example learning through abduction or other forms of reasoning. The associative learning of tacit knowledge is old/primitive; in contrast explicit reasoning is a uniquely or at least largely human attribute. From a computational view, it builds awkwardly upon the neural substrate, which is naturally associative, and must be very expensive in terms of brain capacity used. This 'hardware' cost suggests that has been of considerable value in our development as a species.

Working together
While there are contrasts between the tacit and explicit, we should avoid simplistic dualism. Different philosophical approaches prioritise one or the other, and popular literature is full of advice on how to 'turn off' more rational decision processes to let intuition take prime place [20, 26]. However, we are not schizophrenic with Jekyll and Hyde personalities vying for control, but rather both kinds of thinking contribute to our cognitive makeup.

Proponents of embodiment emphasise the way that what we think of consciously, what springs to mind, is not under conscious control; it is pre-noetic [22]. Similarly, while the interpretations are not unproblematic, Libet's frequently cited experiments show that certain actions we might have thought were under conscious decision making are in fact 'already decided' unconsciously before we are aware of them [35]. While framed in terms of 'free will', the actions studied in these experiment, spontaneous but arbitrary hand movement, are at best peripheral to any core idea of personal choice. However, even these experiments show that the conscious mind gets a chance to 'veto' unconscious action; hence it has been argued we don't have 'free will', but do have 'free won't' [42].

Complex emotions often involve a combination of more logical/rational thinking and unconscious processes. For example, when experiencing regret one makes a complex counter-factual assessment of what *would have* happened if one had acted differently and how likely this would have been to lead to a different result. However, this complex processing drives an emotional response and hence subconscious associative learning [14].[1]

In a deep review and critique of the psychological embodiment literature, Wilson presents a rich picture [57] where, on the one hand, pure embodied (and tacit) explanations fail to account for common cognitive activities such as planning, yet, on the other hand, virtually all aspects of 'pure' cognitive activity, from memory to reasoning are found to have physical/bodily aspects at play.

This mixing of unconscious and conscious is also common in design where ideas seem to come to mind without conscious thought, yet are evaluated, critiqued and developed in a more rational mind.

Breakdown and Reflection
As has been noted, breakdown gets a bad press in the embodiment literature. However, this seems to be the heart of the reflective practice that is seen as the ideal in Schön's work [47]. Schön describes three levels of expert knowing: *knowing in action, reflection in action,* and *reflection on action*. However, all of these, Schön is keen to point out, differ from abstracted bodies of knowledge applied acontextually to problems in what he terms *'Technical Rationality'*.

The first kind, *knowing in action*, is not unlike *thrownness*: referring to knowing that is "*ordinarily tacit*" and "*implicit in our patterns of action*". This lived knowledge involves "*innumerable judgements of quality*" without criteria that can be explicitly stated and skills without explicit rules or procedures. In terms reminiscent of Heidegger, Schön says our "*knowing is in our action*" [47, p.49].

However, the professional does not stop there, but engages in *reflection in action* monitoring and becoming explicitly aware of the situation and "*the prior understandings which have been implicit in his behaviour*", being open to "*surprise, puzzlement or confusion*" [47, p.68]. This is, in Heideggerian terms, clearly breakdown, yet regarded by Schön as constructive, allowing the professional to attain

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[1] This mix of conscious and unconscious, rational and associative, thinking is used in the 'principle of least regret'. Normally when making a decision, one considers how good each course would be and weighs these up. Instead one can envisage having taken each action and imagine the regret felt at not having done the alternatives – you choose the action with least regret.

deeper understanding of the situation and step out of unproductive blockages.

Finally, the most successful professionals engage in *'reflection on action',* long-term growth through reflecting on practices and processes. This is far rarer than *knowing in action* or *reflection in action* indeed Schön sees a weakness in many practical management schools because managers "*have little access to their own reflection in action*" [47, p.243], and therefore cannot pass on this knowledge to others.

EXTERNALISATION IN DESIGN
The Ubiquity of Externality
External representations are ubiquitous in design and all creative endeavours.

In architecture, we see plans, models, and also formal procedures of consultations and deliverables to clients. In product design we also see sketches and, because the end product is human scale, full-scale mock-ups in blue foam, cardboard or 3D printing, culminating in many cases, with the production-line mould. In addition, both disciplines use CAD and other forms of simulation or virtual walkthrough, as do various kinds of engineers.

Some artists, particularly painters and sculptors, have no external representation other than the nascent form of the ultimate product. However, many employ some form of sketch and may use mood boards or other means to familiarise themselves with the emotional and physical aspects of a brief.

Outside the visual arts it is common for the output of the artist to be some form of intermediate representation (book or score) before the actual performance of the work (reading, or playing). However, again there are often preliminary representations. Poets and song-makers make many drafts and some cut out words and phrases to shuffle around seeking inspiration or simply serendipity (if the two are separable). A composer may hum bars, or sit at a keyboard playing stray notes whilst penning then striking out notes on the stave. Furthermore the performance of a play, opera or symphony all are accomplished, Cage included, in the external sound, silence and sights they create.

In the crafts, as in industrial design, sketches, models and mood boards are common, as are more precise representations such as the scale drawings used in carpentry to plan complex joints, or the 'drafts' used in weaving to turn the desired appearance of the fabric into the pattern of warp threading and sheds.

In software engineering external forms abound from the simple flow diagram to the multifarious notations of UML. Indeed, now that electronic music and various forms of performance are deeply embedded in software, composers and artists may find themselves manipulating box and arrow diagrams rather than physical instruments and manuscript paper.

Within user interface design there are representations of the systems being designed with paper prototypes and storyboards as well as representations of the users and their use situations in personae and scenarios.

The mathematician, is lost without blackboards or notebooks full of diagrams, equations and scribbled notes.

And for all, there is always the paper napkin.

Uses of externalisation in the design process
These different forms of external entities address different facets of design.

product – The most obvious external artefacts are the products of design itself or representations of them: sketches, models, prototypes. These have many functions including communicating to clients, and testing how ideas pan-out in practice. In the case of communicating to others, the design may be close to final form. However, concrete external representations of products can also be more experimental. Indeed both Schon [47] and Alexander [1], use scientific language when talking of this: the concrete design as an 'experiment' or 'hypothesis'.

problem space – External representations can also be used to express the problem to be solved or the context in which the design is to be placed. Mood boards are an example of this, not specifying a specific design, but communicating the values and ethos of an organisation or of a setting. Similarly a requirements specification creates an explicit statement of aspects of the context. Alexander [1] regards design as obtaining a fit between form (product/artefact) and context, and describes the diagrams, which are the core of his conception of 'patterns', as a "*way of representing design problems*". The problem space can be both very concrete, for example, photographs of an intended location for a work of art, or in the case of Quist and Petra's conversation in Schon [47] the physical structure of the site of a school. However, it can also be very abstract, for example the precise formal software requirements specification, or the suggestive impressions from collecting cultural probes [24].

Of course in representing the problem space, it can become itself problematic, something to be 'designed', and it is this reframing of the problem, which Schon considers one of the hallmarks of a 'reflective practioner' [47, p:40].

design space – While a sketch or prototype represents a single design possibility, some representations represent aspects of a whole set of possibilities for the eventual product. This can be done quite concretely by a series of alternative designs, which in someway cover or sample the set of possible designs. However, it may be abstract, for example lists of criteria, properties, options: design rationale notations such as QOC attempt to express the choices for a design [36] and the Bad Ideas method, by prompting one to consider why an idea is bad (or good), forces one to articulate criteria [15]. In some ways the problem space and design space are doing a similar thing, the former focused on the context, but using that to set

constraints on the design, the later transforming those external constraints into criteria and properties of the product of design. However, some issues arise only in representations of the design space, for example, the external (problem) constraints for a chair may be about weight, strength and comfort, but choice of material, while impacting these external constraints, may not be an explicit part of the problem.

The nature of materials and tools has a profound impact on the kinds of externalisations produced. In studies of group design using different materials, it was noticeable that those with plasticine or cardboard and glue, tended to explore the design space by way of example, whereas those with paper and pencil, tended to create more abstract lists of properties [44].

process – Finally, one may have some form of representation of the process being followed. This may be a post-hoc record or some sort of plan or normative schedule. For example, architects follow a prescribed set of stages and in biology and chemistry laboratories the lab notebook is a central part of the activity crucial for intellectual property reasons, but also because of the necessity to be able to reproduce precisely the same conditions in future.

For some artists, for example, Andy Goldsworthy's manipulations of the natural world, it is as much the record of the process of construction as it is the final artefact that comprises the work of art itself.

Properties and Dimensions

The physical and semiotic nature of these external artefacts and representations also differ in various ways:

representation – Some external artefacts are *physical* and in some sense isomorphic with at least aspects of the things being designed, for example, the foam model of the product designer, or (in a different modality) the hummed notes of the composer. Some are more *schematic* or representative such as the sketch or floor plan: in some ways rendering aspects of the final item and yet in a different medium, or some way distanced from it. Finally are more *symbolic* representations such as the words in a mind-map, or equations on the blackboard, which deal more with more abstract concepts, ideas, criteria or properties.

modality – The forms of externalisation differ also in the modality in which they are expressed. There is *written language*, both normal language and also specialised languages such as mathematical or musical notation. These are typically abstract and symbolic. In addition, language may be used in *speech*, whether as part of a discussion, dictaphone notes, or speaking out loud a poem or other work in progress. There are also *drawn* diagrams, sketches or images, some more abstract or schematic, others closer in form to the final product. Similarly there may be aural representations (playing music), or even *olfactory* or *tactile* externalisations, usually also close in form the final product. Finally the externalisation may be done using the whole *body* when acting out scenarios or body-storming [43].

persistence – Some externalisations are naturally *persistent*: the words written on a page, the clay model, or the sketch on the back of an envelope. However, some are *ephemeral* and past as soon as they are framed: the words in a conversation, the notes played on a keyboard, or the movements made during an improvisation session. These two flow into one another when the ephemeral leaves traces: patterns of footsteps on the sand, peeing on snow [5], or whiteboard sketches at the end of a meeting. Indeed one class of techniques we will see later is precisely those that help create traces for discussion and reflection.

EXTERNALISATION AS INTERACTION

To understand how externalisation works as part of activity in general and design in particular, we first need to realise that while interconnected there are many different processes at work involving physical, social and cognitive processes.

interacting with the world

Physical externalisations offer opportunities and resistances because of their physical nature. When a concept, an object of mind, becomes solid it becomes subject to the same laws as objects of nature and the resistances of the world form the outcome as much as the initial mental idea. This is exactly the process described by Sennett as a conversation with materials [50].

This is often tacit and it is exactly this continuous interaction with the environment that is emphasised by those who argue for the centrality of embodiment or enactment in all human activity. For example, Gibson suggests that perception is not static, but is continuously created through interacting with physical things and moving in the physical environment [25]: we can tell the distance of an object by the way in which its edges change as we move our head or move towards it.

However, in a design setting, externalisations may be explicitly created in the form of scale models or diagrams in order to exploit physical resistance; for example, by looking at an architectural model, we may realise that a window is facing a wall, or that there is no room for the planned furniture.

Sometimes this kind of limitation is only realised when an exact scale (or real size) model is acted out in a real scenario. For example, [16, p.202] describes a discussion around the design of an Internet-enabled Swiss army knife. The idea was that useful tips could be shared via a web site and step-by-step instructions for using different blades would be displayed on a small screen on the side of the knife, using the toothpick as a stylus. While discussing this verbally it sounded fine, it was only when acted out that it became apparent that at a critical moment the fingers holding the knife would obscure the display.

However, sometimes simply seeing a representation may enable us to imagine limitations, or constraints or

opportunities. For example, the architecture pupil Petra described by Schon [47, p.83] creates a scale drawing of a school with six classrooms arranged in a staggered form, but realises that these are too "*small in scale*" and so instead changes them into three L shaped configurations. Similarly, in a study where groups were given different materials to work with, those with card tended to create designs around flat or cylindrical (rolled) shapes [44].

Figure 1. Card suggests tubes and sheets (from [44])

These constraints of the world are also evident in less physical situations. For example, in writing this paper it may only be by formatting it in the appropriate style that we discover if it is the right length, or that figures need to be shifted to layout neatly. Similarly, in drawing UML diagrams of a piece of software the tangle of lines may suggest that there is insufficient modularity.

Many design situations now involve some form of virtual model, whether 3D CAD or a traffic simulation. Here computation does the job of the world in offering resistance or 'talking back'. As with physical objects this may be because it recruits the designers own understanding (e.g. walking through a virtual building) or may that the computation does the work (e.g. structural models). Of course, in the case of code, the final output is virtual, but equally a medium to be worked with and against; indeed Sennett views the coder as much a craftsman as the carpenter [50]. This is evident in vignette 1, where Xara finds that comparing outputs of her program helps her 'feel'

Vignette 1: Xara's work involves writing simulations of large-scale software. Because of the complexity of the systems involved it is often hard to understand why particular outputs are produced, even when everything is working correctly. Albert has encouraged her to write and update documentation of her code including example outputs, this was largely to help her to obtain a better understanding of her own code through the process of documentation. Some months after starting this process she remarks on the insight she obtained by comparing different versions of the document and in particular the different outputs produced. As the code was evolving, the same input data produced different outputs over time. Through seeing this, she expresses a changing understanding of the underlying algorithms: she says she is beginning to "feel" the code rather than simply being able to calculate.

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the code.

interacting with others

The importance of shared representations is a common theme in ethnographies. In Heath and Luff's classic study of the London Underground control room [29], the 'fixed line diagram', a large display visible to everyone, shows the locations of trains, track and signals and acts as a common point of reference. Equally, more recent studies of the home reveal a rich collection of resources for shared coordination, from calendars and notice boards, to working out who is at home from the keys in a bowl [10].

Non-physical externalisations are also critical. Star's original conception of *'boundary objects'* centred on the use of a shared taxonomy, a conceptual 'object', as the means by which diverse professionals in a museum environment could interact [52]. Similarly in vignette 2, Betty is able to read Yorick's written argument and thus critique it. Furthermore, she is able to listen to his verbalisation and reflect back aspects of the argumentation that were absent in the written externalisation, but present in his spoken words.

This last point is worth pausing upon. Quite naturally, many people find it easier to speak than to write, as the latter is a more complex skill. However, it is often hard to 'hear' one's own words. The authors have frequently observed that simply reflecting back a student's own words yields reactions such as "I never knew that". We will return to this when considering externalisation tools and techniques.

Interacting with oneself

As well as being a way to interact with the world and with others, externalisation can be a means to interact with oneself both at the moment or in the future. This may sometimes be an 'accident' of externalisation for others, as one communicates with others one elaborates and thus understands an issue better. It may also arise out of

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Vignette 2: Yorick has been writing a paper on the 1970's Cod War in the North Atlantic and is discussing it with Betty. Betty picks on a few paragraphs near the beginning of the paper as they appear to represent related issues and examples, but without an obvious argument structure, and starts to dissect them. On a sentence-by-sentence basis she asks why each is there and how it relates to the argument as a whole. She also asks Yorick to say in words what he is trying to express in the text. Yorick's verbal explanation includes substantially more detail and rationale than in the text. Betty realises that some issues mentioned in the text that she had initially thought irrelevant were in fact part of an argument and she reflects back what she believes to be the underlying argument of the section. Although he had not previously articulated this argument either in the text or verbally, Yorick recognises this was indeed an accurate reflection of the previously implicit feelings he had of the situation.

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interaction with the world, for example, after seeing the thumb over the Swiss army knife 'screen' the importance of how you hold devices became more salient.

Notes, plans and diaries are ways in which we externalise now something that we believe will be of value to us in the future. Unlike externalisations for others, which rely on some form of common ground [8] or inter-subjectivity, externalisation for oneself may only need a word, icon or sketch that reminds one, a form of semi-private language.[2] For example, Threadway reports how the textile artist Charlotte Hodes keeps a log of "*handwritten notes and sketches*", which are "*nebulous thoughts*" and so "*sufficiently fluid to enable free exploration of visual ideas*" [55].

Talking across boundaries

Returning to the inter-personal use of external representations, it may be driven by tacit or explicit knowledge and evoke both tacit and explicit responses.

The prototypical 'informational' (see next section) human–human conversation, especially in academic discourse, is effectively acting at an ***explicit–explicit*** level: the communication involves explicit thinking, representation and interpretation on both sides. However, there is always a level of tacit understanding in even the most apparently explicit interchange, as highlighted in Herb Clark's notion of establishing and negotiating common ground [8, 9].

In contrast a ***tacit–tacit*** level of intercourse is the primary and ostensive purpose of externalisation in many of the arts: a painting may convey emotions, or a poetic metaphor express rich associations. However, tacit–tacit interactions are also common in day-to-day experiences, from holding out a shopping bag for another to fill, to dancing together at a nightclub. Cultural probes can also act in this mode. Using the probe packs, participants take photos, fill out postcards, and otherwise create external artefacts. When returned, the completed probes are placed in the designers' workspace and serve to enculture them; while they may use the probes more analytically (tacit–explicit), they often simply soak in the atmosphere created by the probes empathetically [24].

Externalisation may reach across the ***explicit–tacit*** divide. In advertising and in design aimed at motivation or persuasion [21] there is an *explicit* creation of an external representation (image, object, game), which is intended to create a *tacit* response: in the case of advertising often appealing to desires, emotions; in the case of motivational design maybe attempting to encourage positive feelings about exercise, or make healthy eating seem cool. The use of mood boards for brands is another example of this: the mood board is intended to evoke very specific feelings about the corporate brand and image, so that those

designing electronic and print materials can fit within the brand without necessarily themselves explicitly thinking about the brand values. Even in academic writing we may have an explicit idea of the expected emotional impact of writing: do we keep the reader in suspense, but risk confusion, or 'give away' the whole story in the abstract?

Finally, and perhaps most interesting, externalisations can make *tacit* understanding available to *explicit* interrogation by others. Looking again at vignette V2, Yorick verbally expresses an argument, which is then reflected back and elaborated by Betty. Although Betty also adds to the argument, she also hears elements in Yorick's verbalisation, which he clearly 'knew' tacitly in the sense that he said them, but did not know explicitly enough to articulate. Similarly in the arts one may analyse a poem exposing the subtle use of metre and language by which it creates its emotive effects. We will return to this ***tacit–explicit*** mode later when we re-examine reflection.

from producer	to recipient / reader	
	tacit	explicit
tacit	poetry, dancing	reflection on speech/action
explicit	advertising mood board	academic paper

Table. 1. Modes of interaction with others

Table 1 summarises these modes of explict/implicit communications. However, this itself, while avoiding the dualism that separates these completely, still runs the risk of over simplifying. Where would one put Derrida in such a picture? Even Einstein's imaginary 'sitting on a light beam' strains the boundaries.

DOING IT

Functions of Externalisation

So far we have looked at examples of externalisation, seen it as a rich process, which often involves many layers of action and thought at the same time, and seen how it operates within and across the tacit–explicit divide. However, externalisation is not a purposeless phenomenon, but something that achieves something. We identify four functions of externalisation:

informational – This is the obvious explicit–explicit communicative function of writing, noted in the last section: you have some existing thoughts or ideas and set these down on paper so that someone else can understand the same things that you do (Figure 2). Similarly an architect may make a scale model or virtual reality simulation in order to convey the shape, appearance or experience of a building to a client. Note that this process may not be perfect. The words or pictures on the paper, or model on the table may not perfectly capture the idea or picture in your head. Similarly, the impression that this creates in your readers' or clients' heads may be not be the

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[2] Note 'semi-' in the sense that it neither need be perfectly private, nor give rise to perfect recall, the two attributes that were the subject of Wittgenstein's critique [59/Wi53])).

same as in your own. However, whilst not a perfect act of communication, it is achieving a communicative purpose.
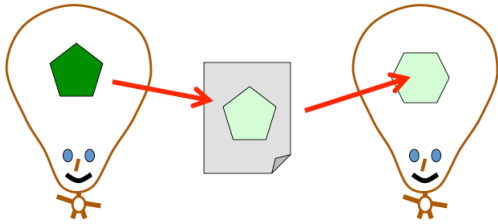

Figure 2. informational – passing on to others already formed ideas

formational – Most writers have noticed the common yet strange phenomenon that they know more after they have written than they did before. This is weird if one regards externalisation solely as an act of communication. The act of writing demands a particular word, the need to sketch demands that the location of a door is specified; what had been vague or fuzzy thoughts becomes specific and concrete; the very process of elaboration of thoughts changes the thoughts. Rather then pre-existing ideas being *re*-presented in an external form, the idea is itself *formed* in the process of presentation. This can be problematic leading to premature commitment, hence the need at some stages of design for deliberately fuzzy representations; for example, Buxton [4] emphasises the importance of the way sketched lines are imprecise and often don't join at the corners.
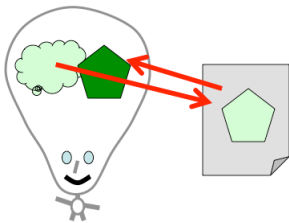

Figure 3. formational – vague ideas becoming clearer by the process of externalisation

transformational – While the informational function is most obvious when considering communication media, for those involved in craft or product design the most important thing is that the external representation has properties that can be used to help in understanding or planning the eventual outcome. We may measure lengths on a scale diagram, add up lists of numbers, play back a tune, or simply run our hands over the planned shape of the wing of a car. Sennett [50] talks about the relationship
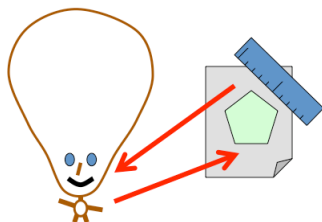

Figure 4. transformational – thinking using materials

between craftsman and material as a form of conversation and Schön [47] refers to the "back talk" of the situation, part of *knowing in action*. In problem solving research it is well known that changes of representation can offer obvious solutions to what appeared to be intractable problems, and perhaps this move from internal to external is the most radical transformation of all. It is this function of externalisation as an augmentation of cognitive activity that is critical in distributed cognition accounts and in those studying embodiment.

transcendental[3] – This final meta-cognitive function is the least obvious, but ultimately perhaps the most powerful. Because our thoughts have been expressed externally we can peruse them as if they were any other thing. This is most obvious when we in some way capture the abstract aspects: concepts, arguments, criteria, etc. In a mind map one can see both the names of concepts written down and also the relationships between them as connecting lines and clustered word bubbles. In an academic paper, like this, one can analyse the way the argument is structured and recognise its strengths and gaps. This function is most common with symbolic representations such as words, as the symbols in some sense 'flatten' the conceptual landscape: the word "stone" is similar to the word "concept" or "efficiency"; so that talking about thoughts and thoughts about thoughts become little different from talking about feet or walking.
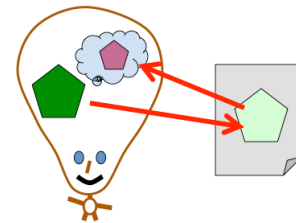

Fugure 5. transcendental – our thoughts and ideas become the object of thought

Without minimising the importance of communication in the informational function, or the embodied cognition of the transformational function; we will shift our attention to the formational and transcendental aspects as it is in these that embodiment and reflection meet.

From knowing to knowing about knowing

It is the transcendental function of externalisation that we see at work in accounts of professional reflection. Often this is through the resistances felt through interactions with others or with the world that then force reflection. Recall Quist is the tutor architect in Schön [47]. Quist and Petra are discussing her initial ideas for the site and her problems. Quist says, "*You should begin with a discipline, even if it is arbitrary, because the site is so screwy ...*". The odd patterns of contours in the site, its 'screwiness' forces Quist to step back, consider and explicate higher-level

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[3] 'Transcendental' here is being used in its meaning as a different (higher) plane or level of reasoning, not in any mystical sense.

heuristics. However, the screwiness itself was evident not from walking the terrain, but from the representation in terms of contour lines on the page. The externalisation allows Quist's *tacit* understanding of the spatial characteristics to operate, noticing the site feels 'screwy' and the by articulating this, makes it available as an *explicit* issue to be faced.

At a larger scale, Alexander's pattern language is doing just this, reflecting on centuries of craft knowledge made external in buildings and streets, and from that extracting the patterns of events and spaces that make these 'work' for people [1]. Furthermore, by making these patterns explicit, one can not only apply and teach them, but also discuss them, maybe debate whether a particular pattern is right, or how patterns fit together. Similarly, by naming his six 'S's (site, structure, skin, services, space plan and stuff), Brand was able to analyse and articulate the aspects of traditional buildings that made them able to evolve [3]. In music theory also, Magnusson describes how the need to create code means that digital instruments make explicit the knowledge that was implicit in traditional analogue instruments [37].

At an even larger level this can be seen as the ultimate success of language and the symbolic. Words allow us to talk about things and so collaborate. However, words also are things in themselves, identifiable on the page, and yet remarkably similar in form no matter whether what they represent is concrete or abstract, verb or adjective. In his use of archaeology to uncover past human and pre-human cognition, Mithen identifies the importance of *cognitive fluidity*, the ability to work between multiple modular intelligences (social, physical, etc.), which arose somewhere between 30 and 60 thousand years ago [39]. This fluidity is necessary for material symbolism, and so essential for language, thus language cannot be the sole source for it. One of the authors has argued that imagination acts as an alternative cognitive connection between these modules, maybe kick-starting the process [13].

Whatever the origins, language creates an important ratchet as symbols and words are a great conceptual leveller. Once they are external symbols, we can manipulate 'wolf' and 'worry', 'heavy' and 'health' as they are things not ideas or concepts. At its extreme, this is precisely the agenda of the formalist movement at the turn of the 19/20 century, but is also the stuff of day-to-day language use. Language is one of the core tools of the transcendental function of externalisation, as it turns the world of ideas into the world of material 'stuff', and thus allows us to have ideas about ideas as easily as ideas about stuff, and those ideas about ideas are named, become material and thus the subject of

"There are known knowns ...
We also know there are known unknowns; ...
But there are also unknown unknowns ..."

Donald Rumsfeld, 2002

When we tap into our tacit knowledge
we are uncovering the unknown knowns.

discussion. At each stage the level of discourse is raised, allowing us to think more generically, more conceptually.

Andy Clark sees language within a framework of external mind, as a sort of bringing of the external word into the internal [7]. The external material symbols become available in our imagination so are amenable to our internal means to apprehend and deal easily with the external material world. Some writers, such as Searle [49] stress the role of language in creating reality, especially in establishing *institutional facts* (Obama is the President of the United States, because he was declared to be it), however Renfrew notes that it is often "*the material reality, the material symbol, that takes precedence*" [46, p.127]. It seems there is a rich interplay whereby material realities shape language, but language, while not in the end limiting thought [12], does shape it, making some things easier to say and think. This then changes material culture – the fact that we have words for 'chair' and 'table' means we see the world in these terms, and so the world becomes populated with easily classifiable chairs and tables [19].

By understanding this rich interplay, it is possible to exploit it, to expose our internal categories in our external actions, and to use external tools to challenge those categories.

Tools and Methods

In general, understanding the ways in which externalisation works, can help us make sense of various tools and techniques for design and creativity, and moreover to develop new ones.

tapping into the tacit – Some techniques work by appealing directly to our tacit understanding. Rich *scenarios* and *personae* do this. They are deliberately far more detailed than crude user profiles including 'unnecessary' details that make the people and the physical situation seem to real to us. By appealing to our imagination, they spark our natural social and physical understandings in a way that an abstracted 'user group' cannot. Similarly *(re)coding dialectic*, provides a way for analysts to validate and evolve their vocabulary, models or categorisation schemes (whether these are based an *a priori* theory or inductive methods) [18]. The analyst is asked to (re)code existing transcripts or observations with the scheme. It is obvious that extra thought is required where there are gaps. Less obviously, where a category (say 'X') does apply, the analyst is prompted to say to themselves "this item is *just* X" or "no more than X". This "just a" phrase often sparks a visceral response "no it is not just an X ..." and in explicating this tacit response, the scheme is refined and developed.

resistance and breakdown – Another class of techniques attempt to bring aspects of our tacit understanding of the external world to our attention, problematising them, and so making them available for reflection. Many artists,

ethnographers and comedians are experts at *estangement*, taking the everyday and making it in some way strange: a focus of wonder, analysis or laughter; the things we take for granted are instead granted centre stage.

This can become an explicit analytic method. In one exercise, designers named and arranged the activities they used in their personal design process, then, one-by-one, the activities were removed and the designers reacted to the envisaged loss [27]. In *Making Tea*, chemists' use of lab books was examined by asking them to make tea using both chemistry and kitchen equipment, in each case treating the exercise as if it were a laboratory procedure [48/sD09]. This created a common ground between researcher and chemist, but also made the chemists' everyday, invisible practices in the lab 'strange' and salient. The early stages of *Bad Ideas* do the same, by asking participants to come up with a bad or silly idea, rather than a good one, they instantly find themselves in a strange part of the design space, and so are able to see it more clearly [15].

In some areas near constant breakdown can have a positive effect. In studies of novice object-oriented programmers, simply asking them to vocalise during early design lead to improved performance [32]. This is also evident in pair programming, which is popular in agile software development methods [51].

reducing and relating – When words or symbols are on paper, they become available, but often need to be brought together to see similarities and differences, to bring out commonality or explore conflicts. The codes used in content analysis and grounded theory, do this for transcript data. The transcripts (or video/audio recordings which they record), may be to large to apprehend, but when reduced to a stream of codes relationships themes and higher order categories become evident. We see this in vignette 3 where Zoe becomes aware of cross cutting categories due to similar names and words. A similar technique can be used

> **Vignette 3:** Zoe engaged in an extensive qualitative study of libraries using grounded theory. She studied different libraries then analysed each separately using grounded theory and is finally bringing the results together. To do this she reduced the rich descriptions of each category and sub-category to simple lists in a spreadsheet so that similar concepts can be identified in the different libraries studied. However, in doing this, she notices that even within a single library's results, there are sub-concepts with very similar names appearing under different concepts: for example, "oversize books" occurs under "shelving" and "large books" under "scanning during check-out/check-in". This at first appears to be a problem in the analysis, but in discussing this with Charles, they realise that in fact this corresponds to a cross-cutting issue, that of the physical properties of books, which should perhaps be a concept in its own right that has inter-relationships with other concepts such as "shelving" and "scanning".

in dealing with reviews of literature, software or products. By using a few bullet points to capture the salient points of each item, what was a huge pile of papers, documentation, or objects gets reduced to a few A4 sheets of paper – similar terms in bullet points become apparent and thematic concepts, that were clearly there tacitly in that they were used to write the bullet points, suddenly become explicit.

engagement and reflection – There is often a tension: to let our tacit skills work we need thrownness, engagement in what we are doing, but reflection can get in the way of this. If a poet were to think at the end of each line, "I wonder what poetic techniques I have used", it is unlikely more than one line would get written. Where the externalisation is persistent: on paper, in clay, or captured digitally, then this tension can be resolved partially by *separating in time* thrownness and breakdown, action and reflection: the poet may write then critique, the painter stands back.

For more analytic processes whether exploring a design brief, establishing user requirements, or academic research, reflection is often achieved through text. We have already noted how simply reflecting back students' words can elicit surprise, as if the idea was new. This is particularly the case with abstract and relational concepts; students know about the concrete nouns and noun categories that they use, but are less likely to recognise the adjectives, criteria and property words – even though they speak them. In requirements engineering it is common to perform noun-verb analysis on written materials (documentation, manuals etc.). In a similar way it is possible to analyse one's own writing and examine critically the vocabulary. This is a common weakness of mind maps, which tend to focus on nouns and concrete classes; but explicitly naming the linking lines and arrows may yield new insights.

tracing the ephemeral – This separation works when the externalisation is persistent: writing, drawing, sculpting, modelling; but fails for the ephemeral: spoken words, improvised dance or music, drama or body storming. A *facilitator* or *observer* may aid this, so that the actor (the person engaged in tacit action) can continue unreflectively, while the observer watches for novel ideas and issues. For example, training simulators have been developed for special forces to develop cultural sensitivity; some participants take active roles, while others observe; in addition facilitators draw the observers' attention to interesting points [45]. In this case the active participants are not reflecting themselves, it is more that their actions, would be similar to those of the observer so provoking self-reflection on the part of the (novice) observers.

When the performer needs to reflect on their own performance or when the action happens too quickly for effective observation, some form of recording is needed, laying down a *trace* where there is none naturally. This is exactly what is seen in physical sports where trainers will film athletes, and then watch alongside one another in order to improve their performance. Note that this involves three phases: first through recording and observing making tacit

behaviour available for explicit reflection, then through explicit analysis working out improved techniques, finally the explicitly understood techniques have to be practiced so that they are committed to tacit 'muscle memory'. This same process can be used in more cognitive design situations, for example, simply recording conversations (or learning to type and note-take less reflectively) so that the resulting written trace can be later examined in a more reflective mode.

In the *Replay* method [27], observation and video recording are used during dramatic and design-focused improvisation, both forms of ephemeral externalisation. By asking some actors to take a more reflective role, they become like the tutor or trainer, observing and eliciting interesting issues, themes or ideas from the otherwise fleeting actions of the other actors. Recordings are later replayed for further reflection by the group. Similar techniques are used in cooperative evaluation and video-based user evaluations of user interfaces [40], and cultural probes, as well as their tacit–tacit role, also act as ways of recording (albeit with disruption) the quintessence of the quotidian for later analysis.

CONCLUSIONS

Externalisation is ubiquitous in design and it is important to understand its role so that we can make the most of it, and develop ways to improve its power. However, there is a theoretical and practical tension between external representation as part of embodied action and as a means for reflection. We have shown how externalisation is in fact a link point between the tacit and explicit, enabling unreflective embodied action to become the subject of analytic reflection. This analysis offers a way to understand, refine and develop practical design and creativity techniques. This paper is itself effectively a meta-reflection, and we hope by exposing these issues they can become part of the tacit as well as explicit understanding we bring to bear on our understanding of practical design.

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