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What's A Mallet For: A Woodworker's Critique of The Workmanship of Risk

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Abstract: At the woodworker's bench, a wooden mallet is used primarily for striking chisels. This is a straightforward answer to the question, 'What's a mallet for?'. It is an account that focuses upon tool use as an activity that *does something to the world* – a mallet drives a chisel in order to remove waste wood. In this paper however, I aim to reconsider mallets, and tools more generally, not just as artefacts that enable us to do things to the world, but also as *instruments for finding out how those things are going*. The paper is based around a critique of David Pye's concept of the workmanship of risk. My argument states that understandings of production such as Pye's rely on an entirely pragmatic account of tool use, and action more generally, as a means of realising preconceived ideas in the material world. I draw on the concept of epistemic actions, which are actions intended to improve our understanding of a situation and aid decision making, in order to counter this tendency. This discussion is presented alongside a portable workbench and work-in-progress mallet I am making. By demonstrating the production and use of a mallet at the workbench during RTD 2017, I aim to illustrate my argument and describe its significance for how we talk about, and practice, designing and making.

Luscombe | A portable workbench, spokeshave, coping saw and mallet-in-progress

Introduction

At the woodworker's bench, a wooden mallet is used primarily for striking chisels. It is especially suited to this task in two ways. Firstly, owing to the large area of its face, a mallet does not require a high degree of striking precision. Rather than concentrating on trying to hit the handle of a chisel, this enables a woodworker to instead focus their attention on the chisel's cutting edge. Second, because it has a wooden head, the mallet does not tend to damage chisel handles, or recoil from them. Wooden mallets deliver a firm, easily controllable blow.

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The paper is based around a critique of David Pye's concept of the workmanship of risk. My argument states that commonplace understandings of production, such as Pye's, rely on an entirely pragmatic account of tool use, and action more generally, as a means of realising preconceived ideas in the material world. I draw on the concept of epistemic actions, which are intended to improve our understanding of a situation and aid decision making, in order to counter this tendency.

The ideas within this paper are a result of reflecting on my own practice as a woodworker and learning from the writing of others. The discussion is presented alongside a portable workbench, upon which I will exhibit a mallet head I have made, some unfinished mallet handles and a small collection tools with which the handles may be completed (see the feature image on the previous page). The exhibition of the workbench, tools and mallet parts will be used to demonstrate some of the concepts introduced in the in the paper, engaging conference attendees with these ideas in a practical way. In the final part of this paper, for example, I contrast the character of two tools - a spokeshave and coping saw - in order to describe their influence upon the process of designing and making a mallet handle. Using the spokeshave or coping saw at the workbench will give delegates the opportunity to reflect on the significance of these differences in practice.

Whilst grounded in the context of woodworking, the discussion of tools as simultaneously for doing things and also finding out how those things are going is intended to be of broader interest to the research through design community. I hope that others may find parallels with their own practice, and be prompted to consider the epistemic character of the designing and making tools that they use.

How To Chop a Mortise & The Problem with Pye

Chopping a Mortise using the Workmanship of Risk

The traditional ‘carpenter’s mallet’ has a rectangular head and tapered handle (Watson [1982] 2002, pp.184-5) (Fig. 1). As with all other traditional mallet forms, the carpenter’s pattern has developed to make use of the materials and manufacturing techniques readily available to the woodworker. Until the advent of industrialised production, most woodworking tools would be made in this way, by a woodworker themselves utilising well-suited offcuts. The carpenter’s mallet may therefore be produced using a small collection of hand tools (Fig. 2) and two pieces of otherwise waste wood.

Perhaps the most difficult process in the manufacture of the mallet is chopping the mortise (Fig. 3). This is a rectangular hole cut through the mallet head, with sides tapered to match the taper of the handle. The fit of the mortise must be close, so as to provide an effective joint that does not work loose. To chop a mortise with a chisel successfully requires practice. The procedure is an instance of what design and craft theorist David Pye calls the workmanship of risk. This phrase describes techniques wherein the quality of the result is continually at risk and relies upon the ‘judgement, dexterity and care’ ([1968] 1995, p.20) of a

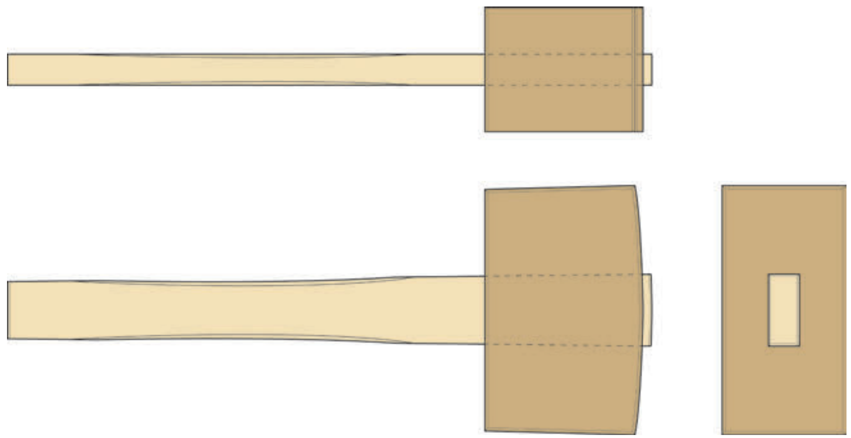

Figure 1. A traditional carpenter's mallet pattern

Figure 2. The tools required for mallet making (left to right: Panel saw, Chisel, No.4 Plane, Spokeshave, Marking Guage, Mallet).

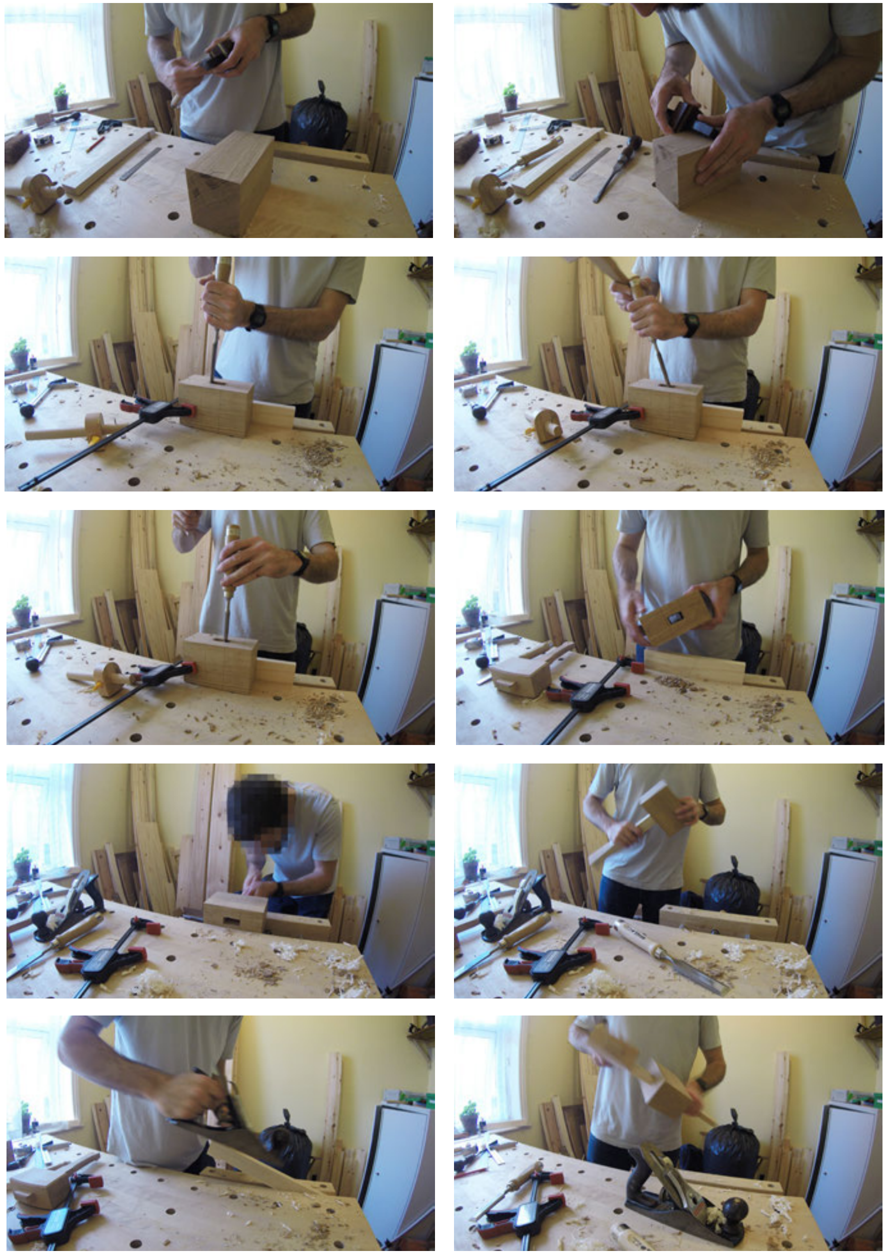

Figure 3. The process of marking out and chopping a mortise, and planing the handle to fit. Notice the mortise guage being set to the width of the chisel in the first image.

practitioner throughout the process. The risk is that the result could, at any moment, deviate from the design intention. Our mortise could be cut at the wrong angle, made too big, or taper incorrectly.

Many aspects of mortise chopping can be considered strategies for mitigating this risk. One example involves making the width of the mortise the same width as a chisel. Provided the chisel does not twist in the cut, we can then be assured that the mortise width will be cut exactly to size. Such strategies for improving precision are common throughout woodworking. And they are consistent with Pye's more general account of workmanship – '[a]ll workmen using the workmanship of risk', he writes, 'are constantly devising ways to limit the risk by using things such as jigs and templates. If you want to draw a straight line with your pen, you do not go at it freehand, but use a ruler, that is to say, a jig. There is still a risk of blots and kinks, but less risk' (Ibid., p.21).

In *The Nature and Art of Workmanship* (Ibid.), David Pye presents the workmanship of risk in contrast to the workmanship of certainty. Where the workmanship of risk describes processes that rely on continual adjustment, care and dexterity throughout, the workmanship of certainty relates to techniques wherein the results of production are 'predetermined and unalterable once production begins' (Ibid., p.22). Our efforts to improve precision when making mallets or drawing lines with a ruler can, therefore, be understood as attempts to make the outcomes more certain.

The Enduring Relevance of Pye's Analyses

Pye's workmanship of risk and certainty introduced, as craft theorist Glenn Adamson observes, a 'purposeful reframing of [the] dichotomy between craft and industry, or hand and machine' (2007, p.73). By defining production in terms of risk and certainty, Pye's analyses can be applied universally across different processes, scales, types of production and work environments. *The Nature and Art of Workmanship* considers all kinds of making, from the free workmanship of Pye's own wood carving practice, to the highly regulated manufacture of industrially-produced artefacts. In fact, much of Pye's writing can be understood as an attempt to discredit any valorisation of handwork over machine work. Pye was determined that the techniques of production – be they the swing of a mallet, or the pass of a machine tool – should be the subject of rational analysis, rather than indicators of a greater or lesser degree of moral virtue. Pye is quick to insist that even the largest volume manufacturing processes can rely on the workmanship of risk at some point ([1968] 1995, p.21). And he uses his own woodworking experience to describe how even the seemingly unguided chisel is inclined to travel in a certain direction, with the shape of its bevel and the grain of the timber forming a semi-determining system (Ibid., p.28).

For Adamson, Pye's legacy is clear – his writing on workmanship constitutes 'the most compelling technical discussion of skilled work ever written' (Adamson 2007, p.72). In other reappraisals of craft's value, David Pye's ideas remain key reference points (see, for example, McCullough 1998, pp.202-3). Contemporary woodworkers such as Peter Galbert still find a valuable link between Pye's writing and their work (2015, p. xiii). And in broader anthropological enquiry, Pye's analyses of human production are readily repurposed in studies of craft practice (see, for example, Keller and Keller 1996, p.56; Bunn 2011, p.24; Ingold 2001, p.21).

The Problem with Pye

In what follows, I aim to demonstrate that, despite being widespread and having a common sense appeal, David Pye's theory of production is a limited one. In short, I argue that Pye's account of making, as the realisation of a pre-existing design intent precludes a richer understanding of the influence of tools, techniques and materials upon creative practice (this is an argument already rehearsed across disciplines interested in human production. See, for example, Ingold, T. (2010), Knappett, C. (2005) & Malafouris, L. (2013)). The focus of my criticism lies in what I consider to be Pye's entirely pragmatic understanding of productive techniques. Under Pye's analyses, tools are always employed in the pursuit of pre-formed objectives, with all action assumed to be an effort to move towards those objectives. Later in this paper, I introduce the notion of epistemic action in order to demonstrate the flaws in this one-directional account of action. Epistemic actions are those performed in order to help work things out, to uncover new information and help people make decisions (Kirsh & Maglio 1994). For now, however, I aim to further interrogate the foundation of Pye's pragmatic approach and describe its limitations.

Pye's Separation of Workmanship from Design

The technical clarity to which David Pye aspires is, as design and craft theorists Christopher Frayling and Helen Snowdon observe, only made possible by a separation of the processes of design from those of workmanship (1982, p.19). In order to describe the techniques of making according to the risk or certainty with which they may achieve a predetermined objective, it is necessary for Pye to divorce them from any role in processes of design. The workmanship of risk involves a risk that results will deviate from intentions. Whether a design is specified on paper, or in the mind of a practitioner, Pye always assumes that it exists in advance of its material realisation.

It is a consequence of this assumption that the imprecision of the word 'skill' was so troubling for Pye ([1968] 1995, p.52) – the way in which skill can be applied to describe both physical operations or to decision making blurs the distinction upon which Pye's account of workmanship relies. Pye therefore claimed that it is 'necessary to differentiate between skill as the exercising of constraint on movement and "skill" as know-how, for know-how, in making, is design. Thus according to the terms of this book one should say that anybody has skill enough to build a good dry-stone wall but that few know how to design one, for the placing of the stones is a matter of knowledge and judgement, not of dexterity' (Pye [1978] 1999, p.52). Pye would rather not discuss dry-stone walling as a skilled activity, because it does not demand a high degree of physical dexterity. If someone can lift and place a stone, then, with instruction, they should be able to make a good wall. Dry-stone walling demands a kind of knowledge that can be described in words, and, for Pye, this kind of knowledge is a matter of design.

Pye's account of production divides designing and making along the same lines as many other thinkers (for a discussion, see Ingold 2010, pp.91-3). But I now aim to demonstrate that this account of production is not as comprehensive as it might seem. My argument rests on Pye's failure to see the potential for making practice, and action more generally, to operate in anything other than a pragmatic way. That is to say that Pye assumes all action to be intended to move a practitioner directly towards a goal.

In Pye's account of dry-stone walling, for example, the critical type of knowledge is mental know-how, as divorced from the relatively straightforward action of picking up and placing stones. It is assumed that these actions are employed to enact instructions sent out from an internal world of thought. In practice, however, action is not only used in this way. It is not only part of a one-directional path from an internal idea towards a predetermined external result. In an example that is more domestic, but analogous with the work of a dry-stone wall building, philosopher of mind Andy Clark has observed that, to complete a jigsaw, one does not sit staring at puzzle pieces in an effort to develop a plan of action (1997, p.36). No one imagines that it is possible to consider all the required moves and piece rotations in your head and then enact them with successful results. What the successful jigsaw player must do is pick pieces up, spin them around, and try things out for fit. The completion of a jigsaw in the real world proceeds by way of step-by-step transformations, which give both pragmatic results (the correct fitting of a piece) and an improved understanding of the task (as in the grouping of similarly coloured pieces). Even if we assume that the dry-stone wall builder has a clear vision of the ultimate outcome (just as there is only one correct solution to a jigsaw puzzle), they must still use action to both build the wall and improve their understanding of the task. Actions like sensing the weight of a stone, rotating it to assess its suitability, physically sorting stones into types, or checking their balance as they are placed can all be considered epistemic, rather than pragmatic actions. It is under this kind of interrogation that the sharply demarcated boundary between design and workmanship, thinking and doing, or know-how and skill, begins to falter. It leaves no space for epistemic action.

Epistemic Action

Epistemic action is a term developed by David Kirsh and Paul Maglio, in order to distinguish between two types of actions – those that aim to change the state of the world to accomplish a goal (pragmatic actions), and those that are taken 'to change the world in order to simplify the problem-solving task' (epistemic actions) (1994, p.513). In an influential paper studying how expert Tetris players rotated puzzle pieces on a video game screen in order to aid decision making, Kirsh and Maglio introduced the concept of epistemic action to redress what they saw as a failure in their field of cognitive science. Kirsh and Maglio aimed to challenge planning-based approaches to cognition, which see action as fundamentally pragmatic, and where the 'only reason to act was for advancement in the physical world' (Ibid., p.526). In this view, thinking always proceeds action and action can, at best, lead someone to re-evaluate their conclusions. Crucially, and herein lies Kirsh and Maglio's main criticism, in solely pragmatic accounts of human behaviour, action is never undertaken 'in order to alter the way cognition proceeds [...,] cognition is logically prior: cognition is necessary for intelligent action, but action is never necessary for intelligent cognition.' (Ibid., p.526) The tendency to prioritise cognition over action, therefore assuming every action to be pragmatic is the same tendency we find in David Pye's writing above.

In expert Tetris play, Kirsh and Maglio observe how rotating and moving a piece on screen is not always done to advance towards the goals of the game, but can be used to test potential means of action, speed up decision making and reduce errors. 'The point of [epistemic] actions', conclude Kirsh and Maglio, 'is not for the effect they have on the environment as much as for the effect they have on the agent.' (Ibid., p.546)

Epistemic Action and The Extended Mind

The concept of epistemic action has been taken up across disciplines interested in the relationship between thought, action and the material world (see, for example, Knappett 2005, p.42; Malafouris 2013, p.194). One of the best known and most influential applications of Kirsh and Maglio's work is found in a paper by philosophers of mind Andy Clark (of the above jigsaw example) and David Chalmers, entitled *The Extended Mind* (1998). Clark and Chalmers begin by asking 'Where does the mind stop and the rest of the world begin?' (Ibid., p.7). As suggested by the paper's title, Clark and Chalmers' answer is to understand the mind not as limited by the bounds of the skull, skin or body, but as a coupling of humans and their environment. Thinking thus takes place not only within the confines of human brains and bodies, but within a cognitive system that relies on two-way interactions between people and things.

For Clark and Chalmers, examples of such cognitive systems can be found everywhere – in the rearrangement of Scrabble tiles, the use of pen and paper to solve maths problems, interactions with navigation instruments and an Alzheimer's patient's notebook. Indeed, they regard the 'general paraphernalia of language, books, diagrams, and culture' (Ibid., p.8) to all operate as parts of extended minds. Under Clark and Chalmers' analysis of cognition, any aspect of a human's environment has the potential to become part of a human mind. Minds are everywhere, forever being reconfigured as people pursue new goals and rely on different parts of the world to aid cognition.

Kirsh and Maglio's description of epistemic action is an important influence upon Clark and Chalmers. The theory of extended mind builds upon the idea that actions are performed not just to advance towards a goal, but also to work things out. If parts of the world are used during a process that 'were it done in the head, we would have no hesitation in recognizing as part of the cognitive process' (Ibid.), then Clark and Chalmers believe the things used during that process should be recognized as the components of minds. 'In a very real sense', they write, 'the re-arrangement of [Scrabble] tiles on the tray is not part of action; it is part of thought' (Ibid., p.10). Importantly for the present study, Clark and Chalmers propose that this epistemic action 'demands spread of epistemic credit' (Ibid., p.8).

What is a Mallet For?

In an effort to demonstrate how my criticism of Pye and the above discussion of epistemic actions might benefit designing and making practice, I conclude this paper by returning to the subject of mallet use. The aim is to complement Pye's useful, but wholly pragmatic, account of human production with an examination of the epistemic nature of tool use. Ultimately, I suggest that the tools and techniques of designing and making may be understood not only by the degree of certainty with which they may achieve pre-conceived ends, but by the ways in which they support epistemic action. Before discussing the significance of this understanding for practice, I first revisit a subject that Pye preferred to avoid - the nature of skill. Through studying skill in more detail, I aim to develop a description of tool use that, inspired by the theory of extended mind, is simultaneously epistemic and pragmatic.

Nikolai Bernstein on Dexterity

As observed by Glenn Adamson, if there is any place in David Pye's theories for the concept of skill, it is only as an equivalent to the determining jigs of machines (2007, p.73). Just as jigs allow an action to proceed in a predetermined way, *The Nature and Art of Workmanship* considers human dexterity to be the ability to control movement according to a specific intent. The skill employed by a woodworker when chopping a mortise is the ability to control a chisel's path. It is uncontroversial to say that all skilled work like this, or all workmanship of the risky kind, requires practice and repetition. The mallet and chisel may be wielded with precision only once a woodworker has developed the requisite dexterity. How exactly this dexterity operates, or how the process of becoming dexterous occurs, however, were not questions which David Pye tackled directly. For a more detailed analysis of the nature of dexterity, I turn to neurophysiologist Nikolai Bernstein's pioneering and posthumously published book, On Dexterity and Its Development (Bernstein 1996).

Bernstein shared Pye's physical interpretation of skill and chose to study the technique of expert blacksmiths in order to gain insight into how this skill is developed (Gurfinkel and Cordo 1998, p.3). Bernstein criticised the idea that skilled action was the result of learned sequences of movements, somehow stored in the central nervous system and sent out to the muscles in a one-way process. Using the then novel technique of high speed photography (much of Bernstein's work was carried out in the 1920s), Bernstein tracked the movement of experienced blacksmiths' arms and their hammers whilst they repeatedly hit the same point on an anvil. Plotting the trajectories of the arm joints and the face of the hammer, Bernstein identified that, although the movement of the hammerhead was highly consistent across multiple strikes, the arrangement of the arm joints varied each time. The outcome of the blacksmith's action was repeatable, even though the means by which this solution was arrived at changed with every strike. This was evidence to Bernstein that the smith had not become skilled by internalising a repeatable programme for their hammer swing. The years spent developing precise hammering skill were not, it appeared, used to develop a specific pattern of muscle and joint movement. The blacksmiths of Bernstein's experiment were instead experts at solving the problem of delivering the hammer face to exactly the same point, despite the variable elasticity of their muscles and the unpredictable recoil of the tool (Latash 1996, pp.286-7). At first, this seems a strange paradox – how can it be the motion of the hammer that is reproducible, rather than the motion of the blacksmith's arm itself (Ingold 2001, p.21; Latash 1996, p.286)? But if, as Bernstein describes, the essence of dexterity lies in a sensitivity to ever changing, emergent and unpredictable internal and external states, the repetition without repetition witnessed in the study of blacksmiths is a necessary condition of skilled activity. The consequence of this repeated solving is an enhanced sensitivity to the progress of a task and, therefore, an improved ability to apply force with precision.

Tool use is both epistemic and pragmatic

I hope now to make clear the parallels between Bernstein's discussion of skilled activity and Kirsh and Maglio's description of epistemic action. In both, we find criticisms of one-way interpretations of action. Bernstein refutes the idea that skilled hammer movements are the result of fixed, repeatable patterns sent outwards from the nervous system to the muscles. And Kirsh and Maglio demonstrate that expert Tetris players do not work out solutions in their head and then input those solutions into the game. In both Bernstein's study of hammering and Kirsh and Maglio's analysis of Tetris then, responding to sensory feedback is key to the tasks' success. Throughout a game of Tetris, players use action not just to complete the game's objectives, but also to help work out the best moves. The rotation and lateral movement of zoids is used both to generate sensory feedback (to help cognition) and to achieve success in the game. Similarly, throughout the process of hammering, with every swing and strike, a practitioner must be continually alert and perceptive to feedback. The strike of the hammer, in addition to achieving a pragmatic result in the world, provides sensorial feedback. As they are shaping metal, knocking in nails, or driving chisels, hammers and mallets also report on the progress of these tasks. In both Tetris gameplay and skilled tool use, we find what Tim Ingold calls a 'coupling of perception and action' (2011, p.58). It is this coupling that erodes any boundary between thought and action, or, as theorists of the extended mind would claim, between mind and world.

This description of tool use as simultaneously pragmatic and epistemic allows us to develop a richer account of what tools are for. I wish to argue that a mallet, just as it might usually be considered for achieving pragmatic results (wasting wood with a chisel etc.), is also for reporting on the progress of the task. And tools and techniques more generally may be discussed in terms of their potential for working things out through epistemic action, in addition to their pragmatic effectiveness.

Bernstein's observations on dexterity are fundamental to this description of tool use. If we are to ignore Bernstein's contribution and assume mallet use to involve the enacting of a pre-programmed, learned sequence of movement, then the effectiveness of a mallet would depend little upon the quality of feedback it provides throughout the process. The best mallet might simply be the one that gets the job done as quickly as possible. But if we acknowledge the requirement of a mallet user to be continually aware of, and respondent to, the sensory feedback of their tool, then the quality of that feedback is critical to success. This point is perhaps obvious to experienced users of tools, where the feeling of working a material can be tangibly deadened by, for example, even a subtly dulled cutting edge (Watson [1982] 2002, p.353). But this more comprehensive description of a tool use is not accounted for in one-way, pragmatic acounts of action such as David Pye's.

The Epistemic Character of Tools and Techniques

I conclude this paper by suggesting that the synergy of epistemic and pragmatic action witnessed at the level of each mallet strike may also be applied to the processes of designing and making more generally. And, just as we may describe the risk or certainty with which tools and techniques achieve pre-specified aims (their pragmatic effectiveness), I suggest we should also consider their epistemic character. This has practical implications during designing and making practice. If some tools and techniques have a character that supports epistemic action, then they may be selected over others not just on the grounds of how well they achieve a result, but also for the aid to decision making that they offer along the way. One such selection can be demonstrated using the workbench, tools and unfinished mallet handles presented at RTD 2017.

The Spokeshave and The Coping Saw

When making a mallet, one of the latter stages in the process involves shaping the handle, so that it is more comfortable in the hand. Using a spokeshave, the shaping can proceed by small steps, in increments determined by the maximum thickness of shaving the tool can take (Fig. 4). The nature of spokeshave use thus sees a woodworker presented with the emergent form after each pass with the tool. We may then pause to check the result and make adjustments if required, until the handle becomes pleasing to hold.

An alternative to the spokeshave method would be to saw the handle to shape and then smooth the rough sawn edge with a scraper. If it is to be sawn by hand, a coping saw would typically be used for this kind of shaping work (Fig. 5). Although it is not necessary to do so, a pencil line is usually marked as a guide for the saw cut. Using the coping saw, all the

Figure 4. Using a spokeshave

Figure 5. Using a coping saw

waste is removed simultaneously, at the moment the cut is complete. In contrast to the step-by-step, incremental process associated with the spokeshave, the sawing technique therefore offers little opportunity for sensing the quality of an emergent result throughout. Whether we mark the pencil line or not, use of the coping saw requires that the completed shape of the handle be anticipated in advance of cut's completion. Where the nature of the spokeshave allows us to discover the best shape as we go, the coping saw offers no opportunity to test the resultant shape along the way. Whilst both techniques may be used to arrive at the same outcome then, the epistemic character of the alternative approaches varies.

In this small example, I hope to have introduced the significance of a discussion of the epistemic character of tools and techniques. Complementing David Pye's analyses of risk and certainty in production with a consideration of techniques' epistemic character would, I suggest, provide designers, makers and those employing designing and making in research with a valuable insight into their practice.

References

Adamson, G. (2007). *Thinking through craft*. Oxford: Berg.

Bernstein, N. (1996). On Dexterity and Its Development. In: Latash, M., & Turvey, M. eds. *Dexterity and Its Development*. Mahwah: Lawrence Erlbaum

Bunn, S. (2011). Materials in making. In: Ingold, T. ed. *Redrawing Anthropology: Materials, Movements, Lines*. Farnham: Ashgate. pp.21-32.

Clark, A. (1998). *Being There: Putting Brain, Body, and World Together Again*. Cambridge, Massachusetts: MIT press.

Clark, A., & Chalmers, D. (1998). The Extended Mind. *Analysis*, 58(1), pp.7-19.

Frayling, C., & Snowdon, H. (1982). Skill - A Word To Start an Argument. *Crafts* (56), p.19

Galbert, P. (2015). *The Chairmaker's Notebook*. Fort Mitchell: Lost Art Press.

Gurfinkel, V., & Cordo, P. (1998). The Scientific Legacy of Nikolai Bernstein. In: Latash, M. ed. *Progress in Motor Control* (Vol 1). Champaign: Human Kinetics.

Ingold, T. (2001). Beyond Art and Technology: The Anthropology of Skill. In: Schiffer, MB. ed. *Anthropological Perspectives on Technology*. Albuquerque: University of New Mexico Press.

Ingold, T. (2010). The Textility of Making. *Cambridge Journal of Economics* (34), pp.91–102

Ingold, T. (2011). *Being Alive: Essays on Movement, Knowledge and Description*. London: Routledge.

Keller, C. M., & Keller, J. D. (1996). *Cognition and Tool use: The Blacksmith at Work*. Cambridge: Cambridge University Press.

Kirsh, D., & Maglio, P. (1994). On Distinguishing Epistemic from Pragmatic Action. *Cognitive Science*, 18(4), pp.513-549.

Knappett, C. (2005). *Thinking Through Material Culture: An Interdisciplinary Approach*. Philadelphia: University of Pennsylvania Press

Latash, M. (1996) The Bernstein Problem: How Does the Central Nervous System Make Its Choices?. In: Latash, M., & Turvey, M. eds. *Dexterity and Its Development*. Mahwah: Lawrence Erlbaum

Malafouris, L. (2013). *How Things Shape Mind*. Cambridge, Massachusetts: MIT press.

McCullough, M. (1998). *Abstracting Craft: The Practiced Digital Hand*. Cambridge, Massachusetts: MIT press.

Pye, D. [1968] (1995). *The Nature and Art of Workmanship*. London: The Herbert Press.

Pye, D. [1978] (1999). *The Nature and Aesthetics of Design*. London: The Herbert Press.

Watson, A. [1982] (2002). *Hand Tools: Their Ways and Workings*. New York: W.W. Norton & Company.

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